

Local Building Official

(Print Name):_____ Signature:_____ Date:_____

Local Fire Marshal

(Print Name):_____ Signature:_____ Date:_____

Local Health Official

(Print Name):_____ Signature:_____ Date:_____

Local Federal 504 Official

(Print Name):_____ Signature:_____ Date:_____

Specifications

State Project # 094-0109 RNV

January 14, 2022—Phase 1 of 3

Renovations

**Anna Reynolds Elementary School
Newington, CT**



**Volume II of II
Divisions 21—34**

**Issued for Local Approval
State Project #094-109 RNV**

KAESTLE BOOS
associates, inc

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**DO NOT REMOVE
THIS PAGE INTENTIONALLY LEFT BLANK**

Local Building Official

(Print Name): _____ Signature: _____

Date: _____

Local Fire Marshal

(Print Name): _____ Signature: _____

Date: _____

Local Health Official

(Print Name): _____ Signature: _____

Date: _____

Local Federal 504 Official

(Print Name): _____ Signature: _____

Date: _____

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Local Building Official

(Print Name): _____ Signature: _____

Date: _____

Local Fire Marshal

(Print Name): _____ Signature: _____

Date: _____

Local Health Official

(Print Name): _____ Signature: _____

Date: _____

Local Federal 504 Official

(Print Name): _____ Signature: _____

Date: _____

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PROJECT TEAM AND LOCAL OFFICIALS LIST

ANNA REYNOLDS ELEMENTARY SCHOOL RENOVATIONS

Newington, CT

KBA # 21011.00 | SPN #094-0109 RNV

Updated: 1/7/22

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Chris Miner, Town Council Representative

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PROJECT TEAM AND LOCAL OFFICIALS LIST

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RENOVATIONS

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SECTION 21 05 00 - FIRE PROTECTION BASIC MATERIALS AND METHODS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Pipe, fittings, sleeves, escutcheons, seals, and connections for sprinkler systems. (combination sprinkler and standpipe systems.)

1.3 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.
- B. Section 21 13 00 - Fire-Suppression Sprinkler Systems: Sprinkler systems design.
- C. Section 22 05 53 - Identification for Plumbing Piping and Equipment: Piping identification.

1.4 REFERENCE STANDARDS

- A. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX – Welding and Brazing Qualifications; 2019.
- B. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250; 2020.
- C. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2016.
- D. ASME B16.4 - Gray Iron Threaded Fittings: Classes 125 and 250; 2016.
- E. ASME B16.9 - Factory-Made Wrought Butt welding Fittings; 2018.
- F. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings; 1999 (Reapproved 2018).
- G. ASTM A197/A197M - Standard Specification for Cupola Malleable Iron; 2000 (Reapproved 2019).
- H. ASTM A795/A795M - Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use; 2021
- I. NFPA 13 - Standard for the Installation of Sprinkler Systems; 2013.
- J. UL (DIR) - Online Certifications Directory Current Edition.
- K. UL 312 - Check Valves for Fire-Protection Service; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.5 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for project requirements.
- B. Product Data: Provide manufacturers catalogue information. Indicate valve data and ratings.
- C. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.
- D. Project Record Documents: Record actual locations of components and tag numbering.
- E. Operation and Maintenance Data: Include installation instructions and spare parts lists.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Conform to UL (DIR) requirements.
- C. Valves: Bear UL and FM product listing label or marking. Provide manufacturer's name and pressure rating marked on valve body.

1.7 CONTRACTOR'S RESPONSIBILITIES

- A. All permits and fees.
- B. Hoisting, rigging, transportation costs and installation of necessary appurtenances.
- C. The Contractor shall visit the premises and note all pertinent facts and details including conditions under which the work must be carried out. No allowance will be made for failure to have done so.
- D. Holes - Cutting and Patching: Cutting will be by core boring, patch will require both waterproofing and fireproofing.
- E. Expenses for Fire Watches are the responsibility of the Fire Protection Contractor.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store valves in shipping containers, with labeling in place.
- B. Provide temporary protective coating on cast iron and steel valves.
- C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

PART 2 PRODUCTS

2.1 FIRE PROTECTION SYSTEMS

- A. Sprinkler Systems: Comply with NFPA 13.
- B. Welding Materials and Procedures: Comply with ASME BPVC-IX.

2.2 ABOVE GROUND PIPING

- A. Steel Pipe: ASTM A 795 Schedule 10 or ASTM A795 Schedule 40, black.
 - 1. Standard weight Schedule 40 with grooved coupling in sizes 1-1/2" and 2". Standard square cut grooves to coupling manufacturer's specifications.
 - 2. Standard weight Schedule 40 with threaded coupling and fittings in sizes 2" and smaller.
 - 3. Light wall Schedule 10 with grooved couplings in sizes 2-1/2" and larger. Rolled grooves; no cut grooves or threading will be allowed on Schedule 10.
- B. Fittings
 - 1. Steel Fittings: ASME B16.9 wrought steel, buttwelded.
 - 2. Cast Iron Fittings: ASME B16.1, flanges and flanged fittings and ASME B16.4 threaded fittings.
 - 3. Malleable Iron Fittings: ASME B16.3, threaded fittings, ASTM A47 and ASTM A197.
 - 4. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.

2.3 PIPE HANGERS AND SUPPORTS

- A. Hangers for Pipe Sizes 3/8 to 3 inch: Malleable iron, split ring extension hanger.
- B. Hangers for Pipe Sizes 1 inch and Over: Carbon steel, adjustable ring, with knurled swivel. NFPA threaded rod sizes.
- C. Hanger attachment to structural steel beam: Universal or wide mouth malleable iron C-type beam clamp with locknut, U.L. Listed. Secure with retaining strap hammered tight to beam flange.
- D. Hanger attachment to concrete: Set-in expansion anchors to rated capacity or self drilling anchors where weight of piping does not exceed half of rated capacity.
- E. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- F. Wall Support for Pipe Sizes 4 inches and Over: Welded steel bracket and wrought steel clamp.

- G. Vertical Support: Steel riser clamp.
- H. Floor Support: Cast iron adjustable pipe saddle with U-bolt, threaded pipe adjuster, cast iron floor flange, and steel pipe support.

2.4 BALL VALVES

- A. Up to and including 2 inches:
 - 1. Bronze two piece body, brass, chrome plated bronze, or stainless steel ball, teflon seats and stuffing box ring, lever handle and balancing stops, threaded ends with union.

2.5 BUTTERFLY VALVES

- A. Bronze Body:
 - 1. Stainless steel disc, resilient replaceable seat, threaded or grooved ends, extended neck, handwheel and gear drive and integral indicating device, and built-in tamper proof switch rated 10 amp at 115 volt AC. UL listed and FM approved
- B. Ductile Iron Body
 - 1. Epoxy coated ductile iron, chrome or nickel plated ductile iron or aluminum bronze disc, resilient replaceable EPDM seat, wafer, lug, or grooved ends, extended neck, handwheel and gear drive, 175 PSI non-shock water pressure. Integral indicating device, and internal tamper switch rated 10 amp at 115 volt AC. UL listed and FM approved

2.6 CHECK VALVES

- A. Up to and including 2 inch:
 - 1. Bronze body and swing disc, rubber seat, threaded ends.
- B. 4 inch and Over:
 - 1. Iron body, bronze mounted, swing check with rubber disc, renewable disc and seat, flanged maintenance port, grooved or flanged ends with automatic ball check. 175 PSI non-shock water pressure. UL listed and FM approved.

2.7 DRAIN VALVES

- A. Ball Valve:
 - 1. Brass with cap and chain, 3/4 inch hose thread.

PART 3 EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

- B. Remove scale and foreign material, from inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

- A. Install sprinkler system and service main piping, hangers, and supports in accordance with NFPA 13.
- B. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- C. Install piping to conserve building space, to not interfere with use of space and other work.
- D. Group piping whenever practical at common elevations.
- E. Sleeve pipes passing through partitions, walls, and floors.
- F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- G. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

3.3 HANGERS AND SUPPORTS

- A. Pipe Hangers and Supports:
 - 1. Place hangers within 12 inches of each horizontal elbow. Any sprinkler pipe over 1'-6" in length requires a hanger and the maximum overhang beyond the last hanger shall not exceed 1'-6". Hangers are to be installed on both sides of grooved pipe couplings.
 - 2. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe. End of line hangers for pendent sprinklers shall prevent upward movement of pipe.
 - 3. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - 4. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

3.4 PIPING SYSTEM

- A. The piping system shall be arranged so that the entire system can be flushed and drained through accessible low points. Slope piping towards main drain or provide auxiliary drains for water in trapped sections of pipe.

- B. Pipe and fittings for drain lines shall be galvanized.
- C. Do not penetrate building structural members unless indicated.
- D. Provide sleeves when penetrating floors, walls, and foundations. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required. Firestop floor penetrations in un-rated floors to a minimum of 1 hour UL fire rating.
- E. Escutcheons:
 - 1. Install and firmly attach escutcheons at piping penetrations into finished spaces.
 - 2. Provide escutcheons on both sides of partitions separating finished areas through which piping passes.
 - 3. Use chrome plated escutcheons in occupied spaces and to conceal openings in construction.
- F. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- G. Grooved fittings and couplings shall be installed in accordance with the manufacturer's recommendations. Piping shall be cut and prepared per the coupling manufacturer's standards.
- H. Threaded joints shall be made with teflon liquid joints compound applied to male threads only.
- I. Chrome-plated escutcheon shall be used on all exposed piping with penetrates either walls or ceilings.

3.5 VALVES

- A. Install valves with stems upright or horizontal, not inverted. Remove protective coatings prior to installation.
- B. Provide drain valves at main shut-off valves, low points of piping and apparatus. All drain piping shall be galvanized.

END OF SECTION 21 05 00

SECTION 210800 - COMMISSIONING OF FIRE SUPPRESSION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SUMMARY

- A. This section includes commissioning process requirements for Fire Suppression systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
- C. Certificates of readiness
- D. Certificates of completion of installation, prestart, and startup activities.
- E. Test reports
- F. O&M manuals

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the contractor for the equipment being tested. For example, the fire protection contractor of Division 21 shall ultimately be responsible for all standard testing equipment for the plumbing system in Division 21. A sufficient quantity of two-way radios shall be provided by each subcontractor.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.
- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems.
- B. Red-lined Drawings:
 - 1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
 - 2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
 - 3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
 - 4. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. Operation and Maintenance Data:
 - 1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
 - 2. The CxA will review the O&M literature once for conformance to project requirements.
 - 3. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the contractor.
- D. Demonstration and Training:
 - 1. Contractor will provide demonstration and training as required by the specifications.
 - 2. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training.
 - 3. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.
 - 4. The CxA shall be notified at least 72 hours in advance of scheduled pump test so that testing may be observed by the CA and Owner's representative. A copy of the test record shall be provided to the CxA, Owner, and Architect.
 - 5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.
 - 6. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain Fire Pump.
 - 7. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining units.
 - 8. Review data in O&M Manuals.
- E. Systems manual requirements:

1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.
2. The GC shall include final approved versions of the following information for the Systems Manual:
 - a. As-Built System Schematics
 - b. Verified Record Drawings
 - c. Test Results (not otherwise included in Cx Record)
 - d. Periodic Maintenance Information for computer maintenance management system
 - e. Recommendations for recalibration frequency of sensors and actuators
 - f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
 - g. Training Records, Information on training provided, attendees list, and any on-going training
 - h. Copy of all related NFPA 20 and 70 documentation
3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.
4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Fire Protection Contractor. The commissioning responsibilities applicable to the Fire Protection Contractor of Division 21 are as follows (all references apply to commissioned equipment only):
- B. Perform commissioning tests at the direction of the CxA.
- C. Attend construction phase coordination meetings.
- D. Participate in Fire Suppression systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- E. Provide information requested by the CxA for final commissioning documentation.
- F. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- G. Prepare preliminary schedule for Fire Suppression system orientations and inspections, operation and maintenance manual submissions, training sessions, flushing and cleaning, equipment start-up, and task completion for owner. Distribute preliminary schedule to commissioning team members.
- H. Update schedule as required throughout the construction period.
- I. During the startup and initial checkout process, execute the Fire Protection-related portions of the prefunctional checklists for all commissioned equipment.

- J. Assist the CxA in all verification and functional performance tests.
- K. 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.
- L. Gather operation and maintenance literature on all equipment and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.
- M. Coordinate with the CxA to provide (48) hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- N. Participate in, and schedule vendors and contractors to participate in the training sessions.
- O. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 - 1. Fire Suppression equipment including pumps, piping, and all other equipment furnished under this Division.
 - 2. Automatic sprinkler system.
 - 3. Fire stopping in fire rated construction, including caulking, gasketing and sealing of smoke barriers.
 - 4. Air compressor,
- P. The equipment supplier shall document the performance of his equipment.
- Q. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- R. Equipment Suppliers
 - 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 - 2. Assist in equipment testing per agreements with contractors.
 - 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- S. Provide training of the Owner's operating staff using expert qualified personnel, as specified.
- T. Refer to Division 01 Section "General Commissioning Requirements" for additional contractor responsibilities.

3.3 OWNER'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Design Professional's Responsibilities.

3.5 CxA'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

3.6 TESTING PREPARATION

- A. Certify in writing to the CxA that Fire Suppression systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that Fire Suppression 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. 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).
- D. Inspect and verify the position of each device and interlock identified on checklists.
- E. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- F. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of Fire Protection testing shall include entire Fire Suppression installation. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions.
- D. The CxA along with the Fire Suppression contractor shall prepare detailed testing plans, procedures, and checklists for Fire Suppression systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. 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.

- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. 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.
- I. If tests cannot be completed because of a deficiency outside the scope of the Fire Suppression system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.8 FIRE SUPPRESSION SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 21 sections. Provide submittals, test data, inspector record, and certifications to the CxA.
- B. Fire Suppression Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of sprinkler distribution systems.
- C. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
 - 1. Compressed Air System
 - 2. Fire Pump/Sprinkler System
 - 3. Sprinkler System

3.9 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.10 APPROVAL

- A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.11 DEFERRED TESTING

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.12 OPERATION AND MAINTENANCE MANUALS

- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
- B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.13 TRAINING OF OWNER PERSONNEL

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

END OF SECTION 21 08 00

SECTION 21 13 00 - FIRE SUPPRESSION SPRINKLERS

PART 2 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Wet-pipe sprinkler systems.
- B. System design, installation, and certification.

1.3 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.
- B. Section 21 05 00 - Fire Protection Basic Materials and Methods: Pipe, fittings, and valves.
- C. Section 22 05 53 - Identification for Plumbing Piping and Equipment.
- D. Section 26 05 83 - Wiring Connections: Electrical characteristics and wiring connections.
- E. Section 28 46 00 - Fire Detection and Alarm.

1.4 SYSTEM DESCRIPTION

- A. Systems to provide coverage for the existing school building.
- B. Provide hydraulically designed modifications to existing automatic wet pipe sprinkler systems for renovation of existing school. Water supply from existing 6" water service connected to existing municipal water main in Reservoir Road.
- C. Relocate existing 4" sprinkler main serving the 2000 Addition from the Area F Corridor to Classroom soffits and extend the 2000 Addition Sprinkler System Zone back towards the Fire Protection Riser; demolishing the existing system in all of the east wing classrooms and replacing sprinkler system as part of the 2000 Addition zone. Also the sprinkler system shall be removed and replaced in the west classroom wing; the new sprinkler layout to match the east classroom wing with a looped main run in the Classroom soffits.
- D. Replace all existing sprinkler heads.
- E. Furnish all necessary labor, materials, tool, equipment, appurtenances, instruments, etc. necessary to fully complete the Fire Protection System in accordance with the plans and specifications and both local and state fire codes and NFPA 13.

1.5 REFERENCE STANDARDS

- A. FM (AG) - FM Approval Guide current edition.
- B. NFPA 13 - Standard for the Installation of Sprinkler Systems; 2013.
- C. UL (DIR) - Online Certifications Directory current edition.

1.6 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for project requirements.
- B. Product Data: Provide data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- C. Shop Drawings:
 - 1. Submit preliminary layout of finished ceiling areas indicating only sprinkler locations coordinated with ceiling installation.
 - 2. Indicate hydraulic calculations, detailed pipe layout, hangers and supports, sprinklers, components and accessories. Indicate system controls.
 - 3. Sealed plans with detailed pipe layout indicating, hangers and supports, sprinklers, components and accessories. Indicate sprinkler locations fully coordinated with final ceiling layouts.
 - 4. Submit shop drawings and hydraulic calculations to authority having jurisdiction, Rating Bureau and RZ Design Associates, Inc. for approval.
- D. Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations.
- E. Operation and Maintenance Data: Include components of system, servicing requirements, record drawings, Test Certificates, replacement part numbers and availability, and location and numbers of service depot.

1.7 QUALITY ASSURANCE

- A. Comply with UL (DIR) requirements.
- B. Design by a NICET Level IV Certified Sprinkler Technician or under direct supervision of a Professional Fire Protection Engineer experienced in design of this type of work and licensed in Connecticut.
- C. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

- D. Installer Qualifications: Company specializing in performing the work of this section with minimum three years experience and approved by manufacturer.
- E. Equipment and Components: Provide products that bear UL (FM) label or marking.

1.8 CONTRACTOR'S RESPONSIBILITIES

- A. Drawings are diagrammatic; do not rely on scaling of drawings. Make such deviations and offsets as necessary to meet the space requirements.
- B. The contractor shall be responsible for water damage to the property of the owner, the work of other trades, and existing building systems during all phases of the work.
- C. Coordination Drawings: The Fire Protection Contactor shall incorporate the shop drawing sprinkler design into the master coordination drawings and work with the other trade contractors to resolve conflicts.

1.9 EXTRA MATERIALS

- A. Provide extra sprinklers of type and size matching those installed, in quantity required by referenced NFPA design and installation standard.
- B. Provide suitable wrenches for each sprinkler type.
- C. Provide red enamel finished steel sheet metal storage cabinet in location designated.

PART 2 PRODUCTS

2.1 SPRINKLERS

- A. Suspended Ceiling Type: Recessed pendent type with matching push on escutcheon plate.
 - 1. Finish: Chrome plated.
 - 2. Escutcheon Plate Finish: Chrome plated.
 - 3. Fusible Link: Glass bulb type, quick response, temperature rated for specific area hazard.
- B. Suspended Ceiling Type: Concealed pendent with white cover plate for gypsum board ceilings.
 - 1. Fusible Link: Glass bulb type or fusible link type, quick response, temperature rated for specific area hazard.
- C. Exposed Area Type: Standard upright type.
 - 1. Finish: Brass.
 - 2. Fusible Link: Glass bulb type, quick response, temperature rated for specific area hazard.
- D. Sidewall Type: Standard horizontal sidewall type with matching push on escutcheon plate.

1. Escutcheon Plate Finish: Chrome plated.
 2. Fusible Link: Glass bulb type, quick response, temperature rated for specific area hazard.
- E. Dry Sprinklers: Standard dry pendent type with matching push on escutcheon plate.
1. Finish: Chrome plated.
 2. Fusible Link: Glass bulb type, quick response, temperature rated for specific area hazard.

2.2 FLEXIBLE SPRINKLER DROPS

- A. Description: Flexible Sprinkler Hose Fittings for use in commercial suspended ceilings.
1. Product Performance Criteria: UL Listed pursuant to UL 2443 Standard for Flexible Sprinkler Hose with Fittings for Fire Protection Service. FM Approved pursuant to FM Class Number 1637 Approval Standard for Flexible Sprinkler Hose with Threaded End Fittings.
 2. Materials and Fabrication: Flexible Sprinkler Hose Assemblies and End Fittings.
 - a. Hose: AISI 304 Stainless Steel corrugated flexible hose with AISI 304 Stainless Steel braided jacket. Welded stainless steel collars and brass slip nuts with EPDM seals. Hose bore 28 mm internal corrugated hose diameter, minimum rated pressure 175 psi, and maximum length 1800 mm (6 Ft).
 - b. Inlet nipple and outlet reducer of Zinc-Plated Carbon Steel. 1" NPT inlet and straight outlet with 1/2" or 3/4 NPT sprinkler reducer with clamp bar flats.
 - c. Ceiling Brackets and Support Bar: Zinc-Plated Carbon Steel assemblies intended for installation into commercial suspended ceilings having medium to heavy support tee bars meeting ATSM C-635 and installed in accordance with ASTM C-636. Assemblies shall be adjustable with set-screws and clamps that anchor the sprinkler securely to the ceiling grid and are suitable for both pendent and concealed type heads.

2.3 SPRINKLER SPECIALTIES

- A. Inspector's Test Connection: Section drain valve with integral test port, single bronze body ball valve with minimum 1" NPT inlet and outlet, chromium plated bronze ball, glass impregnated teflon valve seat, two fused tempered sight glasses and 1/2" test orifice. UL listed and FM approved. Provide AGF Manufacturing Inc. Model 3011SG or approved equal.
- B. Air Venting Valves: Equip wet-pipe sprinkler systems with automatic float type air vent. Provide AGF Model M7900AAV; forged brass body assembly with integrated ball valve, stainless steel strainer and purge valve with hose fitting. Install at high point in each sprinkler zone.

2.4 ACCESSORIES

- A. Water Flow Switch: Vane type switch, aluminum pipe saddle mount, polyethylene paddle, adjustable retard and tamper-proof housing, with two SPDT contacts; rated 10 amp at 125 volt AC and 2.5 amp at 24 volt DC. As manufactured by Potter Electric, Model VSR-F or equal by System Sensor or Notifier.
- B. Alarm Bell: Vibrating bell, 8 inch red powder coat finish, 120 volts AC. Bell shall conform to UL 464; finish with weatherproof back box. As manufactured by Potter Electric, Model PB1208 or equal by System Sensor or Notifier. Minimum 75 dB at 10 feet.

PART 3 EXECUTION

3.1 GENERAL

- A. The complete system shall be installed in accordance with Rules and Regulations pertaining to Light Hazard (not to exceed 168 sq. ft. per head - system hydraulically calculated; not sized per pipe schedule) and Ordinary Hazard Group 1 occupancies and comply with the full requirements of the regulatory agencies.
- B. The Fire Protection Contractor shall have hydrant flow tests conducted on the fire hydrants hydraulically closest to the existing water service entrance. Conduct test and record test data in accordance with NFPA 291.
 - 1. Obtain flow test data, attested to by Clerk of the Works, which is adequate to base the design on. Data will be judged adequate if the actual flow values measured during flow test equal or exceed total demand. Flow values extrapolated from measured flow values may not be used as a basis for design.
- C. The Fire Protection Contractor shall have prepared by a NICET Level IV Certified Sprinkler Technician or under a P.E. work installation drawings (Shop Drawings) and shall submit them to the engineer and Rating Bureau for approval.
- D. Shop Drawings shall include all hydraulic calculations prepared on forms similar to those in NFPA 13 Appendix A.
- E. Design Criteria:

Light Hazard - 0.10 GPM/Sf density over the most remote 1500 sq.ft. for offices and classrooms. Protection area limitation 168 sq.ft. with standard coverage sprinklers.

Ordinary Hazard Group 1 - 0.15 GPM/SF density over the most remote 1500 sq.ft. for Storage and Mechanical Areas. Protection area limitation 130 sq.ft.

Calculations shall allow a 10 percent safety factor for future deterioration of the water supply.
- F. Before commencing work, the Fire Protection Contractor shall coordinate with other trades, so that no possible interferences will occur. If due to inadequate coordination, extra work is entailed, the Fire Protection Contractor shall be held fully responsible.

3.2 INSTALLATION

- A. Install in accordance with referenced NFPA design and installation standard.
- B. Install equipment in accordance with manufacturer's instructions.
- C. Locate outside alarm bell on exterior of building wall adjacent to fire protection riser.
- D. Place pipe runs to minimize obstruction to other work. Special care must be taken to insure that piping above hung ceilings is run to maintain maximum headroom and clearance for access to equipment of other trades and to avoid conflict with electrical conduits, light fixtures, other piping, ductwork etc.
- E. Pipe shall be run concealed throughout finished spaces. Place above finished ceilings or in chases, shafts, wall cavities or soffits. Exposed piping shall be run with care for aesthetics, minimizing fittings and offsets and creating symmetry in the in the installation.
- F. In gridded sprinkler systems, the water velocity shall not exceed 20 ft./sec. in branch lines 2" and smaller.
- G. Pipe size for drops to sprinkler heads located below suspended ceilings shall be 1 inch minimum.

3.3 SPRINKLER HEADS

- A. Sprinkler heads of the proper configuration and numbers are to be installed as required in accordance with regulations pertaining to Light and Ordinary Hazard Occupancies and meet the full requirements of the NFPA, Local Fire Department, State Fire Marshal, Fire Insurance Company, Rating Bureau and other agencies having jurisdiction.
- B. Center sprinklers in ceiling tiles except where indicated otherwise. Provide and adjust arm over assemblies as necessary.
- C. Where flexible sprinkler drop are used the minimum bend radius shall be 7 inches. The ceiling support brackets shall be attached to the main tee bar runner in the grid, not the cross support rails. Follow all manufacturer's instructions.
- D. Apply masking tape or paper cover to ensure concealed sprinklers, cover plates, and sprinkler escutcheons do not receive field paint finish. Remove after painting. Replace painted sprinklers.
- E. Install heads with Teflon liquid joint compound applied to male threads only.
- F. Install guards on sprinklers in locations subject to mechanical damage.
- G. Mount sprinkler head cabinet in the location directed by the Owner Representative. Stock with spare sprinkler heads of each type and or temperature rating and a sprinkler head wrench per NFPA 13.

3.4 INSPECTOR'S TEST CONNECTIONS

- A. Install at end of most remote branch line, valve shall not be over 7'-0" above floor. Terminate connection outside building with 1 inch 45 degree elbow. Flow shall be equivalent to one sprinkler head.
- B. Inspector's test connections shall be mounted so as to be easily reached for test purposes without need for the use of a ladder.

3.5 TESTING

- A. Hydrostatically test entire system. Test system at no less than 200 psi for two (2) hours after completion, in accordance with NFPA 13.
- B. Flush entire piping system of foreign matter. Furnish to the insurance carrier, Contractor's Material and Test Certificate. Fill in and sign form as outlined in NFPA 13.
- C. During and after completion, the entire installation shall be subject to inspection and testing by the insurance carrier.
- D. Notify authority having jurisdiction of testing.

3.6 INTERFACE WITH OTHER PRODUCTS

- A. Ensure required devices are installed and connected as required to fire alarm system.

END OF SECTION 21 13 00

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SECTION 22 05 00 - PLUMBING GENERAL CONDITIONS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 DESCRIPTION

- A. The General Conditions and Supplementary General Conditions are a part of this Division and are to be considered a part of this Contract.
- B. Where items of the General Conditions and Supplementary General Conditions are repeated in other Sections of the Specifications, it is merely intended to qualify or to call particular attention to them. It is not intended that any other parts of the General Conditions and Supplementary General Conditions shall be assumed to be omitted if not repeated therein.
- C. This Section applies equally and specifically to all Contractors supplying labor and/or equipment and/or materials as required under each Section of this Division.
- D. The following information contains specifications of Work in connection with, and in addition to, this Division:
 - 1. All drawings associated with the project.
 - 2. All specifications associated with the project.
- E. Division of work responsibilities shall be as defined and directed by the Bidding Agent and/or the Bidding General Contractor.

1.3 INTENT

- A. It is the intent of the Specifications and Drawings to call for finished work, tested and ready for operation.
- B. Furnish, deliver and install any apparatus, appliance, material or Work not shown on Drawings but mentioned in the Specifications, or vice versa, or any incidental accessories necessary to make the Work complete and perfect in all respects and ready for operation, even if not particularly specified, under their respective Section without additional expense to the Owner.
- C. Include in the work minor details not usually shown or specified but necessary for proper installation and operation, as though they were hereinafter shown or specified.
- D. Provide Engineer written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of Work omitted. In the absence of such written notice, it is mutually agreed that Work under each Section has included the cost of all required items for

the accepted, satisfactory functioning of the entire system without extra compensation.

- E. The Work indicated is diagrammatic. The Architect and/or Engineer may require as part of this Contract, the relocation of devices to reasonable distances from the general locations shown.
- F. Verbal clarifications of the Drawings or Specifications during the bid period are not to be relied upon. Refer any questions or clarifications to the Engineer at least five Working days prior to bidding to allow for issuance of an addendum. After the five-day deadline, Bidder must make a decision and qualify the Bid, if the Bidder feels it necessary.

1.4 DRAWINGS

- A. Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. (Do not scale the Drawings.) Consult the Architectural Drawings and Details for exact location of fixtures and equipment; where same are not definitely located, obtain this information from the Architect.
- B. Closely follow Drawings in layout of Work; check Drawings of other Divisions to verify spaces in which work will be installed. Maintain maximum headroom. Where space conditions appear inadequate, Engineer shall be notified before proceeding with installations.
- C. Engineer may, without extra charge, make reasonable modifications in the layout as needed to prevent conflict with work of other trades and/or for proper execution of the work.
- D. Where variances occur between the Drawings and Specifications or within either of the Documents, include the item or arrangement of better quality, greater quantity or higher cost in the Contract price. The Engineer shall decide on the item and the manner in which the work shall be installed.

1.5 SURVEYS AND MEASUREMENTS

- A. Before submitting a Bid, the Contractor shall visit the site and shall become thoroughly familiar with all conditions under which the work will be installed. Contractor will be held responsible for any assumptions, omissions or errors made as a result of failure to become familiar with the site and the Contract Documents.
- B. Base all measurements, both horizontal and vertical, from established bench marks. All Work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the Work.
- C. Should the Contractor discover any discrepancies between actual measurements and those indicated which prevent following good practice or the intent of the Drawings and Specifications, notify the Engineer do not proceed with that Work until instructions have been received from the Engineer.

1.6 CODES AND STANDARDS

- A. The Codes and Standards listed below apply to all Work. Where Codes or Standards are mentioned in these Specifications, follow the latest edition or revision.

- B. The current adopted editions of the following State or local Codes apply:
 - 1. 2018 Connecticut State Building Code with Amendments to the following:
 - a. 2015 International Building Code
 - b. 2015 International Mechanical Code
 - c. 2015 International Plumbing Code
 - d. Connecticut Gas Equipment and Piping Code
 - e. 2017 National Electrical Code (NFPA 70)
 - f. 2015 International Energy Conservation Code
 - g. ICC/ANSI A117.1-2009 Accessible and Usable Buildings and Facilities
 - h. High Performance Building Standards for State Agency Buildings and School Buildings
- C. All materials furnished and all work installed shall comply with the rules and recommendations of the NFPA, the requirements of the local utility companies, the recommendations of the fire insurance rating organization having jurisdiction and the requirements of all Governmental departments having jurisdiction.
- D. Include in the Work, without extra cost to the Owner, any labor, materials, testing, services, apparatus and Drawings in order to comply with all applicable laws, ordinances, rules and regulations, whether or not shown on Drawings and/or specified.

1.7 PERMITS AND FEES

- A. Give all necessary notices, obtain all permits; pay all Government and State sales taxes and fees where applicable, and other costs, including utility connections or extensions in connection with the Work. File all necessary Drawings, prepare all Documents and obtain all necessary approvals of all Governmental and State departments having jurisdiction, obtain all required certificates of inspections for Work and deliver a copy to the Engineer before request for acceptance and final payment for the Work.

1.8 SEISMIC RESTRAINT

- A. General: This project is in a seismic zone per State and/or Local Codes and Ordinances and all materials and equipment shall be installed, supported, and seismically restrained accordingly. Verify current seismic requirements based on project location and with Code requirements.
- B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the jurisdiction where the Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of vibration isolation bases and seismic restraints that are similar to those required for this Project in material, design, and extent.

- C. Shop Drawings: Show designs and calculations, certified by a professional engineer, for the following:
 - 1. Design Calculations: Calculations for selection of vibration isolators, design of vibration isolation bases, design of seismic supports and selection of seismic restraints for all equipment and materials.
 - 2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to the structure and to the supported equipment. Include auxiliary motor slides and rails, and base weights.
 - 3. Seismic Restraint Details: Detail fabrication and attachment of restraints, supports and snubbers.
 - 4. Seismic Separation Assemblies: Refer to the Architectural and/or Structural drawings for locations of seismic joints.
- D. Installation: Installation shall be carried out in strict accordance with the Seismic Engineer's submittal, current Code, accepted standards and the equipment and material manufacturers' recommendations.

1.9 COORDINATION

- A. Carry out all work in conjunction with other trades and give full cooperation in order that all work may proceed with a minimum of delay and interference. Particular emphasis is placed on timely installation of major apparatus and furnishing other Contractors, especially the General Contractor or Construction Manager, with information as to openings, chases, sleeves, bases, inserts, equipment locations, panels, access doors, etc. required by other trades, and to allow for serviceable access to equipment.
- B. Mechanical contractors' shall initiate coordination drawings and sections clearly showing how the work is to be installed in relation to the work of other trades, at no extra charge to the Owner. The Contractors' shall prepare coordination drawings at a scale no less than 1/4"=1'-0", showing the work of all trades, including but not limited to, the following: proposed ductwork installation in detail, including ceiling heights, approved structural steel shop drawings, duct heights, access doors, light fixtures, registers and diffusers, sprinkler piping, electrical distribution conduits, wires, panels and any other electrical work which may conflict with the sheet metal ducts or piping, waste and vent piping, water piping, storm piping, and rain leaders. Provide elevation details showing connections and equipment layout and configuration based on approved submittals. Each shall use a different color code. A coordination meeting of all Contractors involved is then to be held and all possible conflicts are to be resolved. All trades shall sign acceptance of the drawings and then shall submit two (2) prints of each drawing to the Engineer for record.
- C. Contractors are required to examine all of the Project Drawings and mutually arrange Work so as to avoid interference. In general, ductwork, heating piping, sprinkler piping and drainage lines take precedence over water, gas and electrical conduits. The Engineer regarding the arrangement of Work, which cannot be agreed upon by the Contractors, will make final

decisions. Service of equipment will take precedence.

- D. Where the Work of the Contractor will be installed in close proximity to or will interfere with Work of other trades, assist in working out space conditions to make a satisfactory adjustment.
- E. If Work is installed before coordinating with other Divisions or so as to cause interference with Work of other Sections, the Contractor causing the interference will make necessary changes to correct the condition without extra charge to the Owner.
- F. Initial contact and coordination has been conducted with utility entities for the purpose of the preparation of Bid Documents. The Contractor shall coordinate all final specific utility requirements.

1.10 ACCEPTANCES

- A. The equipment, materials, Workmanship, design and arrangement of all Work installed are subject to the review of the Engineer.
- B. Within 30 days after the awarding of a Contract, submit to the Engineer for review a list of manufacturers of equipment proposed for the Work. The intent to use the exact makes specified does not relieve the Contractor of the responsibility of submitting such a list.
- C. If extensive or unacceptable delivery time is expected on a particular item of equipment specified, notify the Engineer, in writing, within 30 days of the awarding of the Contract. In such instances, deviations may be made pending acceptance by the Engineer or the Owner's representative.
- D. Where any specific material, process or method of construction or manufactured article is specified by reference to the catalog or model number of a manufacturer, the Specifications are to be used as a guide and are not intended to take precedence over the basic duty and performance specified or noted on the Drawings. In all cases, verify the duty specified with the specific characteristics of the equipment offered for review. Equipment characteristics are to be used as mandatory requirements where the Contractor proposes to use an acceptable equivalent.
- E. If material or equipment is installed before shop drawing review, liability for its removal and replacement is assumed by the Contractor, at no extra charge to the Owner, if, in the opinion of the Engineer, the material or equipment does not meet the intent of the Drawings and Specifications.
- F. Failure on the part of the Engineer to reject shop drawings or to reject Work in progress shall not be interpreted as acceptance of Work not in conformance with the Drawings and/or Specifications. Correct Work not in conformance with the Drawings and/or Specifications whenever non-conformance is discovered.

1.11 EQUIPMENT DEVIATIONS

- A. Where the Contractor proposes to deviate (substitute or provide an equivalent) from the equipment or materials as hereinafter specified, he shall do so by making a request in writing within 60 days from the Award of Contract. The Contractor shall state in his request whether it

is a substitution or an equivalent to that specified, and the amount of credit involved. A copy of said request shall be included in the Base Bid with manufacturer's equipment cuts.

1. The Base Product Specification shall be based on using the materials and equipment as specified and scheduled with no exceptions. Equipment Manufacturers Scheduled on Drawings are considered Base Product Specification and any other acceptable manufacturers listed in the specifications is considered an equivalent manufacturer to the Base Product Specification. Unlisted manufacturers are considered a substitution and equipment deviation and subject to the requirements for equipment substitution and deviation. When any alternate manufacturer does not qualify acceptable, as determined by the Engineer, provide the Base Bid manufacturer at no additional cost to Owner.
 2. Where an equivalent manufacturer is listed in the specifications, it may or may not indicate that there is an equal product available. Any products must meet all criteria of the Base Product Specification as determined by the Engineer.
- B. Substitutions and Equipment Deviations will not be considered if they have a direct bearing on the changing or revising of Contract Documents or if it involves other Contractor's scope of work or thier equipment. Coordination with all trades is required and must be acceptable to all other involved Contractors.
- C. Substitutions may be considered for one of the following:
1. Substitution for Cause: Changes proposed by the Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of warranty terms.
 2. Substitutions for Convenience: Changes proposed by the Contractor or Owner that are not required in order to meet other Project requirements, but may offer advantage to either the Owner or Contractor.
- D. In these Specifications and on the accompanying Drawings, one or more makes of materials, apparatus or appliances may have been specified for use in this installation. This has been done for convenience in fixing the standard of workmanship, finish and design required for installation. In the event that only one (1) manufacturer of a product is specified and it is found that the manufacturer has discontinued the product, the Contractor shall use an acceptable equivalent product that meets the requirements of an equivalent product, as noted below, and has all the features of the originally specified product. The details of workmanship, finish and design, and the guaranteed performance of any material, apparatus or appliance which the Contractor desires to deviate for those mentioned herein shall also conform to these standards.
- E. Where no specific make of material, apparatus or appliance is mentioned, any first-class product made by a reputable manufacturer may be submitted for the Engineer's review.
- F. Where two or more names are given as equivalents, the Contractor must use the specified item or one of the named equivalents. Where one name only is used and is followed by the words "or acceptable equivalent", the Contractor must use the item named or he may apply for an equipment deviation through the prescribed manner in accordance with this Specification.

- G. Equipment, material or devices submitted for review as an "accepted equivalent" shall meet the following requirements:
 - 1. The equivalent shall have the same construction features such as, but not limited to:
 - 2. Material thickness, gauge, weight, density, etc.
 - 3. Welded, riveted, bolted, etc., construction
 - 4. Finish, undercoatings, corrosion protection
 - 5. The equivalent shall perform with the same or better operating efficiency.
 - 6. The equivalent shall have equal or greater reserve capacity.
 - 7. The equivalent shall be locally represented by the manufacturer for service, parts and technical information.
 - 8. The equivalent shall bear the same labels of performance certification as is applicable to the specified item, such as AMCA or ARI labels.
 - H. Where the Contractor proposes to use an item of equipment other than specified or detailed on the Drawings which requires any redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical, electrical or architectural layout, all such redesign and all new drawings and detailing required therefore shall be prepared by the Designers of Record at the expense of the Contractor and at no additional cost to the Owner.
 - I. Where such accepted deviation or substitution requires a different quantity and arrangement of piping, ductwork, valves, pumps, insulation, wiring, conduit and equipment from that specified or indicated on the Drawings, the Contractor shall, with the acceptance by the Engineer, furnish and install any such additional equipment required by the system at no additional cost to the Owner, including any costs added to other trades due to the substitution.
 - J. The Engineer shall determine if an "accepted equivalent" to a manufacturer listed in the Specifications is considered acceptable.
- 1.12 SHOP DRAWINGS
- A. Refer to individual specification sections for additional submittal information.
 - B. The Contractor shall submit for review detailed shop drawings of all equipment and material specified in each section and coordinated ductwork layouts. No material or equipment may be delivered to the job site or installed until the Contractor has received shop drawings for the particular material or equipment which have been properly reviewed.
 - C. Shop drawings shall be submitted within 60 days after award of Contract before any material or equipment is purchased. The Contractor shall submit for review copies of all shop drawings to be incorporated in the Contract. Refer to the General Conditions and Supplementary General Conditions for the quantity of copies required for submission. Where quantities are not

specified, provide seven (9) copies for review.

- D. Provide shop drawings for all devices specified under equipment specifications for all systems, materials, equipment and/or devices. Shop drawings shall include manufacturers' names, catalog numbers, cuts, diagrams and other such descriptive data as may be required to identify and accept the equipment. A complete list in each category (example: all fixtures) of all shop drawings, catalog cuts, material lists, etc., shall be submitted to the Engineer at one time. No consideration will be given to a partial shop drawing submittal. Partial submissions shall be rejected.
- E. Equipment shop drawings shall contain full range performance curves, graphs, tables or other pertinent data which clearly indicates operational range of a given unit size. Computer generated/plotted curves, based solely on design performance, will not be accepted.
- F. All specific options and/or alternatives shall be clearly indicated. Failure to do so shall be grounds for rejection.
- G. Submittals shall be marked with the trade involved, i.e., HVAC, plumbing, fire protection, etc. and the specific associated specification section.
- H. Where multiple quantities or types of equipment are being submitted, provide a cover sheet (with a list of contents) on the submittal identifying the equipment or material being submitted.
- I. Failure to submit shop drawings in ample time for review shall not entitle the Contractor to an extension of Contract time. Contractor must allow for a one week review at the Engineer's office plus normal delivery time to the G.C., Architect, Engineer, and return to the Architect, and G.C. No claim for extension by reason of such default will be allowed, nor shall the Contractor be entitled to purchase, furnish and/or install equipment which has not been reviewed by the Engineer. The Contractor shall incur all costs associated with delay of construction due to equipment and/or materials arriving late due to late or improper shop drawing submittal.
- J. The Contractor shall furnish all necessary templates, patterns, etc., for installation work and for the purpose of making adjoining work conform; furnish setting plans and shop details to other trades as required.
- K. Acceptance rendered on shop drawings shall not be considered as a guarantee of measurements or building conditions. Where drawings are reviewed, review does not indicate that drawings have been checked in detail; said approval does not in any way relieve the Contractor from his responsibility or necessity of furnishing material or performing work as required by the Contract Drawings and Specifications. Verify available space prior to submitting shop drawings.
- L. Acceptance of shop drawings shall not apply to quantity nor relieve Contractor of his responsibility to comply with intent of Drawings and Specifications.
- M. Acceptance of shop drawings is final and no further changes will be allowed without the written consent of the Engineer.

- N. Shop drawing submittal sheets which may show items that are not being furnished shall have those items crossed off to clearly indicate which items will be furnished.
- O. Contractor shall make any corrections required by Engineer and shall resubmit required number of corrected copies of shop drawings or new samples until accepted. Contractor shall direct specific attention in writing or on resubmitted shop drawings to revisions other than corrections requested by Engineer on previous submissions. Engineer shall review no more than one resubmittal of any shop drawing or sample at Owner's expense. The fees for review of additional resubmittals shall be paid by the Contractor at the Engineer's standard rates.

1.13 CHANGES IN WORK

- A. A Change Order is a written order to the Contractor signed by the Owner and the Architect, issued after Contracts have been awarded, authorizing a change in the work or an adjustment in the Contract sum or the Contract time. A Change Order signed by the Contractor indicates his agreement therewith, including the adjustment in the Contract sum or the Contract time.
- B. All changes in the work shall follow the recommendations of the AIA "General Conditions of the Contract for Construction", Article 12.

1.14 MANUFACTURER'S IDENTIFICATION

- A. All component parts of each item of equipment or device shall bear the manufacturer's nameplate giving name of manufacturer, description, size, type, serial and model number, electrical characteristics, etc., in order to facilitate maintenance or replacement. Nameplate data shall not be obstructed. The nameplate of a Contractor or distributor will not be acceptable.
- B. All material and equipment for the electrical portion of the mechanical systems shall bear the label of or be listed by UL, or other accredited authoritative agencies or testing organizations approved by the authority having jurisdiction.

1.15 RECORD DRAWINGS

- A. Maintain at the job site a record set of Project Drawings on which any changes in location or routing of all equipment, materials and access panels shall be recorded.
- B. At the end of construction, the Contractor shall provide the Owner with a complete set of As-Built Drawings, including all updated coordination drawings, ductwork and piping plans. As-Built drawings shall be drawn on the latest version of Autocad or compatible software, approved in writing, prior to submittal. The Owner shall be provided with a "CD Rom" disk and one set of reproducible mylar sepia's.

1.16 MATERIALS AND WORKMANSHIP

- A. All materials and apparatus required for the work, except as otherwise specifically indicated, shall be new, of first-class quality, and shall be furnished, delivered, erected, connected and finished in every detail and be so selected and arranged as to fit properly into the building spaces. Where no specific type or quality of material is given, a first-class standard article as accepted by industry standards shall be furnished.

- B. The Contractor shall furnish the services of an experienced superintendent who shall be constantly in charge of the installation of the work together with all skilled workmen, fitters, metal workers, welders, helpers and laborers required to unload, transfer, erect, connect, adjust, start, operate and test each system.
- C. Unless otherwise specifically indicated on the Drawings or Specifications, all equipment and materials shall be installed with the acceptance of the Engineer and in accordance with the recommendations of the manufacturer. This includes the performance of such tests as the manufacturer recommends.
- D. All labor for installation of mechanical systems shall be performed by experienced, skilled tradesmen under the supervision of a licensed journeyman foreman. All work shall be of a quality consistent with good trade practice and shall be installed in a neat, workmanlike manner. The Engineer reserves the right to reject any work which, in his opinion, has been installed in a substandard, dangerous or unserviceable manner. The Contractor shall replace said work in a satisfactory manner at no extra cost to the Owner.

1.17 PROTECTION OF MATERIALS AND EQUIPMENT

- A. Work under each Section shall include protecting the work and material of all other Sections from damage by work or workmen and shall include making good all damage thus caused.
- B. The Contractor shall be responsible for work and equipment until the facility has been accepted by the Owner. Protect work against theft, injury or damage and carefully store material and equipment received on site which is not immediately installed. Close open ends of work with temporary covers or plugs during construction to prevent entry of foreign material.
- C. Work under each Section includes receiving, unloading, uncrating, storing, protecting, setting in place and completely connecting equipment supplied under each Section. Work under each Section shall also include exercising special care in handling and protecting equipment and fixtures, and shall include the cost of replacing any of the equipment and fixtures which are missing or damaged.
- D. Equipment and material stored on the job site shall be protected from the weather, vehicles, dirt and/or damage by workmen or machinery. Insure that all electrical or absorbent equipment or material is protected from moisture during storage.

1.18 BASES AND SUPPORTS

- A. Unless otherwise specifically noted, the Contractor shall furnish all necessary supports, rails, framing, bases and piers required for all equipment furnished under this Division.
- B. Unless otherwise indicated in individual trade Sections, pumps, fans, air handlers, boilers, chillers, tanks, compressors and other rotating machinery shall be mounted on a minimum of six (6") inch high concrete pads which shall be furnished and installed per Division 3. All pads shall be extended six (6") inches beyond machine base in all directions with top edge chamfered. Shop drawings of all foundations and pads shall be submitted to the Engineer for review before they are constructed. The Mechanical Contractor shall field coordinate all

required dimensional and necessary loading information.

- C. Construction of foundations, supports, pads, bases and piers where mounted on the floor shall be of the same finish quality as the adjacent and surrounding flooring material.
- D. Unless otherwise shown, all equipment shall be securely attached to the building structure in an acceptable manner. Attachments shall be of a strong and durable nature; any attachments that are insufficient, in the opinion of the Engineer, shall be replaced as directed without extra cost to the Owner.
- E. All equipment supports shall be designed and constructed such that the equipment will be capable of resisting both vertical and horizontal movement. The equipment shall be positively anchored to the bases or supports to resist vertical movement. The equipment and its supports shall be provided with suitable restraints to resist horizontal movement from any direction as dictated by applicable seismic Codes.

1.19 SLEEVES, INSERTS AND ANCHOR BOLTS

- A. The Contractor shall provide, set in place and be held responsible for the location of all sleeves, inserts and anchor bolts required for the work. In the event that failure to do so requires cutting and patching of finished work, it shall be done at the Contractor's expense.
- B. It is the responsibility of the Contractor to furnish cast-in-place steel sleeves, inserts and anchors in sufficient time to be installed during initial concrete pours. Where job schedules make this impossible, coordinate and obtain acceptance from the Structural Engineer for alternate installation methods.
- C. All pipes and conduits passing through floors, walls or partitions shall be provided with sleeves having an inside diameter one (1") inch larger than the outside diameter of the pipe, conduit or insulation enclosing the pipe.
- D. Piping insulation shall run continuous through sleeve.
- E. Penetrations through fire-rated walls, ceilings and all floors (except slab on grade) in which piping or ducts pass shall be filled solidly with acceptable fire-stopping material. Sleeves shall be steel or a UL / FM listed and approved assembly.
- F. When ducts, piping or conduit penetrate the floor of a mechanical room located above an occupied space, such penetrations shall be made completely watertight, such that a liquid leak shall not pass through the penetration.

1.20 FIRE-STOPS AND SEALS

- A. Refer to Division 7 Specification for additional and more specific information.
- B. Fire-stopping systems shall be submitted as shop drawing.
- C. Penetrations through fire-rated walls, ceiling or floors shall be sealed with a UL approved fire-stop fitting classified for an hourly rating equivalent to the fire rating of the wall, ceiling or

floor.

- D. Thruwall and floor seals shall be used to provide a positive means of sealing pipes or ducts which pass through the concrete foundation of a structure below grade or below ground water level. Seals shall also be used at entry points through concrete walls or floors which must be sealed.

1.21 CUTTING AND PATCHING

- A. All cutting and patching shall be done per Division 1 requirements. The Contractor shall furnish sketches showing the location and sizes of all openings, chases, etc., required for the installation of work.
- B. Work under this Division shall include furnishing, locating and setting inserts and/or sleeves required before the floors and walls are built or be responsible for cutting, drilling or chopping where sleeves and inserts were not installed or correctly located. The Contractor shall do all drilling required for the installation of hangers.
- C. Exercise extreme caution when core drilling or punching openings in concrete floor slabs in order to avoid cutting or damaging structural members. No structural members or structural slabs/floors shall be cut without the written acceptance of the Structural Engineer and all such cutting shall be done in a manner directed by him.
- D. SCAFFOLDING, RIGGING, HOISTING
 - 1. The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery into the premises any equipment and apparatus furnished under this Division. Remove same from premises when no longer required.

1.22 EXCAVATION AND BACKFILLING

- A. Excavation and backfilling shall be done per Division 2 of the Specifications.
- B. It is the responsibility of the Contractor to coordinate sizes, depths, fill and bedding requirements and any other excavation work required under this Division per code and local utility requirements.

1.23 WATERPROOFING

- A. Where any work pierces waterproofing, including waterproof concrete and floors in wet areas, the method of installation shall be reviewed by the Engineer before work is done. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings absolutely watertight.

1.24 ACCESSIBILITY AND ACCESS PANELS

- A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate thickness of partitions, and the adequate clearance in double partitions and hung ceilings for the proper installation of the work.

- B. Locate all equipment which must be serviced, operated or maintained in fully accessible positions. Equipment shall include, but not be limited to: motors, controllers, coil, valves, switchgear, drain points, etc. Access doors shall be furnished if required for better accessibility. Minor deviations from the Drawings may be made to allow better accessibility, but changes of magnitude or which involve extra cost shall not be made without the acceptance of the Engineer.
- C. Access doors in walls, ceilings, floors, etc., shall be field coordinated. It is the responsibility of the Contractor to coordinate and provide information regarding the sizes and quantities of access doors required for his work. The Contractor shall arrange his work in such a manner as to minimize the quantity of access doors required, such as grouping shutoff valves in the same area. Where possible, locate valves in already accessible areas, such as lay-in ceilings, etc.
- D. On a clean set of prints, the Contractor shall mark in red pencil the location of each required access door, including its size and fire rating (if any), and shall submit the print to the Architect for review before access doors are purchased or installed.
- E. Upon completion of the Project, the Contractor shall physically demonstrate that all equipment and devices installed have been located and/or provided with adequate access panels for repair, maintenance and/or operation. Any equipment not so furnished shall be relocated or provided with additional access panels by the installing Contractor at no additional cost to the Owner. All access panel or door locations shall be indicated on Owner's final as-built record drawings.
- F. Permanent ladders for access to equipment when shown on Plans shall be furnished and installed. Coordinate exact requirements in field.

1.25 TEMPORARY OPENINGS

- A. The Contractor shall ascertain from an examination of the Drawings whether any special temporary openings in the building will be required for the admission of apparatus provided under this Division and shall coordinate the requirements accordingly. In the event of failure of the Contractor to give sufficient notice in time to arrange for these openings during construction, the Contractor shall assume all costs of providing such openings thereafter.
- B. SHUTDOWNS
 - 1. When installation of a new system requires the temporary shutdown of an existing operating system, the connection of the new system shall be performed at such time as designated by the Owner's representative.
 - 2. The Architect and the Owner shall be notified of the estimated duration of the shutdown period at least ten (10) days in advance of the date the work is to be performed.
 - 3. Work shall be arranged for continuous performance whenever possible. The Contractor shall provide all necessary labor, including overtime if required, to assure that existing operating services will be shut down only during the time actually required to make necessary connections.

1.26 TAGS AND CHARTS

- A. Each valve and piece of apparatus under this Division shall be provided with suitable brass or laminated plastic tags securely fastened with brass chains, screws or rivets. Equipment shall be numbered with laminated plastic tags or neatly stenciled letters two (2") inches high using designations in equipment schedules and/or shall conform to a directory indicating number, location and use of each item. Directories shall be prepared under each Section and shall be glass framed.
- B. Directory shall indicate valve tag number and the unit number, floor/area branch line, main line, service or other pertinent data to quickly and easily identify the valve's purpose.

1.27 ESCUTCHEONS

- A. The Contractor shall provide escutcheons on pipes wherever they pass through floors, ceilings, walls or partitions in finished visible locations.

1.28 PAINTING

- A. All finish painting in completed areas shall be performed per other divisions of the Specifications.
- B. All materials shipped to the job site under this Division, such as piping, fittings, plumbing fixtures, valves, etc., shall have standard manufacturer's finish, unless otherwise specified by Architect.
- C. All outdoor piping, fittings and hangers shall be properly primed with zinc-rich primer and finished with a minimum of two (2) coats of high grade exterior enamel.

1.29 PIPE EXPANSION

- A. All pipe connections shall be installed to allow for freedom of movement of the piping during expansion and contraction without springing. Provide engineered design, layout, details and fabrication, submitted with registered professional engineer sign and seal, of swing joints, expansion loops and expansion joints with proper anchors and guides. Pay particular attention to plastic piping with high coefficients of expansion.
- B. Consideration of required seismic lateral restraints shall be given when anchoring piping and making provision for expansion.

1.30 ELECTRICAL CONNECTIONS

- A. Unless otherwise specified, all wiring shall be furnished and installed per Division 16 Specifications.
- B. All motor controllers not factory mounted on mechanical equipment shall be furnished, mounted, and installed by the Division 16 contractor, and shall be coordinated with this contractor. Provide properly sized overload heaters and all required accessories with all motor controllers. See Division 16 Motor Controllers for motor controller requirements.

- C. All power wiring shall be furnished and installed per Division 16 complete from power source to motor or equipment junction box including power wiring through the motor controller and proper means of disconnect per NEC and Division 16. The Division 16 Contractor shall provide all disconnects, unless noted otherwise.

1.31 QUIET OPERATION

- A. Equipment and material used in the various systems described herein shall not produce a sound level greater than 55 decibels in the area served. If noise level is deemed objectionable by the Owner/Engineer, the Contractor shall test and record sound levels in the presence of the Owner/Engineer. The sound level shall be observed on the "A" weighting network of a sound level or sound survey meter. The ASHRAE "Guide and Data Book" provides a means to determine sound level of mechanical equipment when the total of background plus equipment sound levels exceeds the minimum acceptable equipment sound level.
- B. If objectionable noises or vibrations of any magnitude are produced and transmitted to occupied portions of the building by apparatus, piping, ducts or other parts of the mechanical work, the Contractor shall make such changes or additions as necessary without extra cost to the Owner.

1.32 MAINTENANCE

- A. The Contractor shall provide the necessary skilled labor to assure the proper operation and to provide all required current and preventative maintenance for all equipment and controls provided under this Division until final acceptance of the building by the Owner. The Contractor shall not assume acceptance of the building by the Owner until he receives written notification.
- B. The Contractor shall receive calls for any and all problems experienced in the operation of the equipment provided under this Division and he shall take steps to immediately correct any deficiencies that may exist.
- C. The Contractor shall provide a check list and shall put a copy of it in the boiler or main mechanical room. The check list shall itemize each piece of equipment furnished under his Section.
- D. The Contractor shall certify on this check list that he has examined each piece of equipment and that, in his opinion, it is operating as intended by the manufacturer, it has been properly lubricated, and that all necessary current and preventative maintenance has been performed as recommended by the manufacturer and by good and accepted practice.
- E. The Contractor shall check all controls in the building to ascertain that they are functioning as designed. This shall apply to all thermostats, aquastats, humidistats, freezestats and firestats, etc. This portion of the work shall be performed by the Contractor who installed the controls.
- F. During construction, the Contractor shall ensure that all filters are in place on all equipment. If the equipment is operated during construction (see restrictions section of this specification), strict attention shall be paid to maintaining clean and effective filters and cleaning ductwork and equipment. Filters shall be new and/or clean when the system testing and balancing takes

place. The Contractor shall bear the cost of all filters and media during construction until final acceptance by the Owner. This requirement shall apply equally to fluid filters and strainers.

- G. Where normal preventative maintenance for any piece of equipment requires special tools, the Contractor shall furnish the appropriate tools for that piece of equipment (i.e., special filter removal hooks, valve wrenches, etc.).

1.33 LUBRICATION

- A. All equipment installed under this Contract having moving parts and requiring lubrication shall be properly lubricated according to manufacturer's recommendations prior to testing and operation. Any such equipment discovered to have been operated before lubrication by the Contractor is subject to rejection and replacement at no additional cost to the Owner.
- B. The Contractor shall furnish and install, as appropriate on all equipment requiring lubrication, Zerk pressure gun grease fittings or sight gravity-feed oilers equipped with shutoff and needle valve adjustment.
 - 1. Units furnished with sealed bearings and lifetime lubrication are exempted.
 - 2. All fittings and oilers are to be fully accessible for lubrication with equipment which does not require special adapters.
 - 3. Where fittings would be otherwise inaccessible, furnish and install extended grease lines.

1.34 CLEANING

- A. The Contractor shall be responsible for keeping the jobsite clean, safe and neat throughout the duration of construction. The Contractor shall clean up his own debris daily and shall coordinate removal of rubbish and debris with the General Contractor/Construction Manager.
- B. No debris, construction materials, cigarette butts, coffee cups, etc., shall be left above suspended ceilings.
- C. Terminal equipment and plumbing fixtures shall be cleaned at substantial completion.
- D. If any part of a system should be stopped or damaged by any foreign matter after being placed in operation, the system shall be disconnected, cleaned and reconnected wherever necessary to locate and/or remove obstructions. Any work damaged in the course of removing obstructions shall be repaired or replaced when the system is reconnected at no additional cost to the Owner.
- E. During the course of construction, all pipes shall be capped in an acceptable manner to insure adequate protection against the entrance of foreign matter.
- F. Upon completion of all work under the Contract, the Contractor shall remove from the premises all rubbish, debris and excess materials left over from his work. Any oil or grease stains on floor areas caused by the Contractor shall be removed and floor areas left clean.

1.35 OPERATING INSTRUCTIONS

- A. Upon completion of all work and tests, the Contractor shall furnish the necessary skilled labor and helpers for operating his system and equipment for a period specified under each applicable Section of this Division. During this period, he shall fully instruct the Owner or the Owner's representative in the operation, adjustment and maintenance of all equipment furnished. The Contractor shall give at least 72 hours notice to the Owner, Engineer, and Commissioning Agent in advance of this period.
 - 1. Prior to the instruction period, the contractor shall have approved Owner's Manuals on site for aiding in the instructions.
- B. The Contractor shall formally submit for delivery to the Engineer a minimum of three (3) Owner's Manuals, to be complete bound sets of typewritten or blueprinted instructions for operating and maintaining all systems and equipment included in this Division. All instructions shall be submitted in draft for review prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instruction.
- C. The Contractor, in the above-mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this Division.
- D. The appropriate Contractor shall physically demonstrate procedures for all routine maintenance of all equipment furnished under each respective Section to assure accessibility to all devices.
- E. An authorized manufacturer's representative shall attest in writing that the equipment has been properly installed prior to startup of any major equipment. These letters will be bound into the operating and maintenance books.
- F. Refer to individual trade Sections for any other particular requirements related to operating instructions.

1.36 ADJUSTING AND TESTING

- A. Prior to factory start-up procedures, the Contractor shall perform prefunctional checks and procedures to ensure that the equipment is installed properly and are operational.
 - 1. The prefunctional checklists and procedures are to be provided by the Commissioning Agent. These forms must be filled out and approved before final start-up and adjustments are made by the factory representative.
- B. After all the equipment and accessories to be furnished are in place, they shall be put in final adjustment and subjected to such operating tests so as to assure the Engineer and the Commissioning Agent that they are in proper adjustment, the controls operate as described in the sequence of operation and all systems are in satisfactory, permanent operating condition.
- C. A factory service engineering representative shall inspect the installation and assist in the initial startup and adjustment to the equipment. The period of these services shall be for such time as necessary to secure proper installation and adjustments. After the equipment is placed in permanent operation, the service engineering representative shall supervise the initial operation

of the equipment and instruct the personnel responsible for operation and maintenance of the equipment.

1. The following equipment will require this inspection: pumps, equipment, water temperature controls and valves, water heaters, specialized plumbing fixtures, and electric/electronic faucets and flush valves.
2. The service engineering representative shall notify the Contractor in writing that the equipment was installed according to manufacturer's recommendations and is operating as intended by the manufacturer.
 - a. The written notification shall include a complete start-up report on manufacturer's letterhead with all information including date and signature.
 - b. The report shall be made available to the Engineer and Commissioning Agent for review before acceptance is granted.

1.37 GUARANTEES

- A. The Contractor shall guarantee all equipment, material and workmanship under these Specifications and the Contract for a period of one (1) year from the date of final acceptance by Owner, unless otherwise noted.
- B. All refrigeration compressors shall have five (5) year guarantee from the date of final acceptance by the Owner unless otherwise noted.
- C. All water heaters shall have an optional minimum five (5) year guarantee from the date of final acceptance by the Owner unless otherwise noted.
- D. During this guarantee period, all defects developing through faulty equipment, materials or workmanship shall be corrected or replaced immediately by the Contractor without expense to the Owner. Such repairs or replacements shall be made to the Engineer's satisfaction.

1.38 RESTRICTIONS

- A. Water heaters provided under this Division may not be used for temporary hot water requirements due to premature wear and dirt/dust infiltration. Written approval may be obtained from the Owner only after submission of a written cleaning plan and guarantee/warranty extension.
- B. Piping shall not be run in any concrete floor slab. Written approval from the Structural Engineer may be obtained only after submission and approval of a layout shop drawing.

PART 2 PRODUCTS - NOT USED.

PART 3 EXECUTION - NOT USED.

END OF SECTION 22 05 10 22 05 00

SECTION 22 05 05 - PLUMBING DEMOLITION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Plumbing demolition.
 - 1. Existing plumbing fixtures, water piping, sanitary/waste piping, vent piping and storm piping as indicated on the plans, described in notes or implied by nature of the work.
 - a. All plumbing water piping removed from active lines to remain shall be capped watertight.
 - b. All sanitary branch piping removed from active systems to remain shall either have a new cleanout provided at termination or the branch line shall be removed to within 24" of the active main and capped.
 - c. Removal shall be complete to behind finished surfaces.
- B. Demolition shall include the removal of all hangers and supports, anchors and other items not required for the new work.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching and extending work: As specified in individual sections.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify existing conditions in the field. Note which items are to remain and which items are to be removed as indicated on drawings.
- B. Verify that abandoned wiring and equipment serve only abandoned facilities.
- C. Demolition drawings are based on casual field observation and existing record documents.
- D. Report discrepancies to Engineer before disturbing existing installation.
- E. Beginning of demolition means the installer accepts existing conditions.

3.2 PREPARATION

- A. Disconnect electrical systems in walls, floors, and ceilings to be removed.
- B. Provide temporary piping, ductwork, control wiring, and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or piping, coordinate shut-down time with owner.
- C. Existing Domestic Cold Water System: Maintain existing systems in service. Disable systems only to make switchovers and/or connections. Minimize outage duration.
 - 1. Obtain permission from Owner at least 24 hours before partially or completely disabling system.
- D. Existing Sanitary System: Maintain existing system in service. Disable system only to make switchovers and/or connections. Minimize outage duration.

3.3 DEMOLITION AND EXTENSION OF EXISTING PLUMBING WORK

- A. All demolition work shall be scheduled and coordinated in order to accommodate construction phasing schedule.
- B. Remove, relocate, and extend existing installations to accommodate new construction.
- C. Remove abandoned piping to source of supply, provide isolation valve and cap at mains.
- D. Contractor shall make safe all work associated with this division.
- E. Disconnect and remove plumbing piping and fittings serving equipment that has been removed.
- F. Disconnect and remove existing equipment, piping and fittings as indicated on the drawings.

3.4 CLEANING AND REPAIR

- A. Clean and repair existing materials and equipment which remain or are to be reused in accordance with manufacturer's recommended maintenance procedures.

END OF SECTION 22 05 05

SECTION 22 05 16 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Flexible pipe connectors.
- B. Expansion joints and compensators.
- C. Pipe loops, offsets, and swing joints.

D. RELATED REQUIREMENTS

PART 2 PRODUCTS

2.1 FLEXIBLE PIPE CONNECTORS - STEEL PIPING

- A. Manufacturers:
 - 1. The Metraflex Company; [____]: www.metraflex.com/#sle.
 - 2. Substitutions: See Section 01 60 00 - Product Requirements.

2.2 ACCESSORIES

- A. Pipe Alignment Guides:

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install flexible pipe connectors on pipes connected to vibration isolated equipment. Provide line size flexible connectors.
- C. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.
- D. Anchor pipe to building structure where indicated. Provide pipe guides so movement is directed along axis of pipe only. Erect piping such that strain and weight is not on cast connections or apparatus.

- E. Provide support and equipment required to control expansion and contraction of piping.
Provide loops, pipe offsets, and swing joints, or expansion joints where required.

END OF SECTION 22 05 16

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

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Pipe sleeves.
- B. Pipe sleeve-seals.

1.3 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.

1.4 REFERENCE STANDARDS

- A. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type) 2016.
- B. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems 2013a (Reapproved 2017).

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements for submittal procedures.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Installer Qualifications: Company specializing in performing work of the type specified this section.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store sleeve and sleeve seals in shipping containers, with labeling in place.
- B. Provide temporary protective coating on cast iron and steel sleeves if shipped loose.

1.8 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a five year period after Date of Substantial Completion.

PART 2 PRODUCTS

2.1 PIPE SLEEVES

A. Vertical Piping:

1. Sleeve Length: 1 inch above finished floor.
2. Provide sealant for watertight joint.
3. Drilled Penetrations: Provide 1-1/2 inch angle ring or square set in silicone adhesive around penetration.

B. Pipe Passing Through Below Grade Exterior Walls:

1. Zinc coated or cast iron pipe.
2. Provide watertight space with link rubber or modular seal between sleeve and pipe on both pipe ends.

C. Pipe Passing Through Mechanical, Laundry, and Animal Room Floors above Basement:

1. Galvanized steel pipe or black iron pipe with asphalt coating.
2. Connect sleeve with floor plate except in mechanical rooms.

2.2 PIPE-SLEEVE SEALS

A. Manufacturers:

1. Flexicraft Industries; PipeSeal: www.flexicraft.com/#sle.
2. Substitutions: See Section 01 60 00 - Product Requirements.

B. Modular Mechanical Seal:

1. Synthetic rubber interlocking links continuously fill annular space between pipe and wall/casing opening.
2. Provide watertight seal between pipe and wall/casing opening.
3. Elastomer element size and material in accordance with manufacturer's recommendations.
4. Glass reinforced plastic pressure end plates.

PART 3 EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and foreign material, from inside and outside, before assembly.

3.2 INSTALLATION

- A. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- B. Install piping to conserve building space, to not interfere with use of space and other work.
- C. Install piping and pipe sleeves to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- D. Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
- E. Aboveground Piping:
 - 1. Pack solid using mineral fiber complying with ASTM C592.
 - 2. Fill space with an elastomer caulk to a depth of 0.50 inch where penetrations occur between conditioned and unconditioned spaces.
- F. All Rated Openings: Caulk tight with fire stopping material complying with ASTM E814 in accordance with Section 07 84 00 to prevent the spread of fire, smoke, and gases.
- G. Manufactured Sleeve-Seal Systems:
 - 1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
 - 2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
 - 3. Locate piping in center of sleeve or penetration.
 - 4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
 - 5. Tighten bolting for a water-tight seal.
 - 6. Install in accordance with manufacturer's recommendations.
- H. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

3.3 CLEANING

- A. Upon completion of work, clean all parts of the installation.
- B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

END OF SECTION 22 05 17

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SECTION 22 05 19 - METERS AND GAUGES FOR PLUMBING PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Pressure Gauges:
- B. Thermometers.
- C. Static Pressure gauges.

1.3 RELATED REQUIREMENTS

- A. Section 221006 - Plumbing Piping

1.4 REFERENCE STANDARDS

- A. ASME B40.100 - Pressure Gauges and Gauge Attachments 2013.
- B. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers 2014 (Reapproved 2020).
- C. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers 2014 (Reapproved 2021).
- D. AWWA C700 - Cold-Water Meters -- Displacement Type, Metal Alloy Main Case 2020.
- E. AWWA M6 - Water Meters -- Selection, Installation, Testing, and Maintenance 2012, with Addendum (2018).
- F. UL 393 - Indicating Pressure Gauges for Fire-Protection Service Current Edition, Including All Revisions.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide red-marked product data sheets for each furnished item with associated components and accessories.
- C. Project Record Documents: Record actual locations of components and instrumentation.

PART 2 PRODUCTS

2.1 PRESSURE GAUGES

A. Manufacturers:

1. Dwyer Instruments, Inc: www.dwyer-inst.com.
2. Moeller Instrument Company, Inc: www.moellerinstrument.com.
3. Omega Engineering, Inc: www.omega.com.

B. Bourdon Tube for Liquids and Gases:

1. Dial Size and Cover: 4-1/2 inch diameter scale with polycarbonate window.
2. Dial Text and Markings: Black color on white background with scaled kPa and psi units.
3. Accuracy: ASME B40.100, adjustable commercial grade (D) with 5 percent of span.
4. Scale: Psi.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install metering products in accordance with manufacturer's instructions for intended fluid type and service.
- B. Install water meters with inlet and outlet isolation valves in compliance with AWWA M6.
- C. Install pressure gages with pulsation dampers. Provide gage cock to isolate each gage. Extend nipples to allow clearance from insulation.
- D. Locate test plugs adjacent thermometers and thermometer sockets.

3.2 SCHEDULES

A. Pressure Gages, Location:

1. Pumps
2. Expansion Tanks
3. Pressure reducing valves
4. Backflow preventers
5. Scale range shall be consistent with the service

B. Stem Type Thermometers, Location and Scale Range:

1. Domestic hot water supply and recirculation, 0 to 150 degrees F.

END OF SECTION 22 05 19

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

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Angle valves.
- B. Applications.
- C. Ball valves.
- D. Butterfly valves.
- E. Check valves.
- F. Lubricated plug valves.

1.3 RELATED REQUIREMENTS

- A. Section 22 05 53 - Identification for Plumbing Piping and Equipment.
- B. Section 22 07 19 - Plumbing Piping Insulation.
- C. Section 22 10 05 - Plumbing Piping.

1.4 ABBREVIATIONS AND ACRONYMS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. NRS: Non-rising stem.
- E. OS&Y: Outside screw and yoke.
- F. PTFE: Polytetrafluoroethylene.
- G. RS: Rising stem.
- H. TFE: Tetrafluoroethylene.
- I. WOG: Water, oil, and gas.

1.5 REFERENCE STANDARDS

- A. ASME B1.20.1 - Pipe Threads, General Purpose (Inch) 2013 (Reaffirmed 2018).
- B. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250 2020.
- C. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard 2020.
- D. ASME B16.10 - Face-to-Face and End-to-End Dimensions of Valves 2017.
- E. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2018.
- F. ASME B16.34 - Valves — Flanged, Threaded, and Welding End 2020.
- G. ASME B31.9 - Building Services Piping 2020.
- H. ASTM A48/A48M - Standard Specification for Gray Iron Castings 2003 (Reapproved 2021).
- I. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings 2004 (Reapproved 2019).
- J. ASTM A536 - Standard Specification for Ductile Iron Castings 1984 (Reapproved 2019)e1.
- K. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings 2017.
- L. AWWA C606 - Grooved and Shouldered Joints 2015.
- M. MSS SP-45 - Drain and Bypass Connections 2020.
- N. MSS SP-67 - Butterfly Valves 2017, with Errata.
- O. MSS SP-71 - Gray Iron Swing Check Valves, Flanged and Threaded Ends 2018.
- P. MSS SP-78 - Gray Iron Plug Valves, Flanged and Threaded Ends 2011.
- Q. MSS SP-80 - Bronze Gate, Globe, Angle, and Check Valves 2019.
- R. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends 2010, with Errata .
- S. NSF 61 - Drinking Water System Components - Health Effects 2020.
- T. NSF 372 - Drinking Water System Components - Lead Content 2020.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.

- C. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- D. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listings.

1.7 QUALITY ASSURANCE

- A. Manufacturer:
 - 1. Obtain valves for each valve type from single manufacturer.
 - 2. Company must specialize in manufacturing products specified in this section, with not less than three years of documented experience.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Minimize exposure of operable surfaces by setting plug and ball valves to open position.
 - 2. Protect valve parts exposed to piped medium against rust and corrosion.
 - 3. Protect valve piping connections such as grooves, weld ends, threads, and flange faces.
 - 4. Adjust globe, gate, and angle valves to the closed position to avoid clattering.
 - 5. Secure check valves in either the closed position or open position.
 - 6. Adjust butterfly valves to closed or partially closed position.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection and protect flanges and specialties from dirt.
 - a. Provide temporary inlet and outlet caps.
 - b. Maintain caps in place until installation.
 - 2. Store valves in shipping containers and maintain in place until installation.
 - a. Store valves indoors in dry environment.
 - b. Store valves off the ground in watertight enclosures when indoor storage is not an option.

1.9 EXERCISE THE FOLLOWING PRECAUTIONS FOR HANDLING:

- A. Handle large valves with sling, modified to avoid damage to exposed parts.
- B. Avoid the use of operating handles or stems as rigging or lifting points.

PART 2 PRODUCTS

2.1 APPLICATIONS

- A. See Drawings for specific valve locations in addition to those locations listed below.
- B. Listed pipe sizes shown using nominal pipe sizes (NPS) and nominal diameter (DN).
- C. Provide the following valves for the applications if not indicated on drawings:
 - 1. Shutoff: Ball, butterfly, gate or plug.
 - 2. Dead-End: Single-flange butterfly (lug) type.
 - 3. Throttling: Provide globe, angle, ball, or butterfly.
 - 4. Swing Check (Pump Outlet):
 - a. 2 NPS and Smaller: Bronze swing check valves with bronze disc.
 - b. 2-1/2 NPS and Larger for Domestic Water: Iron swing check valves with closure control, metal or resilient seat check valves.
 - c. 2-1/2 inch and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.
- D. Substitutions of valves with higher CWP classes or WSP ratings for same valve types are permitted when specified CWP ratings or WSP classes are not available.
- E. Required Valve End Connections for Non-Wafer Types:
 - 1. Steel Pipe:
 - a. 2 inch and Smaller: Threaded ends.
 - b. 2-1/2 inch to 4 inch: Grooved or flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - c. 5 inch and Larger: Grooved or flanged ends.
 - 2. Copper Tube:
 - a. 2 inch and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
 - b. 2-1/2 inch to 4 inch: Grooved or flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - c. 5 inch and Larger: Grooved or flanged ends.

2.2 GENERAL REQUIREMENTS

- A. Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.
- B. Valve Sizes: Match upstream piping unless otherwise indicated.
- C. Valve Actuator Types:
 - 1. Gear Actuator: Quarter-turn valves 8 inch and larger.
 - 2. Handwheel: Valves other than quarter-turn types.
 - 3. Hand Lever: Quarter-turn valves 6 inch and smaller except plug valves.
 - 4. Wrench: Plug valves with square heads.
 - 5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator, of size and with chain for mounting height, as indicated in the "Valve Installation" Article.
- D. Insulated Piping Valves: With 2 inch stem extensions and the following features:
 - 1. Gate Valves: Rising stem.
 - 2. Ball Valves: Extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
 - 3. Butterfly Valves: Extended neck.
 - 4. Memory Stops: Fully adjustable after insulation is installed.
- E. Valve-End Connections:
 - 1. Threaded End Valves: ASME B1.20.1.
 - 2. Flanges on Iron Valves: ASME B16.1 for flanges on iron valves.
 - 3. Pipe Flanges and Flanged Fittings 1/2 inch through 24 inch: ASME B16.5.
 - 4. Solder Joint Connections: ASME B16.18.
 - 5. Grooved End Connections: AWWA C606.
- F. General ASME Compliance:
 - 1. Ferrous Valve Dimensions and Design Criteria: ASME B16.10 and ASME B16.34.
 - 2. Solder-joint Connections: ASME B16.18.
 - 3. Building Services Piping Valves: ASME B31.9.

G. Potable Water Use:

1. Certified: Approved for use in compliance with NSF 61 and NSF 372.
2. Lead-Free Certified: Wetted surface material includes less than 0.25 percent lead content.

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

I. Source Limitations: Obtain each valve type from a single manufacturer.

2.3 BRONZE, ANGLE VALVES

A. Class 125: CWP Rating: 200 psig:.

1. Comply with MSS SP-80, Type 1.
2. Body: Bronze; ASTM B62, with integral seat and screw in bonnet.
3. End Connections: Pipe thread.
4. Stem: Bronze.
5. Disc: Bronze.
6. Packing: Asbestos free.
7. Handwheel: Bronze or aluminum.

2.4 BRASS, BALL VALVES

A. Three Piece, Full Port with Stainless Steel Trim:

1. Comply with MSS SP-110.
2. WSP Rating: 150 psi.
3. CWP Rating: 600 psi.
4. Body: Forged brass.
5. End Connections: Pipe thread.
6. Seats: PTFE.
7. Stem: Stainless steel.
8. Ball: Stainless steel, vented.

2.5 IRON, SINGLE FLANGE BUTTERFLY VALVES

A. Lug Style: Bi-directional dead-end service without use of downstream flange.

1. Comply with MSS SP-67, Type I.

2. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
3. Stem: One or two-piece stainless steel.
4. Seat: EPDM.
5. Disc: Stainless steel.
6. Finish: Epoxy coated.
7. Manufacturers:
 - a. Apollo Valves; [____]: www.apollovalves.com
 - b. Nibco.
 - c. Dezurik

2.6 BRONZE, SWING CHECK VALVES

A. General:

1. Fabricate from dezincification resistant material.
2. Copper alloys containing more than 15 percent zinc are not permitted.

B. Class 125 CWP Rating; 200 psig (1,380 kPa) WOG:

1. Design: Y-pattern, horizontal or vertical flow.
2. Body: Bronze, ASTM B62.
3. Ends: Threaded.
4. Disc: Bronze.

2.7 IRON, SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125 with Lever and Spring-Closure Control.

1. Comply with MSS SP-71, Type I.
2. Description:
 - a. CWP Rating: 200 psi.
 - b. Design: Clear or full waterway.
 - c. Body: ASTM A126, gray iron with bolted bonnet.
 - d. Ends: Flanged as indicated.
 - e. Trim: Bronze.

- f. Gasket: Asbestos free.
- g. Closer Control: Factory installed, exterior lever, and weight.

2.8 BRONZE, GATE VALVES

A. General:

- 1. Fabricate from dezincification resistant material.
- 2. Copper alloys containing more than 15 percent zinc are not permitted.

B. Rising Stem or OS&Y:

- 1. Pressure-Temperature Range: MSS SP-80, Type I.
- 2. Body: ASTM B62, bronze with integral seat and screw-in bonnet.
- 3. End Connections: Threaded or solder.
- 4. Stem: Bronze.
- 5. Disc: Solid wedge; bronze.
- 6. Packing: Asbestos free.
- 7. Handwheel Operator: Malleable iron.

C. Non-Rising Stem (NRS):

- 1. Comply with MSS SP-80, Type I.
- 2. Class 125: CWP Rating: 200 psig:.
- 3. Body: ASTM B62, bronze with integral seat and screw-in bonnet.
- 4. Ends: Threaded or solder joint joint.
- 5. Stem: Bronze.
- 6. Disc: Solid wedge; bronze.
- 7. Packing: Asbestos free.
- 8. Handwheel: Malleable iron, bronze, or aluminum.

2.9 LUBRICATED PLUG VALVES

A. Regular Gland with Flanged Ends:

- 1. Comply with MSS SP-78, Type II.
- 2. Class 125: CWP Rating: 200 psi.

3. Body: ASTM A48/A48M or ASTM A126, cast iron with lubrication sealing system.
4. Pattern: Regular or short.
5. Plug: Cast iron or bronze with sealant groove.

2.10 CHAINWHEELS

- A. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
 1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
 2. Attachment: For connection to ball and butterfly valve stems.
 3. Sprocket Rim with Chain Guides: Ductile iron. Include zinc coating.
 4. Chain: Hot-dip galvanized steel. Sized to fit sprocket rim.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Discard all packing materials and verify that valve interior, including threads and flanges are completely clean without signs of damage or degradation that could result in leakage.
- B. Verify valve parts to be fully operational in all positions from closed to fully open.
- C. Confirm gasket material to be suitable for the service, to be of correct size, and without defects that could compromise effectiveness.
- D. Should valve be determined to be defective, replace with new valve.

3.2 INSTALLATION

- A. Provide unions or flanges with valves to facilitate equipment removal and maintenance while maintaining system operation and full accessibility for servicing.
- B. Provide separate valve support as required and locate valve with stem at or above center of piping, maintaining unimpeded stem movement.
- C. Where valve support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
- D. Install check valves where necessary to maintain direction of flow as follows:
 1. Lift Check: Install with stem plumb and vertical.
 2. Swing Check: Install horizontal maintaining hinge pin level.

- E. Provide chainwheels on operators for valves 4 inch and larger where located 96 inch or more above finished floor, terminating 60 inch above finished floor.

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. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Support and attachment components.

1.3 RELATED REQUIREMENTS

- A. Section 03 30 00 - Cast-in-Place Concrete: Concrete equipment pads.

1.4 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware 2016a.
- C. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General - Purpose Piping 2014 (Reapproved 2020).
- D. ASTM A36/A36M - Standard Specification for Carbon Structural Steel 2019.
- E. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings 1999, with Editorial Revision (2018).
- F. ASTM A283/A283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates 2018.
- G. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures 1999 (Reapproved 2018).
- H. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel 2019.
- I. MFMA-4 - Metal Framing Standards Publication 2004.
- J. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018.
- K. UL (DIR) - Online Certifications Directory Current Edition.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
2. Coordinate the work with other trades to provide additional framing and materials required for installation.
3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:

1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 30 00.

1.6 QUALITY ASSURANCE

- A. Comply with applicable building code.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:

1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.

3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of [____]. Include consideration for vibration, equipment operation, and shock loads where applicable.
 4. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - c. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Metal Channel (Strut) Framing Systems:
1. Provide factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
 2. Comply with MFMA-4.
 3. Channel Material:
 - a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
 4. Minimum Channel Thickness: Steel sheet, 12 gauge, 0.1046 inch.
 5. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height.
- C. Channel Nuts:
1. Provide carbon steel channel nut with epoxy copper or zinc finish and long, regular, or short spring as indicated on drawings.
- D. Hanger Rods:
1. Threaded zinc-plated steel unless otherwise indicated.
- E. Pipe Supports:
1. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
 2. Liquid Temperatures Up To 122 degrees F:
 - a. Overhead Support: MSS SP-58 Types 1, 3 through 12 clamps.

b. Support From Below: MSS SP-58 Types 35 through 38.

F. Pipe Stanchions:

1. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
2. Provide coated or plated saddles to isolate steel hangers from dissimilar metal tube or pipe.

G. Beam Clamps:

1. MSS SP-58 types 19 through 23, 25 or 27 through 30 based on required load.
2. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
3. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.

H. Riser Clamps:

1. For insulated pipe runs, provide two bolt-type clamps designed for installation under insulation.
2. MSS SP-58 type 1 or 8, carbon steel or steel with epoxy plated, plain, stainless steel, or zinc plated finish.
3. Copper Tube Pipe Clamp: MSS SP-58 type 8, epoxy plated copper.
4. UL (DIR) listed: Pipe sizes 1/2 to 8 inch.

I. Offset Pipe Clamps: Double-leg design two-piece pipe clamp.

J. Strut Clamps:

1. Pipe Clamp: Two-piece rigid, universal, or outer diameter type, carbon steel with epoxy copper or zinc finish.
2. Cushioned Pipe or Tubing Strut Clamp: Provide strut clamp with thermoplastic elastomer cushion having dielectric strength of 670 V/mil.
3. Service Temperature Range: Minus 65 to 275 degrees F.

K. Insulation Clamps:

1. Two bolt-type clamps designed for installation under insulation.
2. Material: Carbon steel with epoxy copper or zinc finish.

L. Pipe Hangers:

1. Hangers:
 - a. Provide hinged split ring and yoke roller hanger with epoxy copper or plain finish.
 - b. Material: ASTM A47/A47M malleable iron or ASTM A36/A36M carbon steel.
 - c. Provide hanger rod and nuts of the same type and material for a given pipe run.
 - d. Provide coated or plated hangers to isolate steel hangers from dissimilar metal tube or pipe.

M. Anchors and Fasteners:

1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- C. Unless specifically indicated or approved by Engineer, do not provide support from suspended ceiling support system or ceiling grid.
- D. Unless specifically indicated or approved by Engineer, do not provide support from roof deck.
- E. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- F. Equipment Support and Attachment:
 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.

- 4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- G. Secure fasteners according to manufacturer's recommended torque settings.
- H. Remove temporary supports.

END OF SECTION 22 05 29

SECTION 22 05 33 - HEAT TRACING FOR PLUMBING PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Self-regulating temperature maintenance electric heating cable.
- B. Accessories.
- C. Controls.

1.3 RELATED REQUIREMENTS

- A. Section 22 07 19 - Plumbing Piping Insulation.

1.4 REFERENCE STANDARDS

- A. UL515 - Electric Resistance Heat Tracing for Comercial Applications
- B. IEEE 515.1 - IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Commercial Applications 2012.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data for electric heat tracing.
- C. Shop Drawings: Indicate electric heat tracing layout, including power connections, tees, end seal, cable length and circuit cable length..
- D. Manufacturer's Installation Instructions: Indicate installation instructions and recommendations.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions of equipment and controls, maintenance and repair data, and parts listings.

1.6 QUALITY ASSURANCE

- A. Qualifications

1. Manufacturers
 - a. Manufacturer to show minimum of thirty (30) year experience in manufacturing electric self-regulating heating cables.
 - b. Manufacturer will be ISO-9001 registered.
 - c. Manufacturer to provide products consistent with IEEE 515.1 and CSA 22.2 No 130-03 requirements.
 - d. The self-regulating temperature maintenance cable shall be qualified and tested to demonstrate a useful lifetime in excess of 40 years.
 - e. The manufacturer shall provide an extensive global reference list for this application, including installations that have been in operation for over 15 years.
 2. Installers
 - a. System installer shall have complete understanding of product and product literature from manufacturer or authorized representative prior to installation. Electrical connections shall be performed by a licensed electrician.
 3. Electrical Components, Devices, and Accessories: Listed and labelled as defined in NFPA 70, Article 100, by a Nationally Recognized Testing Laboratory (NRTL), and marked for intended use.
- B. Certifications
1. The system (heating cable, connection kits, and controller) shall be UL Listed, CSA Certified, or FM Approved for hot water temperature maintenance.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Delivery And Acceptance Requirements

1. Deliver, store and handle products to prevent their deterioration or damage due to moisture, temperature changes, contaminates or other causes.
2. Deliver products to site in original, unopened containers or packages with intact and legible manufacturers' labels identifying the following:
 - a. Product and Manufacturer
 - b. Length/Quantity
 - c. Lot Number
 - d. Installation and Operation Manual
 - e. MSDS (if applicable)

B. Storage And Handling Requirements

1. Store the heating cable in a clean, dry location with a temperature range 0°F (-18°C) to 140°F (60°C).
2. Protect the heating cable from mechanical damage.

1.8 WARRANTY

A. Manufacturer Warranty

1. Manufacturer shall warrant all goods listed below for two (2) years from date of purchase against faulty workmanship and use of defective materials when such goods are properly installed, operated, and maintained according to product documentation:
 - a. Heating cables, connection kits & accessories
 - b. Thermostats, controllers, panels contactors, sensors and accessories

B. Special Warranty -

1. Contractor shall provide the owner an extended product warranty for the heat tracing products listed below. The contractor must complete and forward to owner the Installation, Inspection or Commissioning Record(s) located in the back of installation manual for the heat trace system being installed, and complete the online warranty registration form within thirty (30) days from the date of installation, otherwise only standard limited warranty applies.
 - a. Heating Cable & Components = Ten (10) Years from Date of Purchase
2. Products not automatically offered with a 10 year manufacturer's warranty, as a standard matter of course, will not be allowed. Warranty information must be published on the manufacturer's website

PART 2 PRODUCTS

2.1 HEAT TRACING SYSTEM

A. Manufacturers:

1. Basis of Design Manufacturer: Subject to the compliance with requirements, provide Raychem heat tracing products of Pentair Thermal Building Solutions.
www.pentairthermal.com
 - a. Substitutions: See Section 01 60 00 - Product Requirements.

B. Materials

1. Heating cables shall be Raychem HWAT-R2, self-regulating temperature maintenance heating cables specifically designed for this application, tested and approved to IEEE

515.1 and CSA 22.2 No 130-03.

- a. The construction of the self-regulating temperature maintenance heating cable shall consist of a continuous core of conductive polymer that is radiation crosslinked, extruded between two (2) 16 AWG nickel-plated copper bus wires that varies its power output in response to pipe temperature changes.
- b. The heating cable shall have a modified polyolefin inner jacket for dielectric integrity long life expectancy.
- c. The heating cable shall have a laminated aluminum foil layer (Mylar wrap) for additional mechanical protection and shall act as a plasticizer diffusion shield.
- d. The heating cable shall have a thicker gauge (5/24) tinned copper braid with minimum 70% coverage for ground path and mechanical ruggedness.
- e. The heating cable shall have a polyolefin outer jacket printed with cable model #, agency listings, batch number and meter marks (for ease of installation within maximum circuit length).
- f. The heating cable shall have a self-regulating factor of at least 70 percent for HWAT-R2. The self-regulating factor is defined as the percent reduction of the heating cable power output going from a 40°F pipe temperature to 150°F pipe temperature
- g. The heating cable shall operate on line voltages of 208 volts without the use of transformers
- h. The heating cable shall be included in a UL Listed, CSA Certified, or FM Approved system.
- i. Constant wattage cables are not acceptable.

2. Heating Cable Connection Kits

- a. Heating cable connection kits shall be Raychem RayClic.
- b. Contractor shall provide power connections, splices/tees, and end seal kits to properly connect & terminate the heating cable.
- c. All splices, tees and crosses shall be installed underneath the pipe insulation with service loops installed to allow for future service of the piping.
- d. Connection kits shall be rated Type 4X to prevent water ingress and corrosion. All components shall be UV stabilized and shall not require the installing contractor to cut into the heating-cable core to expose the bus wires.
- e. Connection kits shall be UL Listed, CSA Certified, and FM approved.

3. Attachment of Heating Cable

- a. Attachment method of heating cable to the piping shall be Raychem model
 - 1) GT-66 - general purpose, high temperature, glass filament tape for installation @ 40°F and above. Contractor to fix the heating cable to the pipe every 12" by wrapping the GT-66 tape around the pipe & over the heating cable.
 - 2) AT-180 - aluminum tape, high temperature for all plastic piping for installations @ 32°F and above. Tape is installed lengthwise over the heating cable.
 - b. Metal cable ties are not permitted
4. Identification of Heating Cable System
- a. Contractor shall provide & install Raychem model ETL "Electric Heat Traced" labels on exterior of pipe insulation every ten (10) feet on opposite sides of the pipe for the entire length of heat traced piping.
 - b. In addition, all splices, tees, crosses and power connections shall be labeled on the exterior of the pipe insulation indicating that presence of a connection kit.
5. Energy Efficient Control System
- a. Single Circuit Local Digital Controller
 - 1) All self-regulating temperature maintenance cable shall be controlled via an energy saving, programmable single circuit controller to provide adjustable maintained temperatures in the range of 105°F (40°C) to 140°F (60°C), known as Raychem HWAT-ECO, manufactured by Pentair.
 - 2) Digital controller shall operate on 208 - 240 V.
 - 3) Pre-programmed duty cycles based on ambient temperature ranging from
 - 4) 60 - 80°F.
 - 5) The pre-programmed duty cycles shall be based on Raychem HWAT heating cables only. No other heating cables may be used with the HWAT-ECO controller.
 - 6) Flexible temperature control from 105 - 140°F.
 - 7) Three programmable temperature set points for maximum energy efficiency: Maintain, Economy, Off
 - 8) Controller shall have heat cycle setting.
 - 9) Heating cable manufacturer shall provide a local digital controller with 24/7 pre-programmed time based profiles specific to the selected heating cable application such as schools, hospitals and prisons.

- 10) Controller shall have remote temperature setting through 0 - 10 Vdc BMS interface.
 - 11) Controller shall have a pipe temperature sensor, low/high pipe temperatures alarms and high temperature cut-out to maximize the energy efficiency of the HWAT system by verifying that the hot pipe temperature is at the correct temperature (low temperature alarm); and to monitor and alarm if the pipe temperature is hotter than intended (high temperature alarm and cut-out).
 - 12) Multiple HWAT-ECO controllers can be networked together (master/slave association) to allow BMS to interface with a master HWAT-ECO to control cloned circuits, and to minimize the number of HWAT-ECO controllers that must be individually programmed.
 - 13) Controller shall have 24 A switching capacity rating.
 - 14) Enclosure type shall be NEMA 12 (ABS).
 - 15) Controller shall have NO/NC alarm contacts. Controller shall alarm on:
 - (a) Loss of power
 - (b) Controller reinitialized
 - (c) Internal controller temperature too high
 - (d) Pipe temperature too high
 - (e) Pipe temperature too low
 - (f) Master/slave error
 - 16) Digital controller shall have c-UL-us approvals specifically for use with the HWAT-R2 heating cable.
6. Thermal Pipe Insulation
- a. Pipes must be thermally insulated in accordance with the HWAT Design Guide requirements. No deviation from the insulation schedule will be allowed.
 - b. Thermal insulation must be a type that is flame retardant (closed?cell or fiberglass) with waterproof covering.
7. Approval
- a. The system (heating cable, connection kits, and controller) shall be UL Listed, CSA Certified, or FM Approved for hot water temperature maintenance.
 - b. The temperature maintenance system shall have a design, installation and operating manual specific to domestic hot water piping.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verification Of Conditions

1. Prior to installation of heating cable system, verify that all piping which will be heat trace has passed all hydrostatic/pressure test and is signed off by plumbing inspector.

B. Preinstalling Testing

1. Prior to installing heating cable on the piping an insulation resistance test shall be performed by the installing contractor to ensure integrity of heating cable as describe in the installation & maintenance manual.

3.2 PREPARATION

A. Protection Of In-Place Conditions

1. All heating cable ends shall be protected from moisture ingress until cable is terminated.
2. Acceptable methods are installing RayClic-E end seals.

3.3 INSTALLATION

- A. Comply with manufacturer's recommendations in the HWAT System Installation and Operation Manual - H57548.
- B. Apply the heating cable linearly on the pipe after piping has successfully completed any pressure tests. Secure the heating cable to piping with fiberglass tape.
- C. Install electric heating cable according to the drawings and the manufacturer's instructions. The installer shall be responsible for providing a complete functional system, installed in accordance with applicable national and local requirements.
- D. Any deviation in circuitry, insulation, or piping material must be approved by engineer prior to execution.
- E. Distribution pipes & express risers must be isolated electrically. Each shall have their own circuit(s).
- F. Branch lines shall be grouped electrically based on location.
- G. All power connections must be located in accessible areas. Access panels for power connection shall be a minimum of 12" x 12" and within reach of power connection kit.
- H. Refer to Electrical Specification for power connection locations.
- I. All power, tee, and splice connection points shall be shown on the plumbing as-built.

- J. Installation training, provided by an authorized manufacturer's representative must be completed prior to work mobilization.
- K. Interface With Other Work
 - 1. Grounding of controller shall be equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
 - 2. Connection of all electrical wiring shall be according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
 - 3. Pipe Insulation shall be thermally insulated in accordance with the HWAT design guide requirements.

3.4 FIELD QUALITY CONTROL

- A. Initial start-up and field testing (commissioning) of the system shall be performed by factory technician or factory representative per the owner's requirements.
- B. Field Tests And Inspections
 - 1. The system shall be commissioned in accordance to the HWAT Installation and Operation manual.
 - 2. The heating cable circuit integrity shall be tested using a 2500 Vdc megohmmeter at the following intervals:
 - a. Before installing the heating cable
 - b. After heating cable has been installed onto the pipe
 - c. After installing connection kits
 - d. After the thermal insulation is installed onto the pipe
 - e. Prior to initial start-up (commissioning)
 - f. As part of the regular system maintenance
 - g. Minimum acceptable insulation resistance shall be 1000 megohms or greater
 - 3. The technician shall verify the insulation schedule is in compliance with the HWAT Installation and Operation manual.
 - 4. The technician shall verify that the HWAT-ECO control parameters are set to the application requirements.
 - 5. The technician shall verify that the HWAT-ECO alarm contacts are corrected connected to the BMS.
- C. Non-Conforming Work

1. Any heat tracing circuit which fails the any of the above test must be corrected prior to commissioning or startup of the system.

3.5 SYSTEM STARTUP

- A. Provide a factory-certified technician or manufacturer's representative for startup & commissioning of the heat tracing system and controller.
- B. Coordinate all controller settings with plumbing engineer prior to programming the controller.
- C. Provide commissioning report in submittals package to owner.

END OF SECTION 22 05 33

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SECTION 22 05 53 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Pipe markers.
- D. Ceiling tacks.

1.3 RELATED REQUIREMENTS

- A. Section 221005 - Plumbing Piping
- B. Section 220719 - Plumbing Piping Insulation

1.4 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems 2020.
- B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials 2017.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Product Data: Provide manufacturers catalog literature for each product required.
- E. Manufacturer's Installation Instructions: Indicate special procedures, and installation.
- F. Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

- A. Heat Transfer Equipment: Nameplates.
- B. Piping: Pipe markers.
- C. Pumps: Nameplates.
- D. Small-sized Equipment: Tags.
- E. Tanks: Nameplates.
- F. Valves: Tags.
- G. Water Treatment Devices: Nameplates.

2.2 NAMEPLATES

- A. Manufacturers:
 - 1. Brimar Industries, Inc.: www.pipemarker.com/#sle.
 - 2. Kolbi Pipe Marker Co.: www.kolbipipemarkers.com.
 - 3. Seton Identification Products: www.seton.com.
- B. Description: Laminated three-layer plastic with engraved letters.
 - 1. Letter Color: White.
 - 2. Letter Height: 1/4 inch.
 - 3. Background Color: Black.
 - 4. Plastic: Comply with ASTM D709.

2.3 TAGS

- A. Manufacturers:
 - 1. Advanced Graphic Engraving: www.advancedgraphicengraving.com.
 - 2. Brady Corporation: www.bradycorp.com.
 - 3. Brimar Industries, Inc.: www.pipemarker.com/#sle.
 - 4. Kolbi Pipe Marker Co.: www.kolbipipemarkers.com.
 - 5. Seton Identification Products: www.seton.com.

- B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
- C. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

2.4 PIPE MARKERS

- A. Manufacturers:
 - 1. Brady Corporation: www.bradycorp.com.
 - 2. Brimar Industries, Inc: www.pipemarker.com/#sle.
 - 3. Kolbi Pipe Marker Co: www.kolbipipemarkers.com.
 - 4. MIFAB, Inc: www.mifab.com.
 - 5. Seton Identification Products: www.seton.com.
- B. Comply with ASME A13.1.
- C. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
- E. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.
- F. Color code as follows:
 - 1. Potable, Cooling, Boiler, Feed, Other Water: Green with white letters.
 - 2. Fire Quenching Fluids: Red with white letters.
 - 3. Toxic and Corrosive Fluids: Orange with black letters.
 - 4. Flammable Fluids: Yellow with black letters.
 - 5. Combustible Fluids: Brown with white letters.
 - 6. Compressed Air: Blue with white letters.

2.5 CEILING TACKS

- A. Description: Steel with 3/4 inch diameter color coded head.
- B. Color code as follows:
 - 1. Plumbing Valves: Green.

PART 3 EXECUTION

3.1 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

- A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic pipe markers in accordance with manufacturer's instructions.
- D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- E. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.
- F. Use tags on piping 3/4 inch diameter and smaller.
 - 1. Identify service, flow direction, and pressure.
 - 2. Install in clear view and align with axis of piping.
 - 3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

END OF SECTION 22 05 53

SECTION 22 07 16 - PLUMBING EQUIPMENT INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Equipment insulation.

1.3 REFERENCE STANDARDS

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus 2019.
- B. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement 2007 (Reapproved 2019).
- C. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus 2021.
- D. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type) 2016.
- E. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation 2014 (Reapproved 2019).
- F. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.
- G. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.2 GLASS FIBER, RIGID

- A. Manufacturer:
 - 1. Johns Manville Corporation; [____]: www.jm.com/#sle.
 - 2. Knauf Insulation; Earthwool Insulation Board: www.knaufinsulation.com/#sle.

3. Owens Corning Corp; [_____]: www.owenscorning.com/#sle.
- B. Insulation: ASTM C612 or ASTM C592; rigid, noncombustible.
 1. K Value: 0.25 at 75 degrees F, when tested in accordance with ASTM C177 or ASTM C518.
 2. Maximum Service Temperature: 850 degrees F.
 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
 4. Maximum Density: 8.0 lb/cu ft.
- C. Vapor Barrier Jacket:
 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 3. Secure with self-sealing longitudinal laps and butt strips.
- D. Facing: 1 inch galvanized steel hexagonal wire mesh stitched on one face of insulation.
- E. Vapor Barrier Lap Adhesive: Compatible with insulation.
- F. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that equipment has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Factory Insulated Equipment: Do not insulate.
- C. Cover glass fiber insulation with metal mesh and finish with heavy coat of insulating cement.

END OF SECTION 22 07 16

SECTION 22 07 19 - PLUMBING PIPING INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Piping insulation.
- B. Jackets and accessories.

1.3 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.
- B. Section 22 10 05 - Plumbing Piping: Placement of hangers and hanger inserts.

1.4 REFERENCE STANDARDS

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus 2019.
- B. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation 2019.
- C. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel 2008 (Reapproved 2018).
- D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.
- E. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials 2016.
- F. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section with minimum three years of experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.8 FIELD CONDITIONS

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.2 GLASS FIBER

- A. Manufacturers:
 - 1. CertainTeed Corporation: www.certainteed.com.
 - 2. Johns Manville Corporation: www.jm.com.
 - 3. Knauf Insulation: www.knaufusa.com.
 - 4. Owens Corning Corporation; Fiberglas Pipe Insulation ASJ: www.ocbuildingspec.com/#sle.
- B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.
 - 1. K Value: ASTM C177, 0.24 at 75 degrees F.
 - 2. Maximum Service Temperature: 850 degrees F.
 - 3. Maximum Moisture Absorption: 0.2 percent by volume.
- C. Vapor Barrier Jacket: White Kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.

- D. Vapor Barrier Lap Adhesive: Compatible with insulation.
- 2.3 FLEXIBLE ELASTOMERIC CELLULAR INSULATION - FOR USE WITHIN CAVITIES OF
- A. Manufacturer:
 - 1. Aeroflex USA, Inc
 - 2. Armacell LLC, AP Armaflex
 - 3. K-Flex USA LLC; Insul-Tube
 - B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1: Use molded tubular material wherever possible.
 - 1. Minimum Service Temperature: Minus 40 degrees F
 - 2. Maximum Service Temperature: 220 degrees F
 - 3. Connection: Waterproof vapor barrier adhesive.
 - C. Elastomeric Foam Adhesive; Air Dried, Contact adhesive, compatible with insulation.

2.4 JACKETS

- A. PVC Plastic.
 - 1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
 - a. Minimum Service Temperature: 0 degrees F.
 - b. Maximum Service Temperature: 150 degrees F.
 - c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
 - d. Thickness: 10 mil.
 - e. Connections: Brush on welding adhesive.
 - 2. Covering Adhesive Mastic: Compatible with insulation.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with North American Insulation Manufacturers Association (NAIMA) National Insulation Standards.
- C. Exposed Piping: Locate insulation and cover seams in least visible locations.
- D. Insulated pipes conveying fluids below ambient temperature: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- E. Glass fiber insulated pipes conveying fluids below ambient temperature:
 - 1. Provide vapor barrier jackets, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
 - 2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor barrier adhesive or PVC fitting covers.
- F. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- G. Glass fiber insulated pipes conveying fluids above ambient temperature:
 - 1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
 - 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
- H. Inserts and Shields:
 - 1. Application: Piping 1-1/2 inches diameter or larger.
 - 2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - 3. Insert Location: Between support shield and piping and under the finish jacket.
 - 4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - 5. Insert Material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- I. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Section 07 84 00.

- J. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above finished floor): Finish with PVC jacket and fitting covers.
- K. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping.
- L. Heat Traced Piping: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

3.3 SCHEDULES

A. Plumbing Systems:

- 1. Domestic Cold Water (Glass Fiber Insulation):
 - a. Cellular Melamine Foam Insulation:
 - b. Less than 1" pipe size: 1/2" Thickness
 - c. 1" pipe size and larger: 1" thickness
- 2. Domestic Hot Water Supply:
 - a. 1" Pipe size and less 1" Thickness
 - b. 1-1/4" Pipe Size: 1" Thickness (1.5" thickness if heat traced)
 - c. 1-1/2" Pipe Size: 1.5" Thickness (1.5" thickness if heat traced)
 - d. 2" Pipe Size: 1.5" Thickness (2" Thickness if heat traced)
 - e. 2.5" Pipe Size: 1.5" thickness (2.5" thickness if heat traced)
 - f. 3" Pipe Size: 1.5" Thickness (3" thickness if heat traced)
- 3. Storm Piping, Including Roof Drain Bodies:
 - a. Glass Fiber Insulation: 1" Thickness

END OF SECTION 22 07 19

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SECTION 220800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SUMMARY

- A. This section includes commissioning process requirements for Plumbing systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
- C. Certificates of readiness
- D. Certificates of completion of installation, prestart, and startup activities.
- E. O&M manuals
- F. Test reports

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the contractor for the equipment being tested. For example, the plumbing contractor of Division 22 shall ultimately be responsible for all standards testing equipment for the plumbing system in Division 22, except for equipment specific to and used by TAB in their commissioning responsibilities. A sufficient quantity of two-way radios shall be provided by each subcontractor.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.
- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems
- B. Red-lined Drawings:
 - 1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
 - 2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
 - 3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
 - 4. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. Operation and Maintenance Data:
 - 1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
 - 2. The CxA will review the O&M literature once for conformance to project requirements.
 - 3. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the contractor.
- D. Demonstration and Training:
 - 1. Contractor will provide demonstration and training as required by the specifications.
 - 2. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training.
 - 3. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.
 - 4. The CxA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CxA and Owner's representative. A copy of the test record shall be provided to the CxA, Owner, and Architect.
 - 5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
 - 6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
 - 7. Review data in O&M Manuals.
- E. Systems manual requirements:

1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.
2. The GC shall include final approved versions of the following information for the Systems Manual:
 - a. As-Built System Schematics
 - b. Verified Record Drawings
 - c. Test Results (not otherwise included in Cx Record)
 - d. Periodic Maintenance Information for computer maintenance management system
 - e. Recommendations for recalibration frequency of sensors and actuators
 - f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
 - g. Training Records, Information on training provided, attendees list, and any on-going training
3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.
4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning tests at the direction of the CxA.
- B. Attend construction phase controls coordination meetings.
- C. Attend domestic water balancing review and coordination meetings.
- D. Participate in Plumbing systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- E. Provide information requested by the CxA for final commissioning documentation.
- F. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- G. Prepare preliminary schedule for Plumbing system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.
- H. Update schedule as required throughout the construction period.
- I. During the startup and initial checkout process, execute the related portions of the prefunctional checklists for all commissioned equipment.

- J. Assist the CxA in all verification and functional performance tests.
- K. 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.
- L. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA (45) days after submittal acceptance.
- M. Coordinate with the CxA to provide (48) hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- N. Notify the CxA a minimum of (2) weeks in advance of the time for start of the balancing work. Attend the initial balancing meeting for review of the balancing procedures.
- O. Participate in, and schedule vendors and contractors to participate in the training sessions.
- P. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 - 1. Plumbing equipment including domestic water heaters, pumps, plumbing fixtures, and all other equipment furnished under this Division.
 - 2. Gas piping, sanitary waste and vent piping, storm drainage piping, sump pumps and automatic sprinkler system.
 - 3. Fire stopping in fire rated construction, including caulking, gasketing and sealing of smoke barriers.
 - 4. Air compressors
- Q. The equipment supplier shall document the performance of his equipment.
- R. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- S. Balance Contractor
 - 1. Attend initial commissioning coordination meeting scheduled by the CxA.
 - 2. Submit the site-specific balancing plan to the CxA and Design Professional for review and acceptance.
 - 3. Attend the balancing review meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in balancing the Plumbing system.
 - 4. At the completion of the balancing work, and the submittal of the final balancing report, notify the Plumbing contractor and the CM/GC.
 - 5. At the completion of balancing work, and the submittal of the final balancing report, notify the Plumbing Contractor and the CM/GC.
 - 6. Participate in verification of the balancing report, which will consist of repeating measurements contained in the balancing reports. Assist in diagnostic purposes when directed.
- T. Provide training of the Owner's operating staff using expert qualified personnel, as specified.

- U. Equipment Suppliers
 - 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 - 2. Assist in equipment testing per agreements with contractors.
 - 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- V. Refer to Division 01 Section “General Commissioning Requirements” for additional contractor responsibilities.

3.3 OWNER’S RESPONSIBILITIES

- A. Refer to Division 01 Section “General Commissioning Requirements” for Owner’s Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

- A. Refer to Division 01 Section “General Commissioning Requirements” for Design Professional’s Responsibilities.

3.5 CxA'S RESPONSIBILITIES

- A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

3.6 TESTING PREPARATION

- A. Certify in writing to the CxA that Plumbing systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that Plumbing 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 in writing that balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies 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 identified on checklists.

- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 HOT WATER BALANCING VERIFICATION

- A. Prior to performance of Hot Water (re-circulating) Balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- B. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness balancing Work.
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of Plumbing systems at the direction of the CxA.
 - 1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
 - 2. The balancing 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 a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final balancing report.
 - 4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.8 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of Plumbing testing shall include entire Plumbing installation. Testing shall include measuring capacities and effectiveness of operational and control functions.
- 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 Plumbing contractor, balancing subcontractor shall prepare detailed testing plans, procedures, and checklists for Plumbing systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. 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.

- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. 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.
- I. If tests cannot be completed because of a deficiency outside the scope of the Plumbing system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.9 PLUMBING SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 22 sections. Provide submittals, test data, inspector record, and certifications to the CxA.
- B. Plumbing Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in *Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."* Assist the CxA with preparation of testing plans.
- C. Pipe system cleaning, flushing, hydrostatic tests and chemical treatment: Test requirements are specified in Division 22 piping Sections. Plumbing Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
 - 1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 - 2. Description of equipment for flushing operations.
 - 3. Minimum flushing water velocity.
 - 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
- D. Plumbing Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, fuel gas, and sanitary waste and vent piping, storm drainage piping, sprinkler and domestic water distribution systems.
- E. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

- F. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
1. Compressed Air System
 2. Domestic Hot Water System
 3. Domestic Water System
 4. Water Heater
 5. Emergency Eyewash/Shower
 6. Fuel Gas System
 7. Hot Water Circulating Pump
 8. Hot Water Tempering Station Plumbing Fixtures
 9. Storm Drainage System
 10. Water Booster System
 11. Water Storage System
- 3.10 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT
- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.
- 3.11 APPROVAL
- A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.
- 3.12 DEFERRED TESTING
- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.
- 3.13 OPERATION AND MAINTENANCE MANUALS
- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
- B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.
- 3.14 TRAINING OF OWNER PERSONNEL
- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

- B. Plumbing Contractor. The plumbing contractor shall have the following training responsibilities:
1. Provide the CxA with a training plan two weeks before the planned training.
 2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of Plumbing equipment.
 3. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
 4. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
 5. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
 6. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
 7. The plumbing contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls.
 8. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.

END OF SECTION 22 08 00

SECTION 22 10 05 - PLUMBING PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Sanitary waste piping, buried within 5 feet of building.
- B. Sanitary waste piping, above grade.
- C. Domestic water piping, buried within 5 feet of building.
- D. Domestic water piping, above grade.
- E. Storm drainage piping, buried within 5 feet of building.
 - 1. Storm drainage piping, above grade.
 - 2. Pipe flanges, unions, and couplings.
 - 3. Pipe hangers and supports.
 - 4. Pipe sleeve-seal systems.
 - 5. Ball valves.
 - 6. Butterfly valves.
 - 7. Pressure reducing valves.
 - 8. Pressure relief valves.
 - 9. Pressure-temperature valves.
 - 10. Strainers.

1.3 RELATED REQUIREMENTS

- A. Section 08 31 00 - Access Doors and Panels.
- B. Section 22 05 16 - Expansion Fittings and Loops for Plumbing Piping.
- C. Section 22 05 48 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- D. Section 22 05 53 - Identification for Plumbing Piping and Equipment.

- E. Section 22 07 19 - Plumbing Piping Insulation.

1.4 REFERENCE STANDARDS

- A. ANSI Z21.22 - American National Standard for Relief Valves for Hot Water Supply Systems 2015 (Reaffirmed 2020).
- B. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2018.
- C. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings 2018.
- D. ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings: DWV 2016.
- E. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes 2018.
- F. ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings - DWV 2017.
- G. ASME B31.9 - Building Services Piping 2020.
- H. ASME BPVC-IV - Boiler and Pressure Vessel Code, Section IV - Rules for Construction of Heating Boilers 2021.
- I. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators 2021.
- J. ASSE 1003 - Performance Requirements for Water Pressure Reducing Valves for Potable Water Distribution Systems 2020.
- K. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings 1999, with Editorial Revision (2018).
- L. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- M. ASTM B32 - Standard Specification for Solder Metal 2020.
- N. ASTM B42 - Standard Specification for Seamless Copper Pipe, Standard Sizes 2020.
- O. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2020.
- P. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2020.
- Q. ASTM B306 - Standard Specification for Copper Drainage Tube (DWV) 2020.
- R. ASTM B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube 2016.
- S. ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings 2016.

- T. ASTM D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets 2020.
- U. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.
- V. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings 2017.
- W. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast 2017, with Errata (2018).
- X. AWWA C550 - Protective Interior Coatings for Valves and Hydrants 2017.
- Y. AWWA C606 - Grooved and Shouldered Joints 2015.
- Z. AWWA C651 - Disinfecting Water Mains 2014, with Addendum (2020).
- AA. CISPI 301 - Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent Piping Applications 2017 (Revised 2018).
- BB. CISPI 310 - Specification for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications 2020.
- CC. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements 2015.
- DD. ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements 2016.
- EE. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018.
- FF. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends 2010, with Errata .
- GG. NSF 61 - Drinking Water System Components - Health Effects 2020.
- HH. NSF 372 - Drinking Water System Components - Lead Content 2020.
- II. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.5 SUBMITTALS

- A. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
- B. Welders' Certificates: Submit certification of welders' compliance with ASME BPVC-IX.
- C. Shop Drawings: For non-penetrating rooftop supports, submit detailed layout developed for this project, with design calculations for loadings and spacings.

- D. Sustainable Design Documentation: For soldered copper joints, submit installer's certification that the specified installation method and materials were used.
- E. Project Record Documents: Record actual locations of valves.

1.6 QUALITY ASSURANCE

- A. Perform work in accordance with State of Connecticut, applicable codes & Standards.
- B. Valves: Manufacturer's name and pressure rating marked on valve body.
- C. Welding Materials and Procedures: Comply with ASME BPVC-IX and applicable state labor regulations.
- D. Welder Qualifications: Certified in accordance with ASME BPVC-IX.
- E. Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary protective coating on cast iron and steel valves.
- C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.8 FIELD CONDITIONS

- A. Do not install underground piping when bedding is wet or frozen.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Potable Water Supply Systems: Provide piping, pipe fittings, and solder and flux (if used), that comply with NSF 61 and NSF 372 for maximum lead content; label pipe and fittings.
- B. Plenum-Installed Acid Waste Piping: Flame-spread index equal or below 25 and smoke-spread index equal or below 50 according to ASTM E84 or UL 723 tests.

2.2 SANITARY WASTE PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Cast Iron Pipe: CISPI 301, hubless.
 - 1. Fittings: Cast iron.

2. Joints: CISPI 310, neoprene gasket and stainless steel clamp and shield assemblies.

2.3 SANITARY WASTE PIPING, ABOVE GRADE

A. Cast Iron Pipe: CISPI 301, hubless, service weight.

1. Fittings: Cast iron.
2. Joints: CISPI 310, neoprene gaskets and stainless steel clamp-and-shield assemblies.

B. Copper Tube: ASTM B306, DWV.

1. Fittings: ASME B16.29, wrought copper, or ASME B16.23, solvent.
2. Joints: ASTM B32, alloy Sn50 solder.

2.4 DOMESTIC WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

A. Copper Pipe: ASTM B42, annealed.

1. Fittings: ASME B16.26, cast bronze.
2. Joints: Flared.

B. Ductile Iron Pipe: AWWA C151/A21.51.

1. Fittings: Ductile or gray iron, standard thickness.
2. Joints: AWWA C111/A21.11, styrene butadiene rubber (SBR) or vulcanized SBR gasket with 3/4 inch diameter rods.

2.5 DOMESTIC WATER PIPING, ABOVE GRADE

A. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), Drawn (H).

1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
2. Joints: ASTM B32, alloy Sn95 solder.
3. Mechanical Press Sealed Fittings: Double-pressed type, NSF 61 and NSF 372 approved or certified, utilizing EPDM, nontoxic, synthetic rubber sealing elements.

a. Manufacturers:

- 1) Apollo Valves; [____]: www.apollovalves.com/#sle.
- 2) Grinnell Products, a Tyco Business: www.grinnell.com.
- 3) Viega LLC: www.viega.com.

2.6 STORM DRAINAGE PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Cast Iron Pipe: CISPI 301, hubless, service weight.
 - 1. Fittings: Cast iron.
 - 2. Joints: Neoprene gaskets and stainless steel clamp-and-shield assemblies.

2.7 STORM DRAINAGE PIPING, ABOVE GRADE

- A. Cast Iron Pipe: CISPI 301, hubless, service weight.
 - 1. Fittings: Cast iron.
 - 2. Joints: Neoprene gaskets and stainless steel clamp-and-shield assemblies.

2.8 PIPE FLANGES, UNIONS, AND COUPLINGS

- A. Unions for Pipe Sizes 3 inch and Under:
 - 1. Ferrous Pipe: Class 150 malleable iron threaded unions.
 - 2. Copper Tube and Pipe: Class 150 bronze unions with soldered joints.
- B. Flanges for Pipe Sizes Over 1 inch:
 - 1. Ferrous Pipe: Class 150 malleable iron threaded or forged steel slip-on flanges; preformed neoprene gaskets.
 - 2. Copper Tube and Pipe: Class 150 slip-on bronze flanges; preformed neoprene gaskets.
- C. Mechanical Couplings for Grooved and Shouldered Joints: Two or more curved housing segments with continuous key to engage pipe groove, circular C-profile gasket, and bolts to secure and compress gasket.
 - 1. Dimensions and Testing: In accordance with AWWA C606.
 - 2. Housing Material: Provide ASTM A47/A47M malleable iron or ductile iron.
 - 3. Gasket Material: EPDM suitable for operating temperature range from minus 30 degrees F to 230 degrees F.
 - 4. Bolts and Nuts: Hot dipped galvanized or zinc-electroplated steel.
 - 5. When pipe is field grooved, provide coupling manufacturer's grooving tools.
 - 6. Manufacturers:
 - a. Grinnell Products, a Tyco Business: www.grinnell.com.
- D. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.9 PIPE HANGERS AND SUPPORTS

A. Provide hangers and supports that comply with MSS SP-58.

1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
2. Overhead Supports: Individual steel rod hangers attached to structure or to trapeze hangers.
 - a. Cold and Hot Pipe Sizes 6 inch and Larger: Double hangers.
3. Trapeze Hangers: Welded steel channel frames attached to structure.
4. Vertical Pipe Support: Steel riser clamp.
5. Floor Supports: Concrete pier or steel pedestal with floor flange; fixture attachment.
6. Rooftop Supports for Low-Slope Roofs: Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
 - a. Bases: High-density polypropylene.
 - b. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
 - c. Steel Components: Stainless steel or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
 - d. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion-resistant material.
 - e. Height: Provide minimum clearance of 6 inches under pipe to top of roofing.
 - f. Manufacturers:
 - 1) PHP Systems/Design: www.phpsd.com.

B. Plumbing Piping - Drain, Waste, Storm and Vent:

1. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Malleable iron, adjustable swivel, split ring.
2. Hangers for Pipe Sizes 2 inch and Over: Carbon steel, adjustable, clevis.
3. Wall Support for Pipe Sizes to 3 inch: Cast iron hook.
4. Wall Support for Pipe Sizes 4 inch and Over: Welded steel bracket and wrought steel clamp.

5. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

6. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

C. Plumbing Piping - Water:

1. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Malleable iron, adjustable swivel, split ring.

2. Hangers for Cold Pipe Sizes 2 inch and Over: Carbon steel, adjustable, clevis.

3. Hangers for Hot Pipe Sizes 2 to 4 inch: Carbon steel, adjustable, clevis.

4. Hangers for Hot Pipe Sizes 6 inch and Larger: Adjustable steel yoke, cast iron pipe roll, double hanger.

5. Wall Support for Pipe Sizes Up to 3 inch: Cast iron hook.

6. Wall Support for Pipe Sizes 4 inch and Larger: Welded steel bracket and wrought steel clamp.

7. Wall Support for Hot Pipe Sizes 6 inch and Larger: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron pipe roll.

8. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

9. Floor Support for Hot Pipe Sizes to 4 inch: Cast iron adjustable pipe saddle, locknut, nipple, floor flange, and concrete pier or steel support.

10. Floor Support for Hot Pipe Sizes 6 inch and Larger: Adjustable cast iron pipe roll and stand, steel screws, and concrete pier or steel support.

11. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

D. Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:

1. Concrete Wedge Expansion Anchors: Comply with ICC-ES AC193.

2. Masonry Wedge Expansion Anchors: Comply with ICC-ES AC01.

3. Concrete Screw Type Anchors: Comply with ICC-ES AC193.

4. Masonry Screw Type Anchors: Comply with ICC-ES AC106.

5. Concrete Adhesive Type Anchors: Comply with ICC-ES AC308.

6. Other Types: As required.

2.10 PIPE SLEEVE-SEAL SYSTEMS

A. Manufacturers:

1. The Metraflex Company; MetraSeal: www.metraflex.com/#sle.

B. Modular Mechanical Seals:

1. Elastomer-based interlocking links continuously fill annular space between pipe and wall-sleeve, wall or casing opening.
2. Watertight seal between pipe and wall-sleeve, wall or casing opening.
3. Size and select seal component materials in accordance to service requirements.
4. Glass reinforced plastic pressure end plates.

2.11 BALL VALVES

A. Manufacturers:

1. Grinnell Products, a Tyco Business: www.grinnell.com.
2. Nibco, Inc: www.nibco.com.
3. Uponor, Inc: www.uponorengineering.com/sle.

B. Construction, 4 Inches and Smaller: MSS SP-110, Class 150, 400 psi CWP, bronze or ductile iron body, 304 stainless steel or chrome plated brass ball, regular port, teflon seats and stuffing box ring, blow-out proof stem, lever handle with balancing stops, threaded or grooved ends with union.

2.12 PIPING SPECIALTIES

A. Flow Controls:

1. Manufacturers:
 - a. ITT Bell & Gossett: www.bellgossett.com.
 - b. Griswold Controls: www.griswoldcontrols.com.
 - c. Taco, Inc: www.taco-hvac.com.
2. Construction: Class 125, Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet, blowdown/backflush drain.
3. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, maximum minimum pressure 3.5 psi.

2.13 PRESSURE REDUCING VALVES

A. Manufacturers:

1. Amtrol Inc: www.amtrol.com.
2. Cla-Val Company: www.cla-val.com.
3. Flomatic Valves: www.flomatic.com/#sle.
4. Watts Regulator Company: www.wattsregulator.com.

B. Up to 2 Inches:

1. ASSE 1003, bronze body, stainless steel, and thermoplastic internal parts, fabric reinforced diaphragm, strainer, threaded single union ends.

C. Over 2 Inches:

1. ASSE 1003, cast iron body with interior lining complying with AWWA C550, bronze fitted, elastomeric diaphragm and seat disc, flanged.

2.14 PRESSURE RELIEF VALVES

A. Manufacturers:

1. Watts Regulator Company; [_____]: www.wattsregulator.com/#sle.
2. Amtrol, Inc: www.amtrol.com.
3. Bell & Gossett: www.bellgossett.com.

- B. ANSI Z21.22, AGA certified, bronze body, teflon seat, steel stem and springs, automatic, direct pressure actuated.

2.15 PRESSURE-TEMPERATURE VALVES

A. Manufacturers:

1. Cla-Val Co; [_____]: www.cla-val.com/#sle.

- B. ANSI Z21.22, AGA certified, bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, temperature relief maximum 210 degrees F, capacity ASME BPVC-IV certified and labelled.

C. Pressure:

1. Manufacturers:
 - a. Cla-Val Co: www.cla-val.com.
 - b. Henry Technologies: www.henrytech.com.

- c. Watts Regulator Company: www.wattsregulator.com.
 - 2. ANSI Z21.22, AGA certified, bronze body, teflon seat, steel stem and springs, automatic, direct pressure actuated.
 - D. Temperature and Pressure:
 - 1. Manufacturers:
 - a. Cla-Val Co: www.cla-val.com.
 - b. Henry Technologies: www.henrytech.com.
 - c. Watts Regulator Company: www.wattsregulator.com.
 - 2. ANSI Z21.22, AGA certified, bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, temperature relief maximum 210 degrees F, capacity ASME BPVC-IV certified and labelled.
- 2.16 STRAINERS
- A. Manufacturers:
 - 1. Armstrong International, Inc: www.armstronginternational.com.
 - 2. Green Country Filter Manufacturing: www.greencountryfilter.com.
 - 3. WEAMCO: www.weamco.com.
 - B. Size 2 Inches and Under:
 - 1. Threaded brass body for 175 psi CWP, Y pattern with 1/32 inch stainless steel perforated screen.
 - 2. Class 150, threaded bronze body 300 psi CWP, Y pattern with 1/32 inch stainless steel perforated screen.
 - C. Size 1-1/2 inch to 4 inches:
 - 1. Class 125, flanged iron body, Y pattern with 1/16 inch stainless steel perforated screen.
 - D. Size 5 inch and Larger:
 - 1. Class 125, flanged iron body, basket pattern with 1/8 inch stainless steel perforated screen.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that excavations are to required grade, dry, and not over-excavated.

3.2 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt, on inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.3 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- C. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.
- D. Install piping to maintain headroom, conserve space, and not interfere with use of space.
- E. Group piping whenever practical at common elevations.
- F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. See Section 22 05 16.
- G. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
 - 1. See Section 22 07 19.
- H. Provide access where valves and fittings are not exposed.
 - 1. Coordinate size and location of access doors with Section 08 31 00.
- I. Establish elevations of buried piping outside the building to ensure not less than 4 ft of cover.
- J. Install vent piping penetrating roofed areas to maintain integrity of roof assembly.
- K. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc-rich primer to welding.
- L. Provide support for utility meters in accordance with requirements of utility companies.
- M. Excavate in accordance with Division 31.
- N. Backfill in accordance with Division 31.
- O. Install valves with stems upright or horizontal, not inverted. See Section 22 05 23.
- P. Install water piping to ASME B31.9.
- Q. Copper Pipe and Tube: Make soldered joints in accordance with ASTM B828, using specified solder, and flux meeting ASTM B813; in potable water systems use flux also complying with

NSF 61 and NSF 372.

- R. PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.
- S. Sleeve pipes passing through partitions, walls, and floors.
- T. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- U. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.9.
 - 2. Support horizontal piping as indicated.
 - 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 - 4. Place hangers within 12 inches of each horizontal elbow.
 - 5. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - 6. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - 7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - 8. Provide copper plated hangers and supports for copper piping.
 - 9. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
 - a. Painting of interior and exterior plumbing systems and components is specified in Division 09.
 - 10. Provide hangers adjacent to motor-driven equipment with vibration isolation; refer to Section 22 05 48.

11. Support cast iron drainage piping at every joint.

V. Pipe Sleeve-Seal Systems:

1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
3. Locate piping in center of sleeve or penetration.
4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
5. Tighten bolting for a watertight seal.
6. Install in accordance with manufacturer's recommendations.

- W. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

3.4 APPLICATION

- A. Use grooved mechanical couplings and fasteners only in accessible locations.
- B. Install unions downstream of valves and at equipment or apparatus connections.
- C. Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
- D. Install gate, ball, or butterfly valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- E. Install globe valves for throttling, bypass, or manual flow control services.
- F. Provide lug end butterfly valves adjacent to equipment when provided to isolate equipment.
- G. Provide spring-loaded check valves on discharge of water pumps.
- H. Provide flow controls in water recirculating systems where indicated.

3.5 TOLERANCES

- A. Drainage Piping: Establish invert elevations within 1/2 inch vertically of location indicated and slope to drain at minimum of 1/4 inch per foot slope.
- B. Water Piping: Slope at minimum of 1/32 inch per foot and arrange to drain at low points.

3.6 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A. Prior to starting work, verify system is complete, flushed, and clean.
- B. Ensure acidity (pH) of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
- C. Inject disinfectant, free chlorine in liquid, powder, tablet, or gas form throughout system to obtain 50 to 80 mg/L residual.
- D. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.
- E. Maintain disinfectant in system for 24 hours.
- F. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
- G. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
- H. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

3.7 SERVICE CONNECTIONS

- A. Provide new sanitary and storm sewer services. Before commencing work check invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover to avoid freezing.
- B. Provide new water service complete with approved reduced pressure backflow preventer and water meter with by-pass valves, pressure reducing valve, and sand strainer.
 - 1. Provide sleeve in wall for service main and support at wall with reinforced concrete bridge. Calk enlarged sleeve and make watertight with pliable material. Anchor service main inside to concrete wall.

3.8 SCHEDULES

- A. Pipe Hanger Spacing:
 - 1. Metal Piping:
 - a. Pipe Size: 1/2 inch to 1-1/4 inch:
 - 1) Maximum Hanger Spacing: 6.5 ft.
 - 2) Hanger Rod Diameter: 3/8 inches.
 - b. Pipe Size: 1-1/2 inch to 2 inch:
 - 1) Maximum Hanger Spacing: 10 ft.

- 2) Hanger Rod Diameter: 3/8 inch.
- c. Pipe Size: 2-1/2 inch to 3 inch:
 - 1) Maximum Hanger Spacing: 10 ft.
 - 2) Hanger Rod Diameter: 1/2 inch.
- d. Pipe Size: 4 inch to 6 inch:
 - 1) Maximum Hanger Spacing: 10 ft.
 - 2) Hanger Rod Diameter: 5/8 inch.
- e. Pipe Size: 8 inch to 12 inch:
 - 1) Maximum hanger spacing: 14 ft.
 - 2) Hanger Rod Diameter: 7/8 inch.
- 2. Plastic Piping:
 - a. All Sizes:
 - 1) Maximum Hanger Spacing: 6 ft.
 - 2) Hanger Rod Diameter: 3/8 inch.

END OF SECTION 22 10 05

SECTION 22 10 06 - PLUMBING PIPING SPECIALTIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Drains.
- B. Cleanouts.
- C. Hose bibbs.
- D. Hydrants.
- E. Backflow preventers.
- F. Water hammer arrestors.
- G. Mixing valves.

1.3 RELATED REQUIREMENTS

- A. Section 22 10 05 - Plumbing Piping.
- B. Section 22 30 00 - Plumbing Equipment.
- C. Section 22 40 00 - Plumbing Fixtures.

1.4 REFERENCE STANDARDS

- A. ASME A112.6.3 - Floor and Trench Drains 2019.
- B. ASME A112.6.4 - Roof, Deck, and Balcony Drains 2003 (Reaffirmed 2012).
- C. ASSE 1011 - Performance Requirements for Hose Connection Vacuum Breakers 2017.
- D. ASSE 1013 - Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Principle Fire Protection Backflow Preventers 2021.
- E. ASSE 1019 - Performance Requirements for Wall Hydrant with Backflow Protection and Freeze Resistance 2011 (Reaffirmed 2016).
- F. NSF 61 - Drinking Water System Components - Health Effects 2020.
- G. NSF 372 - Drinking Water System Components - Lead Content 2020.

- H. PDI-WH 201 - Water Hammer Arresters 2017.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.
- C. Shop Drawings: Indicate dimensions, weights, and placement of openings and holes.
- D. Certificates: Certify that grease interceptors meet or exceed specified requirements.
- E. Manufacturer's Instructions: Indicate Manufacturer's Installation Instructions: Indicate assembly and support requirements.
- F. Sustainable Design Documentation: Submit appropriate evidence that materials used in potable water systems comply with the specified requirements.
- G. Operation Data: Indicate frequency of treatment required for interceptors.
- H. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
- I. Project Record Documents: Record actual locations of equipment, cleanouts, backflow preventers, water hammer arrestors.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Accept specialties on site in original factory packaging. Inspect for damage.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Specialties in Potable Water Supply Systems: Provide products that comply with NSF 61 and NSF 372 for maximum lead content.

2.2 DRAINS

- A. Manufacturers:
 - 1. Jay R. Smith Manufacturing Company: www.jayrsmith.com.
 - 2. Josam Company: www.josam.com.
 - 3. Zurn Industries, LLC: www.zurn.com.
- B. Roof Drains:

1. Assembly: ASME A112.6.4.
 2. Body: Lacquered cast iron with sump.
 3. Strainer: Removable cast iron dome with vandal proof screws.
 4. Accessories: Coordinate with roofing type, refer to schedule on drawings:
 - a. Membrane flange and membrane clamp with integral gravel stop.
 - b. Adjustable under deck clamp.
 - c. Adjustable extension sleeve for roof insulation.
- C. Parapet Drains:
1. Lacquered cast iron body with aluminum flashing clamp collar and epoxy coated sloping grate.
- D. Canopy and Cornice Drains:
1. Lacquered cast iron body with aluminum flashing clamp collar and epoxy coated flat strainer.
- E. Roof Overflow Drains:
1. Lacquered cast iron body and clamp collar and bottom clamp ring; pipe extended to 3 inches above flood elevation.
- F. Downspout Nozzles:
1. Bronze round with straight bottom section.
- G. Floor Drain:
1. ASME A112.6.3; lacquered cast iron or stainless steel, two piece body with double drainage flange, weep holes, reversible clamping collar, and round, adjustable nickel-bronze strainer. Refer to the schedule on drawings for options and accessories.
- H. Floor Sink:
1. Square lacquered cast iron body with integral seepage pan, epoxy coated interior, aluminum dome strainer, nickel bronze frame, full grate.
- 2.3 CLEANOUTS
- A. Cleanouts at Interior Finished Floor Areas:
1. Lacquered cast iron body with anchor flange, reversible clamping collar, threaded top assembly, and round gasketed scored cover in service areas and round gasketed depressed cover to accept floor finish in finished floor areas.

- B. Cleanouts at Interior Finished Wall Areas:
 - 1. Line type with lacquered cast iron body and round epoxy coated gasketed cover, and round stainless steel access cover secured with machine screw.
- C. Cleanouts at Interior Unfinished Accessible Areas: Calked or threaded type. Provide bolted stack cleanouts on vertical rainwater leaders.

2.4 HOSE BIBBS

- A. Manufacturers:
 - 1. Watts Regulator Company: www.wattsregulator.com.
 - 2. Zurn Industries, LLC: www.zurn.com.
 - 3. Woodford Manufacturing Co: <https://www.woodfordmfg.com/woodford/>.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Interior Hose Bibbs:
 - 1. Bronze or brass with integral mounting flange, replaceable hexagonal disc, hose thread spout, chrome plated where exposed with handwheel, integral vacuum breaker in compliance with ASSE 1011.
- C. Interior Mixing Type Hose Bibbs:
 - 1. Bronze or brass, wall mounted, double service faucet with hose thread spout, integral stops, chrome plated where exposed with handwheels, and vacuum breaker in compliance with ASSE 1011.

2.5 HYDRANTS

- A. Manufacturers:
 - 1. Arrowhead Brass & Plumbing, LLC: www.arrowheadbrass.com.
 - 2. Jay R. Smith Manufacturing Company: www.jayrsmith.com.
 - 3. Zurn Industries, LLC: www.zurn.com.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Wall Hydrants:
 - 1. ASSE 1019; freeze resistant, self-draining type with chrome plated wall plate hose thread spout, handwheel, and integral vacuum breaker.
- C. Floor Hydrants:

2.6 BACKFLOW PREVENTERS

A. Manufacturers:

1. Conbraco Industries, Inc: www.apollovalves.com.
2. Watts Regulator Company, a part of Watts Water Technologies:
www.wattsregulator.com.
3. Zurn Industries, LLC: www.zurn.com.

B. Reduced Pressure Backflow Preventers:

1. ASSE 1013; bronze body with bronze internal parts and stainless steel springs; two independently operating, spring loaded check valves; diaphragm type differential pressure relief valve located between check valves; third check valve that opens under back pressure in case of diaphragm failure; non-threaded vent outlet; assembled with two gate valves, strainer, and four test cocks.

2.7 WATER HAMMER ARRESTORS

A. Manufacturers:

1. Jay R. Smith Manufacturing Company: www.jayrsmith.com.
2. Watts Regulator Company, a part of Watts Water Technologies:
www.wattsregulator.com.
3. Zurn Industries, LLC: www.zurn.com.
4. Substitutions: See Section 01 60 00 - Product Requirements.

B. Water Hammer Arrestors:

1. Stainless steel construction, bellows type sized in accordance with PDI-WH 201, precharged suitable for operation in temperature range minus 100 to 300 degrees F and maximum 250 psi working pressure.
 - a. Water hammer arrestors to be installed at all quick closing valves.

2.8 MIXING VALVES

A. Thermostatic Mixing Valves:

1. Manufacturers:
 - a. Acorn Engineering Company: <https://www.acorneng.com/thermostatic-mixing-valves-controls>
 - b. ESBE: www.esbe.se/en.

- c. Leonard Valve Company: www.leonardvalve.com.
- 2. Valve: Chrome plated cast brass body, stainless steel or copper alloy bellows, integral temperature adjustment.
- 3. Accessories:
 - a. Volume control shut-off valve on outlet.
 - b. Stem thermometer on outlet.
 - c. Strainer stop checks on inlets.
- 4. Cabinet: 16 gage, 0.0598 inch prime coated steel, for recessed mounting with keyed lock.

2.9 FLOOR DRAIN TRAP SEALS

- A. Manufacturers:
 - 1. Jay R. Smith Mfg..
 - 2. Rectorseal (SureSeal).
 - 3. Zurn
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Description: Push-fit EPDM or silicone fitting with a one-way membrane.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install isolation valves on all branch water distribution piping, gang toilets, all plumbing fixtures to accommodate upstream shut-off for required maintenance. Provide in wall access panels as needed.
- C. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.
- D. Encase exterior cleanouts in concrete flush with grade.
- E. Install floor cleanouts at elevation to accommodate finished floor.
- F. Install approved potable water protection devices on plumbing lines where contamination of domestic water may occur; on boiler feed water lines, janitor rooms, fire sprinkler systems, premise isolation, irrigation systems, flush valves, interior and exterior hose bibbs, Kitchen equipment that has direct water connections.

- G. Pipe relief from backflow preventer to nearest drain.
- H. Install water hammer arrestors complete with accessible isolation valve on hot and cold water supply piping to washing machine outlets.
- I. Install air chambers on hot and cold water supply piping to each fixture or group of fixtures (each washroom). Fabricate same size as supply pipe or 3/4 inch minimum, and minimum 18 inches long.

END OF SECTION 22 10 06

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SECTION 22 12 50 - NATURAL GAS PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Pipe, pipe fittings, valves, and connections for gas piping systems.
 - 1. Natural Gas.
 - 2. Regulators and safety devices for Natural and L.P. gas systems

1.3 RELATED SECTIONS

- A. Section 07 84 13 - Firestopping
- B. Section 220510 - PLUMBING GENERAL CONDITIONS
- C. Section 22 05 48 - Vibration and Seismic Controls for Plumbing Systems
- D. Section 22 05 53 - Identification for Plumbing Piping and Equipment
- E. Section 22 05 19 - Meters and Gages for Plumbing Piping
- F. Section 22 10 05 - Plumbing Piping
- G. Section 22 30 00 - Plumbing Equipment

1.4 REFERENCES

- A. Connecticut Fuel Gas Code
- B. NFPA 54
- C. ANSI Z223.1
- D. CSA / AGA Standards
- E. FM P7825 - Approval Guide; Factory Mutual Research Corporation; current edition.
- F. ANSI/ASME B36.10 Welded and Seamless Wrought-Steel pipe
- G. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
- H. ANSI/ASME B1.20.1 - Pipe Threads, General Purpose, Inch

1.5 SYSTEM DESCRIPTION

- A. Provide piping from the gas meter as shown on the plans[_____].
- B. Provide gas piping, including fittings and valves to form a complete system.
 - 1. Piping includes connections to equipment shown on the plans or provided by others.
 - 2. Provide any required gas regulators at equipment connections for reductions in pressure. Coordinate with all other trades for requirements of equipment.

1.6 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures.
- B. Piping and fittings
 - 1. Product Data: Provide Manufacturers literature.
 - 2. Shop Drawings: Indicate all catalog data.
- C. Equipment and Valving
 - 1. Product Data: Provide Manufacturers literature.
 - 2. Shop Drawings: Indicate all catalog data.
- D. Test Reports: Indicate final testing, inspection and approval reports by the AHJ and/or the service utility.
- E. Certificates: Certify that products of this section meet or exceed specified requirements.

1.7 QUALITY ASSURANCE

- A. Perform in accordance with Connecticut Fuel Gas Code standard, State of Connecticut Building Code.
- B. Requirements of the service Utility
- C. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.
- D. Installer Qualifications: Company specializing in performing the work of this section with minimum 3 years of experience.
- E. Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose specified and indicated.
- F. All valves, regulators, etc. shall be tested and rated for respective natural gas applications by UL and CSA.

1.8 PROJECT CONDITIONS

- A. Sequence installation to ensure utility connections are achieved in an orderly and expeditious manner.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Metallic pipe: Steel and wrought-iron pipe, minimum schedule 40, ANSI/ASME B36.10, ASTM A53
- B. Metallic pipe fittings: Steel or malleable iron.
- C. Piping shall be threaded up to 2 1/2" in diameter, over 2 1/2" piping shall be flanged

2.2 MANUFACTURED ITEMS

- A. Line Gas Pressure Regulators
- B. Gas Appliance Regulators
- C. Overpressure Protection Device
 - 1. For systems over 60 psi

2.3 ACCESSORIES

- A. Shutoff Valves
 - 1. Plug type - Heavy duty, iron body construction, flat head type with brass plug and washer, CSA / UL tested and approved
 - 2. Ball type - Bronze body, chrome plated ball, brass stem, PTFE seat, stem packing and bearing CSA/UL tested and approved.
 - 3. Strainer - Bronze body, CSA/UL tested and approved
 - 4. Roof Supports

PART 3 EXECUTION

3.1 PIPING - GENERAL

- A. The service entrance of the gas pipe to the building shall be provided with a line size, CSA/UL tested and approved shut-off plug valve. The valve shall be lockable open or shut with a standard padlock.
- B. Ream ends of pipe free from burrs. Keep free of scale, dirt and oil. Piping shall be blown out with compressed air.

- C. Pipe threads shall be tapered in compliance with ANSI/ASME B1.20.1. Apply pipe joint compound to male threads only.
 - 1. Threaded pipe shall be used for piping of 2" or less. All piping larger than 2" shall have welded fittings and joints.
- D. Provide couplings for pipe size transitions and for joining lengths of pipe. Bushings shall not be used.

3.2 PIPING INSIDE BUILDINGS

- A. Do not cut, notch or drill through beams or joists to install piping.
- B. Slope piping upwards towards risers or equipment at not less than 1/4" in 15 feet.
- C. Piping shall not be installed in concealed locations except with the use of elbows, tees and couplings.
 - 1. Where fittings are inserted in the piping, the pipe shall be reconnected by welding, flanges or a ground joint union.
 - 2. Valves shall not be installed in concealed locations.
- D. Where piping is installed in partition walls, a steel striker plate is to be provided the full length of the concealed pipe run
- E. Changes in direction shall be made by the use of fittings, factory or field bends.
 - 1. Bends shall be made only with bending equipment and shall be free from buckling, cracks or other damage.
 - 2. Pipe shall not be bent more than 90° with the inside radius not less than 6 times the outside diameter of the pipe.
- F. Provide drips at all risers or low points in the system. Drips are to be readily accessible for cleaning or emptying and are not to be used for supporting the piping.
- G. Provide plug type gas cocks in pipe branch lines and connections to equipment and cap until ready for connection to equipment.
 - 1. Ball type shutoffs will be acceptable in branch lines off mains
- H. All gas piping inside and outside the building shall be painted yellow and pipe markers provided.
- I. Branch piping is to be connected from top or side of horizontal piping.
- J. Maximum hanger spacing:
 - 1. 1/2" pipe -6 feet

2. 3/4" to 1" pipe -8 feet
3. 1 1/4" and larger pipe -10 feet

3.3 PIPING OUTSIDE THE BUILDINGS (EXPOSED, NOT BURIED)

- A. Slope piping upwards towards risers or equipment at not less than 1/4" in 15 feet.
- B. Piping shall not be installed in concealed locations except with the use of elbows, tees and couplings.
 1. Where fittings are inserted in the piping, the pipe shall be reconnected by welding, flanges or a ground joint union.
 2. Valves shall not be installed in concealed locations.
- C. Changes in direction shall be made by the use of fittings, factory or field bends.
 1. Bends shall be made only with bending equipment and shall be free from buckling, cracks or other damage.
 2. Pipe shall not be bent more than 90° with the inside radius not less than 6 times the outside diameter of the pipe.
- D. Provide drips at all risers or low points in the system. Drips are to be readily accessible for cleaning or emptying and are not to be used for supporting the piping.
 1. Where drips could be subject to freezing, the AHJ may authorize the drips to be deleted.
- E. Provide plug type gas cocks in pipe branch lines and connections to equipment and cap until ready for connection to equipment.
 1. Ball type shutoffs will be acceptable in branch lines off mains
- F. All gas piping outside the building shall be painted yellow with primer, two coats of paint and pipe markers provided.
- G. Branch piping is to be connected from top or side of horizontal piping.
- H. Maximum roof support spacing:
 1. 1/2" pipe -4 feet
 2. 3/4" to 1" pipe -6 feet
 3. 1 1/4" and larger pipe -8 feet
 4. Within 12" either side of bends, valves and regulators.

3.4 TESTING

- A. All piping, new and existing, shall be tested and shall be in compliance with NFPA-54 with records of inspection and tests performed.
- B. Test medium shall be compressed air or other inert gas.
- C. Test pressure shall be 1-1/2 times the maximum working pressure but not less than 3 PSIG. Duration shall be ½ hour for each 500 cubic feet of pipe or fraction thereof.
 - 1. Piping shall be tested without valves installed.
 - 2. Valves are not to be used as a bulkhead between gas in one section of pipe and test medium in another.
- D. Provide gauges or a manometer of increments not greater than 1/10 pound. Soap solution shall be used at joints or fittings.
 - 1. Pressure gauges shall be permanently installed downstream from each line pressure regulator.
- E. After turning on the gas the piping shall be purged of all test medium and the system shall again be checked for leakage.
- F. The gas utility shall be the governing authority and shall be presented with copies of tests results and records. All rules and regulations must be complied with and coordinated to insure a safe installation.
- G. If any part of the gas system is defective or not in compliance with this specification the contractor shall repair or replace the items at no cost to the Owner.

3.5 REGULATORS

- A. Set primary regulator at no more than 14" W.C., specific equipment requirements and/ or as required by local Gas Co.
- B. Set secondary regulators as necessary for appliances and equipment.
- C. Vent regulators and other equipment to exterior of building and terminate with suppressor.
 - 1. Vents shall be run independently of each other and shall be field located.
- D. Provide strainers on the inlet of each line pressure regulator or electrically operated valve.
- E. Provide a shut-off valve upstream of each gas pressure regulator

3.6 EQUIPMENT CONNECTORS

- A. Connectors shall have a plug type shut-off gas cock installed in rigid tubing in an accessible location upstream of the connector.

1. Flexible connectors of semi-rigid stainless steel with polyethylene jacket may be used for connecting appliances to the shut-off valve.
 2. All connectors shall be provided with a drip leg, full line size.
- B. Connectors shall be made from the top or side of horizontal lines.
- C. Provide unions for connectors at gas-cocks and equipment.
- D. Connectors to kitchen equipment are to be the "quick disconnect" type.

END OF SECTION 22 12 50 22 12 50

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SECTION 22 30 00 - PLUMBING EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Water Heaters:
 - 1. Commercial gas fired.
- B. In-line circulator pumps.

1.3 REFERENCE STANDARDS

- A. ANSI Z21.10.1 - Gas Water Heaters, Volume I, Storage Water Heaters with Input Ratings of 75,000 Btu Per Hour or Less 2019, with Errata (2020).
- B. ANSI Z21.10.3 - Gas-Fired Water Heaters, Volume III, Storage Water Heaters with Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous 2019.

1.4 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittals procedures.
- B. Product Data:
 - 1. Provide dimension drawings of water heaters indicating components and connections to other equipment and piping.
 - 2. Provide electrical characteristics and connection requirements.
- C. Shop Drawings:
 - 1. Indicate dimensions of tanks, tank lining methods, anchors, attachments, lifting points, tappings, and drains.
- D. Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.
- E. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Certifications:
 - 1. Water Heaters: NSF approved.
 - 2. Gas Water Heaters: Certified by CSA International to ANSI Z21.10.1, as applicable, in addition to requirements specified elsewhere.
 - 3. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

1.7 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for domestic water heaters, plus a one year "No-Cost" service policy for domestic water heaters.

PART 2 PRODUCTS

2.1 COMMERCIAL GAS FIRED WATER HEATERS

- A. Type: Automatic, Natural Gas-fired, vertical storage, condensing type
- B. Tank: Glass-lined welded steel; multiple flue passages, 4 inch diameter inspection prot, thermally insulated with minimum 2 inches glass fiber, encased in corrosion-resistant steel, jacket. baked-on enamel finish; floor shield and legs.
- C. Accessories: Provide:
 - 1. Water Connections: Brass
 - 2. Dip tube; Brass.
 - 3. Drain Valve: Brass
 - 4. Anode: Magnesium.
- D. Controls: Graphic digital burner control panel, automatic water thermostat with temperature range adjustable from 120 to 180 degrees F, manual reset high temperature limiting thermostat factory set at 140 degrees F, gas pressure regulator, multi-ribbon or tubular burner, 100 percent safety shut-off, and thermocouple

2.2 WATER HEATER MANUFACTURERS

- A. A.O. Smith Water Products Co
- B. PVI
- C. State Industries

2.3 DIAPHRAGM-TYPE EXPANSION TANKS

- A. Manufacturers:
 - 1. Wessels
 - 2. Amtrol Inc
 - 3. Watts
- B. Construcion: Welded steel, tested and stamped in accordance with ASME BPVC-VIII-1; supplied with National Board Form U-1, rated for working pressure of 125 psig, with flexible EPDM diaphragm sealed into tank, and steel legs or saddles.
- C. Accessories: Pressure gare and air-charging fitting, tank drain; precharge to min. 40 psig

2.4 IN-LINE CIRCULATOR PUMPS

- A. Manufacturers:
 - 1. Bell & Gossett, a xylem brand; [_____]: www.bellgossett.com/#sle.
 - 2. Grundfos. www.grundfos.com
 - 3. Taco
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Casing: Bronze, rated for 125 psig working pressure, with stainless steel rotor assembly.
- C. Impeller: Bronze.
- D. Shaft: Alloy steel with integral thrust collar and two oil lubricated bronze sleeve bearings.
- E. Seal: Carbon rotating against a stationary ceramic seat.
- F. Drive: Flexible coupling.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install plumbing equipment in accordance with manufacturer's instructions, as required by code, and complying with conditions of certification, if any.

B. Coordinate with plumbing piping and related fuel piping work to achieve operating system.

C. Pumps:

1. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

3.2 TRAINING

- A. Upon completion of the installation, the Contractor shall provide the services of an authorized manufacturer's representative to check the installation of the equipment, place equipment into operation and demonstrate fully the operation and care of all equipment to designated owner's personnel.

END OF SECTION 22 30 00

SECTION 22 40 00 - PLUMBING FIXTURES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Water closets.
- B. Urinals.
- C. Lavatories.
- D. Sinks.
- E. Mop sinks.
- F. Under-lavatory pipe supply covers.
- G. Electric water coolers.

1.3 RELATED REQUIREMENTS

- A. Section 01 91 13 - General Commissioning Requirements.
- B. Section 07 92 00 Sealants: Seal Fixtures to Walls and floors
- C. Section 22 10 05 - Plumbing Piping.
- D. Section 22 10 06 - Plumbing Piping Specialties.
- E. Section 22 30 00 - Plumbing Equipment.
- F. Section 26 05 83 - Wiring Connections: Electrical characteristics and wiring connections.

1.4 REFERENCE STANDARDS

- A. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design 2010.
- B. ASHRAE Std 18 - Methods of Testing for Rating Drinking-Water Coolers with Self-Contained Mechanical Refrigeration 2008 (Reaffirmed 2013).
- C. ASME A112.6.1M - Floor-Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use 1997 (Reaffirmed 2017).
- D. ASME A112.18.1 - Plumbing Supply Fittings 2018, with Errata.

- E. ASME A112.19.2 - Ceramic Plumbing Fixtures 2018, with Errata.
- F. ASSE 1070 - Performance Requirements for Water Temperature Limiting Devices 2020.
- G. ICC A117.1 - Accessible and Usable Buildings and Facilities 2017.
- H. NSF 61 - Drinking Water System Components - Health Effects 2020.
- I. NSF 372 - Drinking Water System Components - Lead Content 2020.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.
- C. Samples: Submit two sets of color chips for each standard color if other than white
- D. Manufacturer's Instructions: Indicate installation methods and procedures.
- E. Maintenance Data: Include fixture trim exploded view and replacement parts lists.
- F. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
 - 1. Warranty dates shall reflect the date of project substantial completion as determined by the Architect and shall be in effect as of that date

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.7 REGULATORY REQUIREMENTS

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Accept fixtures on site in factory packaging. Inspect for damage.
- B. Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

1.9 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for electric water cooler.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Potable Water Systems: Provide plumbing fittings and faucets that comply with NSF 61 and NSF 372 for maximum lead content; label pipe and fittings.

2.2 FLUSH VALVE WATER CLOSETS

- A. Water Closets: Vitreous china, ASME A112.19.2, wall hung, siphon jet flush action, china bolt caps.

- 1. Flush Valve: Exposed (top spud).
- 2. Flush Operation: Manual, oscillating handle.
- 3. Handle Height: 44 inches or less.
- 4. Manufacturers:

- a. Advanced Modern Technologies Corporation; [____]:
www.amtcorporation.com/#sle.
- b. American Standard, Inc; [____]: www.americanstandard-us.com/#sle.
- c. Kohler Company; [____]: www.kohler.com/#sle.

- B. Flush Valves: ASME A112.18.1, diaphragm type, complete with vacuum breaker stops and accessories.

- 1. Manufacturers:
 - a. Advanced Modern Technologies Corporation; [____]:
www.amtcorporation.com/#sle.
 - b. Sloan Valve Company; [____]: www.sloanvalve.com/#sle.
 - c. Zurn Industries, Inc; [____]: www.zurn.com/#sle.

- C. Seats:

- 1. Manufacturers:
 - a. Bemis Manufacturing Company; [____]: www.bemismfg.com/#sle.
 - b. Church Seat Company; [____]: www.churchseats.com/#sle.
 - c. Olsonite; [____]: www.olsonite.com/#sle.
- 2. Solid black plastic, open front, extended back, self-sustaining hinge, brass bolts, with cover.

D. Water Closet Carriers:

1. Manufacturers:
 - a. Jay R. Smith MFG. Co; [____]: www.jrsmith.com/#sle.
 - b. Zurn Industries, Inc; [____]: www.zurn.com/#sle.
2. ASME A112.6.1M; adjustable cast iron frame, integral drain hub and vent, adjustable spud, lugs for floor and wall attachment, threaded fixture studs with nuts and washers.
3. Minimum rating of 500 lbs.

2.3 WALL HUNG URINALS

A. Wall Hung Urinal Manufacturers:

1. American Standard, Inc; [____]: www.americanstandard-us.com/#sle.
2. Kohler Company; [____]: www.kohler.com/#sle.
- 3.
4. Substitutions: See Section 01 60 00 - Product Requirements.

B. Urinals: Vitreous china, ASME A112.19.2, wall hung with side shields and concealed carrier.

1. Flush Valve: Exposed (top spud).
2. Flush Operation: Sensor operated.
3. Supply Size: 3/4 inch.
4. Outlet Size: 2 inches.

C. Flush Valves: ASME A112.18.1, diaphragm type, complete with vacuum breaker stops and accessories.

1. Manufacturers:
 - a. Advanced Modern Technologies Corporation; AEF-800 Series:
www.amtcorporation.com/#sle.
 - b. Sloan Valve Company; [____]: www.sloanvalve.com/#sle.
 - c. Zurn Industries, Inc; [____]: www.zurn.com/#sle.

D. Carriers:

1. Manufacturers:
 - a. Jay R. Smith MFG. Co; [____]: www.jrsmith.com/#sle.

- b. Zurn Industries, Inc; [____]: www.zurn.com/#sle.

2.4 LAVATORIES

A. Lavatory Manufacturers:

- 1. American Standard, Inc; [____]: www.americanstandard-us.com/#sle.
- 2. Kohler Company; [____]: www.kohler.com/#sle.
- 3. Substitutions: See Section 01 60 00 - Product Requirements.

B. Vitreous China Wall Hung Basin: ASME A112.19.2; vitreous china wall hung lavatory, [____] by [____] inch minimum, with 4 inch high back, rectangular basin with splash lip, front overflow, and soap depression.

C. Supply Faucet Manufacturers:

- 1. American Standard, Inc; [____]: www.americanstandard-us.com/#sle.
- 2. Kohler Company; [____]: www.kohler.com/#sle.
- 3. Delta.

D. Supply Faucet: ASME A112.18.1; chrome plated combination supply fitting with pop-up waste, water economy aerator with maximum flow of 0.5 gallon per minute (low-flow), indexed handles.

E. Thermostatic Mixing Valve: Thermostatic mixing valve, ASSE 1070 listed, with combination stop, strainer, and check valves, and flexible stainless steel connectors.

- 1. Manufacturers:
 - a. Acorn Engineering Company; [____]: www.acorneng.com/#sle.
 - b. Sloan Valve Co.
 - c. Substitutions: See Section 01 60 00 - Product Requirements.

2.5 SINKS

A. Sink Manufacturers:

- 1. Kohler Company; [____]: www.kohler.com/#sle.
- 2. Elkay
- 3. Just Mfg
- 4. Substitutions: See Section 01 60 00 - Product Requirements.

- B. Single Compartment Bowl: ASME A112.19.3; [] by [] by [] inch outside dimensions 20 gage, 0.0359 inch thick, Type 302 stainless steel, self rimming and undercoated, with ledge back drilled for trim.

1. Drain: 1-1/2 inch chromed brass drain.

2.6 UNDER-LAVATORY PIPE SUPPLY COVERS

A. General:

1. Insulate exposed drainage piping including hot, cold and tempered water supplies under lavatories or sinks per ADA Standards.
2. Construction: 1/8 inch PVC with antimicrobial, antifungal and UV resistant properties.
 - a. Comply with ASME A112.18.9 for covers on accessible lavatory piping.
 - b. Comply with ICC A117.1.

2.7 ELECTRIC WATER COOLERS

A. Electric Water Cooler Manufacturers:

1. Elkay Manufacturing Company; []: www.elkay.com/#sle.
2. Haws Corporation; []: www.hawesco.com/#sle.
3. Murdock Manufacturing, Inc; []: www.murdockmfg.com/#sle.
4. Substitutions: See Section 01 60 00 - Product Requirements.

2.8 BI-LEVEL, ELECTRIC WATER COOLERS

A. Bi-level, Electric Water Cooler Manufacturers:

1. Elkay Manufacturing Company; []: www.elkay.com/#sle.
2. Haws Corporation; []: www.hawesco.com/#sle.
3. Murdock Manufacturing, Inc; []: www.murdockmfg.com/#sle.
4. Substitutions: See Section 01 60 00 - Product Requirements.

- B. Water Cooler: Bi-level, electric, mechanically refrigerated; surface mounted, ADA compliant; stainless steel top, vinyl on steel body, elevated anti-squirt bubbler with stream guard, automatic stream regulator, push button, mounting bracket; integral air cooled condenser and stainless steel grille.

1. Capacity: 8 gallons per hour of 50 degrees F water with inlet at 80 degrees F and room temperature of 90 degrees F, when tested in accordance with ASHRAE Std 18.

2. Electrical: 115 V, 60 Hertz compressor, 6 foot cord and plug for connection to electric wiring system including grounding connector.

2.9 MOP SINKS

A. Mop Sink Manufacturers:

1. Acorn Engineering Company; [____]: www.americanstandard-us.com/#sle.
2. Just Manufacturing Company; [____]: www.justmfg.com/#sle.
3. Fiat Products www.fiatproducts.com
- 4.
5. Substitutions: See Section 01 60 00 - Product Requirements.

B. Dimensions: As indicated on drawings.

C. Accessories:

1. Hose clamp hanger.
2. Mop hanger.
3. Stainless Steel Bumperguard
4. Stainless Steel Wall Guard
5. Service faucet

D. Type: Rectilinear, standard height.

E. Grid strainer: Stainless steel; integral; removable.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- B. Verify that electric power is available and of the correct characteristics.
- C. Confirm that millwork is constructed with adequate provision for the installation of counter top lavatories and sinks.

3.2 PREPARATION

- A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.3 INSTALLATION

- A. Install each fixture with trap, easily removable for servicing and cleaning.
- B. Provide chrome plated rigid or flexible supplies to fixtures with loose key stops, reducers, and escutcheons.
- C. Install components level and plumb.
- D. Install and secure fixtures in place with wall supports and bolts.

3.4 INTERFACE WITH WORK OF OTHER SECTIONS

- A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.5 ADJUSTING

- A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

3.6 CLEANING

- A. Clean plumbing fixtures and equipment. prior to final inspection

3.7 PROTECTION

- A. Protect installed products from damage due to subsequent construction operations.
- B. Do not permit use of fixtures by construction personnel.
- C. Repair or replace damaged products before Date of Substantial Completion.

END OF SECTION 22 40 00

SECTION 23 01 30.51 - HVAC AIR-DISTRIBUTION SYSTEM CLEANING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Cleaning of existing HVAC duct systems, equipment, and related components that are to remain.

1.3 RELATED REQUIREMENTS

- A. Section 01 40 00 - Quality Requirements: Additional requirements for testing and inspection agencies.

1.4 DEFINITIONS

- A. HVAC System: For purposes of this section, the surfaces to be cleaned include all interior surfaces of the heating, air-conditioning and ventilation system from the points where the air enters the system to the points where the air is discharged from the system, including the inside of air distribution equipment, coils, and condensate drain pans; see NADCA ACR for more details.

1.5 REFERENCE STANDARDS

- A. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.
- B. NADCA ACR - Assessment, Cleaning and Restoration of HVAC Systems 2013.
- C. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors current edition, including all revisions.
- D. UL 181A - Closure Systems for Use with Rigid Air Ducts Current Edition, Including All Revisions.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Qualifications Statement: Submit qualifications of proposed cleaning contractor for approval.
- C. Product Data: Manufacturer's data sheets on each product to be used.
- D. Material Safety Data Sheets (MSDS): For all chemical products proposed to be used in the cleaning process; submit directly to Owner.

- E. Project Closeout Report: Include field quality control reports, evidence of satisfactory cleaning, and documentation of items needing further repair.

1.7 QUALITY ASSURANCE

- A. Information Available to Contractor: Upon request, Owner will provide the following:
 - 1. One copy of original construction drawings of HVAC system.
- B. Cleaning Contractor Qualifications: Company specializing in the cleaning and restoration of HVAC systems as specified in this section.
 - 1. Certified by one of the following:
 - a. NADCA, National Air Duct Cleaners Association: www.nadca.com
 - b. Nationally recognized certification program and organization dedicated to the cleaning of HVAC systems.
 - 2. Having minimum of three years documented experience.
 - 3. Employing for this project a supervisor certified by same organization that certified the cleaning contractor.

PART 2 PRODUCTS

2.1 TOOLS AND EQUIPMENT

- A. Vacuum Devices and Other Tools: Exceptionally clean, in good working order, and sealed when brought into the facility.
- B. Vacuum Devices That Exhaust Air Inside Building, Including Hand-Held and Wet Vacuums: Equipped with HEPA filtration with 99.97 percent collection efficiency for minimum 0.3-micron size particles and DOP test number.
- C. Vacuum Devices That Exhaust Air Outside Building, Including Truck- and Trailer-Mounted Types: Equipped with particulate collection including adequate filtration to contain debris removed from the HVAC system; exhausted in manner that prevents contaminant re-entry to building; compliant with applicable regulations as to outdoor environmental contamination.

2.2 REPLACEMENT PRODUCTS

- A. Fibrous Glass Insulation: Provide material complying with UL 181 equivalent to existing material in quality and thickness.

2.3 SURFACE TREATMENTS

- A. Anti-Microbial Materials: EPA registered specifically for use on non-porous HVAC system surfaces and applied per manufacturer's instructions.

- B. Surface Coating for Fibrous Glass Materials: Water-based, zero VOC; flame spread index less than 25, smoke developed index less than 450, Class A, when tested in accordance with ASTM E84.

PART 3 EXECUTION

3.1 PROJECT CONDITIONS

- A. Comply with applicable federal, state, and local requirements.
- B. Perform cleaning, inspection, and remediation in accordance with the recommendations of NADCA "Assessment, Cleaning and Restoration of HVAC Systems" (ACR) and as specified herein.
- C. Where NADCA ACR uses the terms "recommended", "highly recommended", or "ideally" in regard to a certain procedure or activity, do that unless it is clearly inapplicable to the project.
- D. Take precautions to prevent introduction of additional hazards into occupied spaces.
- E. Obtain Owner's approval of proposed temporary locations for large equipment.
- F. Designate a decontamination area and obtain Owner's approval.
- G. When portions of the facility are to remain occupied or in operation during cleaning activities, provide adequate controls or containment to prevent access to spaces being cleaned by unauthorized persons and provide detailed instructions to Owner as to these controls or containment.
- H. If unforeseen mold or other biological contamination is encountered, notify Engineer immediately, identifying areas affected and extent and type of contamination.

3.2 EXAMINATION

- A. Inspect the system as required to determine appropriate methods, tools, equipment, and protection.
- B. Start of cleaning work constitutes acceptance of existing conditions.
- C. When concealed spaces are later made accessible, examine and document interior conditions prior to beginning cleaning.
- D. Document all instances of mold growth, rodent droppings, other biological hazards, and damaged system components.

3.3 PREPARATION

- A. When cleaning work might adversely affect life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with authorities having jurisdiction.

- B. Ensure that electrical components that might be adversely affected by cleaning are de-energized, locked out, and protected prior to beginning work.
- C. Air-Volume Control Devices: Mark the original position of dampers and other air-directional mechanical devices inside the HVAC system prior to starting cleaning.
- D. Access to Concealed Spaces: Use existing service openings and make additional service openings as required to accomplish cleaning and inspection.
 - 1. Do not cut openings in non-HVAC components without obtaining the prior approval of Owner.
 - 2. Make new openings in HVAC components in accordance with NADCA Standard 05; do not compromise the structural integrity of the system.
 - 3. Do not cut service openings into flexible duct; disconnect at ends for cleaning and inspection.
- E. Ceiling Tile: Lay-in ceiling tile may be removed to gain access to HVAC systems during the cleaning process; protect tile from damage and reinstall upon completion; replace damaged tile.

3.4 CLEANING

- A. Use any cleaning method recommended by NADCA ACR unless otherwise specified; do not use methods prohibited by NADCA ACR, or that will damage HVAC components or other work, or that will significantly alter the integrity of the system.
- B. Obtain Owner's approval before using wet cleaning methods; ensure that drainage is adequate before beginning.
- C. Ducts: Mechanically clean all portions of ducts.
- D. Hoses, Cables, and Extension Rods: Clean using suitable sanitary damp wipes at the time they are being removed or withdrawn from their normal position.
- E. Registers, Diffusers, and Grilles: When removing, take care to prevent containment exposure due to accumulated debris.
- F. Fibrous Glass Material: Use HEPA vacuuming equipment, under constant negative pressure, do not permit to get wet, and do not damage surfaces; replace material damaged by cleaning operations.
- G. Existing Damaged Fibrous Glass Material: Report to Engineer all evidence of damage, deterioration, delaminating, friable material, mold or fungus growth, or moisture that cannot be remedied by cleaning or resurfacing with an acceptable insulation repair coating.
 - 1. Remove unremediable material and clean underlying surfaces.
- H. Collect debris removed during cleaning; ensure that debris is not dispersed outside the HVAC system during the cleaning process.

- I. Store contaminated tools and equipment in polyethylene bags until cleaned in the designated decontamination area.

3.5 REPAIR

- A. Repair openings cut in the ventilation system so that they do not significantly alter the airflow or adversely impact the facility's indoor air quality.
- B. At insulated ducts and components, accomplish repairs in such a manner as to achieve the equivalent thermal value.
- C. Reseal new openings in accordance with NADCA Standard 05.
- D. Reseal rigid fiber glass duct systems using closure techniques that comply with UL 181 or UL 181A.
- E. When new openings are intended to be capable of being re-opened in the future, clearly mark them and report their locations to Owner in project report documents.

3.6 FIELD QUALITY CONTROL

- A. Ensure that the following field quality control activities are completed prior to application of any treatments or coatings and prior to returning HVAC system to normal operation.
- B. Visually inspect all portions of the cleaned components; if not visibly clean as defined in NADCA ACR, re-clean and reinspect.
- C. Notify Engineer when cleaned components are ready for inspection.
- D. When directed, re-clean components until they pass.
- E. Submit evidence that all portions of the system required to be cleaned have been cleaned satisfactorily.

3.7 ANTI-MICROBIAL TREATMENT

- A. When directed, apply anti-microbial treatment to internal surfaces.
- B. Apply anti-microbial agent after removal of surface deposits and debris.
- C. Apply anti-microbial treatments and coatings in strict accordance with the manufacturer's written recommendations and EPA registration listing.
- D. Spray coatings directly onto interior ductwork surfaces; do not "fog" into air stream.

3.8 ADJUSTING

- A. After satisfactory completion of field quality control activities, restore adjustable devices to original settings, including, but not limited to, dampers, air directional devices, valves, fuses, and circuit breakers.

3.9 WASTE MANAGEMENT

- A. Double-bag waste and debris in 6 mil, 0.006 inch thick polyethylene plastic bags.
- B. Dispose of debris off-site in accordance with applicable federal, state and local requirements.

END OF SECTION 23 01 30.51

SECTION 23 05 00 - MECHANICAL GENERAL CONDITIONS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 DESCRIPTION

- A. The General Conditions and Supplementary General Conditions are a part of this Division and are to be considered a part of this Contract.
- B. Where items of the General Conditions and Supplementary General Conditions are repeated in other Sections of the Specifications, it is merely intended to qualify or to call particular attention to them. It is not intended that any other parts of the General Conditions and Supplementary General Conditions shall be assumed to be omitted if not repeated therein.

This Section applies equally and specifically to all Contractors supplying labor and/or equipment and/or materials as required under each Section of this Division.

- C. The following information contains specifications of Work in connection with, and in addition to, this Division:
 - 1. All drawings associated with the project.
 - 2. All specifications associated with the project.
- D. Division of work responsibilities shall be as defined and directed by the Bidding Agent and/or the Bidding General Contractor.

1.3 INTENT

- A. It is the intent of the Specifications and Drawings to call for finished work, tested and ready for operation.
- B. Furnish, deliver and install any apparatus, appliance, material or Work not shown on Drawings but mentioned in the Specifications, or vice versa, or any incidental accessories necessary to make the Work complete and perfect in all respects and ready for operation, even if not particularly specified, under their respective Section without additional expense to the Owner.
- C. Include in the work minor details not usually shown or specified but necessary for proper installation and operation, as though they were hereinafter shown or specified.
- D. Provide Engineer written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of Work omitted. In the absence of such written notice, it is mutually agreed that Work under each Section has included the cost of all required items for

the accepted, satisfactory functioning of the entire system without extra compensation.

- E. The Work indicated is diagrammatic. The Architect and/or Engineer may require as part of this Contract, the relocation of devices to reasonable distances from the general locations shown.
- F. Verbal clarifications of the Drawings or Specifications during the bid period are not to be relied upon. Refer any questions or clarifications to the Engineer at least five Working days prior to bidding to allow for issuance of an addendum. After the five-day deadline, Bidder must make a decision and qualify the Bid, if the Bidder feels it necessary.

1.4 DRAWINGS

- A. Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. (Do not scale the Drawings.) Consult the Architectural Drawings and Details for exact location of fixtures and equipment; where same are not definitely located, obtain this information from the Architect.
- B. Closely follow Drawings in layout of Work; check Drawings of other Divisions to verify spaces in which work will be installed. Maintain maximum headroom. Where space conditions appear inadequate, Engineer shall be notified before proceeding with installations.
- C. Engineer may, without extra charge, make reasonable modifications in the layout as needed to prevent conflict with work of other trades and/or for proper execution of the work.
- D. Where variances occur between the Drawings and Specifications or within either of the Documents, include the item or arrangement of better quality, greater quantity or higher cost in the Contract price. The Engineer shall decide on the item and the manner in which the work shall be installed.

1.5 SURVEYS AND MEASUREMENTS

- A. Before submitting a Bid, the Contractor shall visit the site and shall become thoroughly familiar with all conditions under which the work will be installed. Contractor will be held responsible for any assumptions, omissions or errors made as a result of failure to become familiar with the site and the Contract Documents.
- B. Base all measurements, both horizontal and vertical, from established bench marks. All Work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the Work.
- C. Should the Contractor discover any discrepancies between actual measurements and those indicated which prevent following good practice or the intent of the Drawings and Specifications, notify the Engineer do not proceed with that Work until instructions have been received from the Engineer.

1.6 CODES AND STANDARDS

- A. The Codes and Standards listed below apply to all Work. Where Codes or Standards are mentioned in these Specifications, follow the latest edition or revision.

- B. The Codes and Standards listed below apply to all Work. Where Codes or Standards are mentioned in these Specifications, follow the latest edition or revision.
- C. The current adopted editions of the following State or local Codes apply:
 - 1. 2015 International Building Code
 - 2. 2018 Connecticut State Building Code
 - 3. 2015 International Existing Building Code
 - 4. 2015 International Mechanical Code
 - 5. 2015 International Plumbing Code
 - 6. 2017 National Electrical Code (NFPA 70)
 - 7. 2015 International Energy Conservation Code
 - 8. 2015 International Residential Code
 - 9. 2015 International Fire Code
 - 10. 2015 Life Safety Code (NFPA 101)
 - 11. ICC/ANSI A117.1-2009 Accessible and Usable Buildings and Facilities
- D. All materials furnished and all work installed shall comply with the rules and recommendations of the NFPA, the requirements of the local utility companies, the recommendations of the fire insurance rating organization having jurisdiction and the requirements of all Governmental departments having jurisdiction.
- E. Include in the Work, without extra cost to the Owner, any labor, materials, testing, services, apparatus and Drawings in order to comply with all applicable laws, ordinances, rules and regulations, whether or not shown on Drawings and/or specified.

1.7 PERMITS AND FEES

- A. Give all necessary notices, obtain all permits; pay all Government and State sales taxes and fees where applicable, and other costs, including utility connections or extensions in connection with the Work. File all necessary Drawings, prepare all Documents and obtain all necessary approvals of all Governmental and State departments having jurisdiction, obtain all required certificates of inspections for Work and deliver a copy to the Engineer before request for acceptance and final payment for the Work.

1.8 COORDINATION

- A. Carry out all work in conjunction with other trades and give full cooperation in order that all work may proceed with a minimum of delay and interference. Particular emphasis is placed on timely installation of major apparatus and furnishing other Contractors, especially the General

Contractor or Construction Manager, with information as to openings, chases, sleeves, bases, inserts, equipment locations, panels, access doors, etc. required by other trades, and to allow for serviceable access to equipment.

- B. Mechanical contractors' shall initiate coordination drawings and sections clearly showing how the work is to be installed in relation to the work of other trades, at no extra charge to the Owner. The Contractors' shall prepare coordination drawings at a scale no less than 1/4"=1'-0", showing the work of all trades, including but not limited to, the following: proposed ductwork installation in detail, including ceiling heights, approved structural steel shop drawings, duct heights, access doors, light fixtures, registers and diffusers, sprinkler piping, electrical distribution conduits, wires, panels and any other electrical work which may conflict with the sheet metal ducts or piping, waste and vent piping, water piping, storm piping, and rain leaders. Provide elevation details showing connections and equipment layout and configuration based on approved submittals. Each shall use a different color code. A coordination meeting of all Contractors involved is then to be held and all possible conflicts are to be resolved. All trades shall sign acceptance of the drawings and then shall submit two (2) prints of each drawing to the Engineer for record.
- C. Contractors are required to examine all of the Project Drawings and mutually arrange Work so as to avoid interference. In general, ductwork, heating piping, sprinkler piping and drainage lines take precedence over water, gas and electrical conduits. The Engineer regarding the arrangement of Work, which cannot be agreed upon by the Contractors, will make final decisions. Service of equipment will take precedence.
- D. Where the Work of the Contractor will be installed in close proximity to or will interfere with Work of other trades, assist in working out space conditions to make a satisfactory adjustment.
- E. If Work is installed before coordinating with other Divisions or so as to cause interference with Work of other Sections, the Contractor causing the interference will make necessary changes to correct the condition without extra charge to the Owner.
- F. Initial contact and coordination has been conducted with utility entities for the purpose of the preparation of Bid Documents. The Contractor shall coordinate all final specific utility requirements.

1.9 ACCEPTANCES

- A. The equipment, materials, Workmanship, design and arrangement of all Work installed are subject to the review of the Engineer.
- B. Within 30 days after the awarding of a Contract, submit to the Engineer for review a list of manufacturers of equipment proposed for the Work. The intent to use the exact makes specified does not relieve the Contractor of the responsibility of submitting such a list.
- C. If extensive or unacceptable delivery time is expected on a particular item of equipment specified, notify the Engineer, in writing, within 30 days of the awarding of the Contract. In such instances, deviations may be made pending acceptance by the Engineer or the Owner's representative.

- D. Where any specific material, process or method of construction or manufactured article is specified by reference to the catalog or model number of a manufacturer, the Specifications are to be used as a guide and are not intended to take precedence over the basic duty and performance specified or noted on the Drawings. In all cases, verify the duty specified with the specific characteristics of the equipment offered for review. Equipment characteristics are to be used as mandatory requirements where the Contractor proposes to use an acceptable equivalent.
- E. If material or equipment is installed before shop drawing review, liability for its removal and replacement is assumed by the Contractor, at no extra charge to the Owner, if, in the opinion of the Engineer, the material or equipment does not meet the intent of the Drawings and Specifications.
- F. Failure on the part of the Engineer to reject shop drawings or to reject Work in progress shall not be interpreted as acceptance of Work not in conformance with the Drawings and/or Specifications. Correct Work not in conformance with the Drawings and/or Specifications whenever non-conformance is discovered.

1.10 EQUIPMENT DEVIATIONS

- A. Where the Contractor proposes to deviate (substitute or provide an equivalent) from the equipment or materials as hereinafter specified, he shall do so by making a request in writing a minimum of 14 calendar days prior to submitting his bid. The request shall include a detailed description of the proposed deviation, manufacturer's equipment cuts, copy of manufacturer's warranty and a line-by-line comparison detailing how the proposed product differs from the specified product. The proposed deviation must be equivalent or better than the specified product as judged by the Engineer.
 - 1. The Base Bid shall be based on using the materials and equipment as specified and scheduled with no exceptions. Equipment Manufacturers Scheduled on Drawings are considered Base Product Specification and any other acceptable manufacturers listed in the specifications is considered an equipment deviation and subject to the requirements above. When any alternate manufacturer does not qualify acceptable, as determined by the Engineer, provide the Base Product manufacturer at no additional cost to Owner.
 - 2. Where an equivalent manufacturer is listed in the specifications, it may or may not indicate that there is an equal product available. Any products must meet all criteria of the Base Product Specification as determined by the Engineer.
- B. Substitutions and Equipment Deviations will not be considered if they have a direct bearing on the changing or revising of Contract Documents or if it involves other Contractor's scope of work or their equipment. Coordination with all trades is required and must be acceptable to all other involved Contractors.
- C. Substitutions may be considered for one of the following:
 - 1. Substitution for Cause: Changes proposed by the Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of warranty terms.

2. Substitutions for Convenience: Changes proposed by the Contractor that are not required in order to meet other Project requirements, but may offer advantage to either the Owner or Contractor.
- D. In these Specifications and on the accompanying Drawings, one or more makes of materials, apparatus or appliances may have been specified for use in this installation. This has been done for convenience in fixing the standard of workmanship, finish and design required for installation. In the event that only one (1) manufacturer of a product is specified and it is found that the manufacturer has discontinued the product, the Contractor shall use an acceptable equivalent product that meets the requirements of an equivalent product, as noted below, and has all the features of the originally specified product. The details of workmanship, finish and design, and the guaranteed performance of any material, apparatus or appliance which the Contractor desires to deviate for those mentioned herein shall also conform to these standards.
- E. Where no specific make of material, apparatus or appliance is mentioned, any first-class product made by a reputable manufacturer may be submitted for the Engineer's review.
- F. Where two or more names are given as equivalents or where one name only is used and is followed by the words "or acceptable equivalent", the Contractor must use the item named or he may apply for an equipment deviation through the prescribed manner in accordance with this Specification.
- G. Equipment, material or devices submitted for review as an "accepted equivalent" shall meet the following requirements:
 1. The equivalent shall have the same construction features such as, but not limited to:
 2. Material thickness, gauge, weight, density, etc.
 3. Welded, riveted, bolted, etc., construction
 4. Finish, undercoatings, corrosion protection
 5. The equivalent shall perform with the same or better operating efficiency.
 6. The equivalent shall have equal or greater reserve capacity.
 7. The equivalent shall be locally represented by the manufacturer for service, parts and technical information.
 8. The equivalent shall bear the same labels of performance certification as is applicable to the specified item, such as AMCA or ARI labels.
- H. Where the Contractor proposes to use an item of equipment other than specified or detailed on the Drawings which requires any redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical, electrical or architectural layout, all such redesign and all new drawings and detailing required therefore shall be prepared by the Designers of Record at the expense of the Contractor and at no additional cost to the Owner.

- I. Where such accepted deviation or substitution requires a different quantity and arrangement of piping, ductwork, valves, pumps, insulation, wiring, conduit and equipment from that specified or indicated on the Drawings, the Contractor shall, with the acceptance by the Engineer, furnish and install any such additional equipment required by the system at no additional cost to the Owner, including any costs added to other trades due to the substitution.
- J. The Engineer shall determine if an "accepted equivalent" to a manufacturer listed in the Specifications is considered acceptable.

1.11 SHOP DRAWINGS

- A. Refer to individual specification sections for additional submittal information.
- B. The Contractor shall submit for review detailed shop drawings of all equipment and material specified in each section and coordinated ductwork layouts. No material or equipment may be delivered to the job site or installed until the Contractor has received shop drawings for the particular material or equipment which have been properly reviewed.
- C. Shop drawings shall be submitted within 60 days after award of Contract before any material or equipment is purchased. The Contractor shall submit for review copies of all shop drawings to be incorporated in the Contract. Refer to the General Conditions and Supplementary General Conditions for the quantity of copies required for submission. Where quantities are not specified, provide seven (7) copies for review.
- D. Provide shop drawings for all devices specified under equipment specifications for all systems, materials, equipment and/or devices. Shop drawings shall include manufacturers' names, catalog numbers, cuts, diagrams and other such descriptive data as may be required to identify and accept the equipment. A complete list in each category (example: all fixtures) of all shop drawings, catalog cuts, material lists, etc., shall be submitted to the Engineer at one time. No consideration will be given to a partial shop drawing submittal. Partial submissions shall be rejected.
- E. Equipment shop drawings shall contain full range performance curves, graphs, tables or other pertinent data which clearly indicates operational range of a given unit size. Computer generated/plotted curves, based solely on design performance, will not be accepted.
- F. All specific options and/or alternatives shall be clearly indicated. Failure to do so shall be grounds for rejection.
- G. Submittals shall be marked with the trade involved, i.e., HVAC, plumbing, fire protection, etc. and the specific associated specification section.
- H. Where multiple quantities or types of equipment are being submitted, provide a cover sheet (with a list of contents) on the submittal identifying the equipment or material being submitted.
- I. Failure to submit shop drawings in ample time for review shall not entitle the Contractor to an extension of Contract time. Contractor must allow for a one week review at the Engineer's office plus normal delivery time to the G.C., Architect, Engineer, and return to the Architect,

and G.C. No claim for extension by reason of such default will be allowed, nor shall the Contractor be entitled to purchase, furnish and/or install equipment which has not been reviewed by the Engineer. The Contractor shall incur all costs associated with delay of construction due to equipment and/or materials arriving late due to late or improper shop drawing submittal.

- J. The Contractor shall furnish all necessary templates, patterns, etc., for installation work and for the purpose of making adjoining work conform; furnish setting plans and shop details to other trades as required.
- K. Acceptance rendered on shop drawings shall not be considered as a guarantee of measurements or building conditions. Where drawings are reviewed, review does not indicate that drawings have been checked in detail; said approval does not in any way relieve the Contractor from his responsibility or necessity of furnishing material or performing work as required by the Contract Drawings and Specifications. Verify available space prior to submitting shop drawings.
- L. Acceptance of shop drawings shall not apply to quantity nor relieve Contractor of his responsibility to comply with intent of Drawings and Specifications.
- M. Acceptance of shop drawings is final and no further changes will be allowed without the written consent of the Engineer.
- N. Shop drawing submittal sheets which may show items that are not being furnished shall have those items crossed off to clearly indicate which items will be furnished.
- O. Bidders shall not rely on any verbal clarification of the Drawings and/or Specifications. Any questions shall be referred to the Engineer at least five (5) working days prior to Bidding to allow for issuance of an Addendum. After the five (5) day deadline, Bidder shall make a decision and qualify the Bid, if the Bidder deems it necessary.
- P. Contractor shall make any corrections required by Engineer and shall resubmit required number of corrected copies of shop drawings or new samples until accepted. Contractor shall direct specific attention in writing or on resubmitted shop drawings to revisions other than corrections requested by Engineer on previous submissions. Engineer shall review no more than one resubmittal of any shop drawing or sample at Owner's expense. The fees for review of additional resubmittals shall be paid by the Contractor at the Engineer's standard rates.

1.12 CHANGES IN WORK

- A. A Change Order is a written order to the Contractor signed by the Owner and the Architect, issued after Contracts have been awarded, authorizing a change in the work or an adjustment in the Contract sum or the Contract time. A Change Order signed by the Contractor indicates his agreement therewith, including the adjustment in the Contract sum or the Contract time.
- B. All changes in the work shall follow the recommendations of the AIA "General Conditions of the Contract for Construction", Article 12.

1.13 MANUFACTURER'S IDENTIFICATION

- A. All component parts of each item of equipment or device shall bear the manufacturer's nameplate giving name of manufacturer, description, size, type, serial and model number, electrical characteristics, etc., in order to facilitate maintenance or replacement. Nameplate data shall not be obstructed. The nameplate of a Contractor or distributor will not be acceptable.
- B. All material and equipment for the electrical portion of the mechanical systems shall bear the label of or be listed by UL, or other accredited authoritative agencies or testing organizations approved by the authority having jurisdiction.

1.14 RECORD DRAWINGS

- A. Maintain at the job site a record set of Mechanical Drawings on which any changes in location or routing of all equipment, materials and access panels shall be recorded.
- B. At the end of construction, the Contractor shall provide the Owner with a complete set of As-Built Drawings, including all updated coordination drawings, ductwork and piping plans. As-Built drawings shall be drawn on the latest version of Autocad or compatible software, approved in writing, prior to submittal.

1.15 MATERIALS AND WORKMANSHIP

- A. All materials and apparatus required for the work, except as otherwise specifically indicated, shall be new, of first-class quality, and shall be furnished, delivered, erected, connected and finished in every detail and be so selected and arranged as to fit properly into the building spaces. Where no specific type or quality of material is given, a first-class standard article as accepted by industry standards shall be furnished.
- B. The Contractor shall furnish the services of an experienced superintendent who shall be constantly in charge of the installation of the work together with all skilled workmen, fitters, metal workers, welders, helpers and laborers required to unload, transfer, erect, connect, adjust, start, operate and test each system.
- C. Unless otherwise specifically indicated on the Drawings or Specifications, all equipment and materials shall be installed with the acceptance of the Engineer and in accordance with the recommendations of the manufacturer. This includes the performance of such tests as the manufacturer recommends.
- D. All labor for installation of mechanical systems shall be performed by experienced, skilled tradesmen under the supervision of a licensed journeyman foreman. All work shall be of a quality consistent with good trade practice and shall be installed in a neat, workmanlike manner. The Engineer reserves the right to reject any work which, in his opinion, has been installed in a substandard, dangerous or unserviceable manner. The Contractor shall replace said work in a satisfactory manner at no extra cost to the Owner.

1.16 PROTECTION OF MATERIALS AND EQUIPMENT

- A. Work under each Section shall include protecting the work and material of all other Sections from damage by work or workmen and shall include making good all damage thus caused.
- B. The Contractor shall be responsible for work and equipment until the facility has been accepted by the Owner. Protect work against theft, injury or damage and carefully store material and equipment received on site which is not immediately installed. Close open ends of work with temporary covers or plugs during construction to prevent entry of foreign material.
- C. Work under each Section includes receiving, unloading, uncrating, storing, protecting, setting in place and completely connecting equipment supplied under each Section. Work under each Section shall also include exercising special care in handling and protecting equipment and fixtures, and shall include the cost of replacing any of the equipment and fixtures which are missing or damaged.
- D. Equipment and material stored on the job site shall be protected from the weather, vehicles, dirt and/or damage by workmen or machinery. Insure that all electrical or absorbent equipment or material is protected from moisture during storage.

1.17 BASES AND SUPPORTS

- A. Unless otherwise specifically noted, the Contractor shall furnish all necessary supports, rails, framing, bases and piers required for all equipment furnished under this Division.
- B. Unless otherwise indicated in individual trade Sections, pumps, fans, air handlers, boilers, chillers, tanks, compressors and other rotating machinery shall be mounted on a minimum of six (6") inch high concrete pads which shall be furnished and installed per Division 3. All pads shall be extended six (6") inches beyond machine base in all directions with top edge chamfered. Shop drawings of all foundations and pads shall be submitted to the Engineer for review before they are constructed. The Mechanical Contractor shall field coordinate all required dimensional and necessary loading information.
- C. Construction of foundations, supports, pads, bases and piers where mounted on the floor shall be of the same finish quality as the adjacent and surrounding flooring material.
- D. Unless otherwise shown, all equipment shall be securely attached to the building structure in an acceptable manner. Attachments shall be of a strong and durable nature; any attachments that are insufficient, in the opinion of the Engineer, shall be replaced as directed without extra cost to the Owner.
- E. All equipment supports shall be designed and constructed such that the equipment will be capable of resisting both vertical and horizontal movement. The equipment shall be positively anchored to the bases or supports to resist vertical movement. The equipment and its supports shall be provided with suitable restraints to resist horizontal movement from any direction as dictated by applicable seismic Codes.

1.18 SLEEVES, INSERTS AND ANCHOR BOLTS

- A. The Contractor shall provide, set in place and be held responsible for the location of all sleeves, inserts and anchor bolts required for the work. In the event that failure to do so requires cutting and patching of finished work, it shall be done at the Contractor's expense.
- B. It is the responsibility of the Contractor to furnish cast-in-place steel sleeves, inserts and anchors in sufficient time to be installed during initial concrete pours. Where job schedules make this impossible, coordinate and obtain acceptance from the Structural Engineer for alternate installation methods.
- C. All pipes and conduits passing through floors, walls or partitions shall be provided with sleeves having an inside diameter one (1") inch larger than the outside diameter of the pipe, conduit or insulation enclosing the pipe.
- D. Piping insulation shall run continuous through sleeve.
- E. Penetrations through fire-rated walls, ceilings and all floors (except slab on grade) in which piping or ducts pass shall be filled solidly with acceptable fire-stopping material. Sleeves shall be steel or a UL / FM listed and approved assembly.
- F. When ducts, piping or conduit penetrate the floor of a mechanical room located above an occupied space, such penetrations shall be made completely watertight, such that a liquid leak shall not pass through the penetration.

1.19 FIRE-STOPS AND SEALS

- A. Refer to Division 7 Specification for additional and more specific information.
- B. Fire-stopping systems shall be submitted as shop drawing.
- C. Penetrations through fire-rated walls, ceiling or floors shall be sealed with a UL approved fire-stop fitting classified for an hourly rating equivalent to the fire rating of the wall, ceiling or floor.
- D. Thruwall and floor seals shall be used to provide a positive means of sealing pipes or ducts which pass through the concrete foundation of a structure below grade or below ground water level. Seals shall also be used at entry points through concrete walls or floors which must be sealed.

1.20 CUTTING AND PATCHING

- A. All cutting and patching shall be done per Division 1 requirements. The Contractor shall furnish sketches showing the location and sizes of all openings, chases, etc., required for the installation of work.
- B. Work under this Division shall include furnishing, locating and setting inserts and/or sleeves required before the floors and walls are built or be responsible for cutting, drilling or chopping where sleeves and inserts were not installed or correctly located. The Contractor shall do all

drilling required for the installation of hangers.

- C. Exercise extreme caution when core drilling or punching openings in concrete floor slabs in order to avoid cutting or damaging structural members. No structural members or structural slabs/floors shall be cut without the written acceptance of the Structural Engineer and all such cutting shall be done in a manner directed by him.

1.21 SCAFFOLDING, RIGGING, HOISTING

- A. The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery into the premises any equipment and apparatus furnished under this Division. Remove same from premises when no longer required.

1.22 EXCAVATION AND BACKFILLING

- A. Excavation and backfilling shall be done per Division 2 of the Specifications.
- B. It is the responsibility of the Contractor to coordinate sizes, depths, fill and bedding requirements and any other excavation work required under this Division per code and local utility requirements.

1.23 WATERPROOFING

- A. Where any work pierces waterproofing, including waterproof concrete and floors in wet areas, the method of installation shall be reviewed by the Engineer before work is done. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings absolutely watertight.

1.24 ACCESSIBILITY AND ACCESS PANELS

- A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate thickness of partitions, and the adequate clearance in double partitions and hung ceilings for the proper installation of the work.
- B. Locate all equipment which must be serviced, operated or maintained in fully accessible positions. Equipment shall include, but not be limited to: motors, controllers, coil, valves, switchgear, drain points, etc. Access doors shall be furnished if required for better accessibility. Minor deviations from the Drawings may be made to allow better accessibility, but changes of magnitude or which involve extra cost shall not be made without the acceptance of the Engineer.
- C. Access doors in walls, ceilings, floors, etc., shall be field coordinated. It is the responsibility of the Contractor to coordinate and provide information regarding the sizes and quantities of access doors required for his work. The Contractor shall arrange his work in such a manner as to minimize the quantity of access doors required, such as grouping shutoff valves in the same area. Where possible, locate valves in already accessible areas, such as lay-in ceilings, etc.
- D. On a clean set of prints, the Contractor shall mark in red pencil the location of each required access door, including its size and fire rating (if any), and shall submit the print to the Architect

for review before access doors are purchased or installed.

- E. Upon completion of the Project, the Contractor shall physically demonstrate that all equipment and devices installed have been located and/or provided with adequate access panels for repair, maintenance and/or operation. Any equipment not so furnished shall be relocated or provided with additional access panels by the installing Contractor at no additional cost to the Owner. All access panel or door locations shall be indicated on Owner's final as-built record drawings.
- F. Permanent ladders for access to equipment when shown on Plans shall be furnished and installed. Coordinate exact requirements in field.

1.25 TEMPORARY OPENINGS

- A. The Contractor shall ascertain from an examination of the Drawings whether any special temporary openings in the building will be required for the admission of apparatus provided under this Division and shall coordinate the requirements accordingly. In the event of failure of the Contractor to give sufficient notice in time to arrange for these openings during construction, the Contractor shall assume all costs of providing such openings thereafter.

1.26 SHUTDOWNS

- A. When installation of a new system requires the temporary shutdown of an existing operating system, the connection of the new system shall be performed at such time as designated by the Owner's representative.
- B. The Engineer and the Owner shall be notified of the estimated duration of the shutdown period at least ten (10) days in advance of the date the work is to be performed.
- C. Work shall be arranged for continuous performance whenever possible. The Contractor shall provide all necessary labor, including overtime if required, to assure that existing operating services will be shut down only during the time actually required to make necessary connections.

1.27 TAGS AND CHARTS

- A. Each valve and piece of apparatus under this Division shall be provided with suitable brass or laminated plastic tags securely fastened with brass chains, screws or rivets. Equipment shall be numbered with laminated plastic tags or neatly stenciled letters two (2") inches high using designations in equipment schedules and/or shall conform to a directory indicating number, location and use of each item. Directories shall be prepared under each Section and shall be glass framed.
- B. Directory shall indicate valve tag number and the unit number, floor/area branch line, main line, service or other pertinent data to quickly and easily identify the valve's purpose.

1.28 ESCUTCHEONS

- A. The Contractor shall provide escutcheons on pipes wherever they pass through floors, ceilings, walls or partitions in finished visible locations.

1.29 PAINTING

- A. All finish painting in completed areas shall be performed per Division 9 of the Specifications.
- B. All materials shipped to the job site under this Division, such as grilles, registers and/or radiation covers, shall have standard manufacturer's finish, unless otherwise specified by Architect.
- C. The Contractor shall paint the interior of all ducts wherever the interior of the duct can be seen through a register or louver. Paint shall be flat black, rust preventative type.
- D. All outdoor piping, fittings and hangers shall be properly primed with zinc-rich primer and finished with a minimum of two (2) coats of high grade exterior enamel.

1.30 PIPE EXPANSION

- A. All pipe connections shall be installed to allow for freedom of movement of the piping during expansion and contraction without springing. Provide engineered design, layout, details and fabrication, submitted with registered professional engineer sign and seal, of swing joints, expansion loops and expansion joints with proper anchors and guides. Pay particular attention to plastic piping with high coefficients of expansion.
- B. Consideration of required seismic lateral restraints shall be given when anchoring piping and making provision for expansion.

1.31 ELECTRICAL CONNECTIONS

- A. Unless otherwise specified, all wiring shall be furnished and installed per Division 26 Specifications.
- B. All motor controllers not factory mounted on mechanical equipment shall be furnished, mounted, and installed by the Division 26 contractor, and shall be coordinated with this contractor. Provide properly sized overload heaters and all required accessories with all motor controllers. See Division 26 Motor Controllers for motor controller requirements.
- C. All power wiring shall be furnished and installed per Division 26 complete from power source to motor or equipment junction box including power wiring through the motor controller and proper means of disconnect per NEC and Division 26. The Division 26 Contractor shall provide all disconnects, unless noted otherwise.

1.32 QUIET OPERATION

- A. If noise level is deemed objectionable by the Owner/Engineer, the Contractor shall test and record sound levels in the presence of the Owner/Engineer. The sound level shall be observed on the "A" weighting network of a sound level or sound survey meter. The ASHRAE "Guide and Data Book" provides a means to determine sound level of mechanical equipment when the total of background plus equipment sound levels exceeds the minimum acceptable equipment sound level.

- B. If objectionable noises or vibrations of any magnitude are produced and transmitted to occupied portions of the building by apparatus, piping, ducts or other parts of the mechanical work, the Contractor shall make such changes or additions as necessary without extra cost to the Owner.

1.33 MAINTENANCE

- A. The Contractor shall provide the necessary skilled labor to assure the proper operation and to provide all required current and preventative maintenance for all equipment and controls provided under this Division until final acceptance of the building by the Owner. The Contractor shall not assume acceptance of the building by the Owner until he receives written notification.
- B. The Contractor shall receive calls for any and all problems experienced in the operation of the equipment provided under this Division and he shall take steps to immediately correct any deficiencies that may exist.
- C. The Contractor shall provide a check list and shall put a copy of it in the boiler or main mechanical room. The check list shall itemize each piece of equipment furnished under his Section.
- D. The Contractor shall certify on this check list that he has examined each piece of equipment and that, in his opinion, it is operating as intended by the manufacturer, it has been properly lubricated, and that all necessary current and preventative maintenance has been performed as recommended by the manufacturer and by good and accepted practice.
- E. The Contractor shall check all controls in the building to ascertain that they are functioning as designed. This shall apply to all thermostats, aquastats, humidistats, freezestats and firestats, etc. This portion of the work shall be performed by the Contractor who installed the controls.
- F. During construction, the Contractor shall ensure that all filters are in place on all equipment. If the equipment is operated during construction (see restrictions section of this specification), strict attention shall be paid to maintaining clean and effective filters and cleaning ductwork and equipment. Filters shall be new and/or clean when the system testing and balancing takes place. The Contractor shall bear the cost of all filters and media during construction until final acceptance by the Owner. This requirement shall apply equally to fluid filters and strainers.
- G. Where normal preventative maintenance for any piece of equipment requires special tools, the Contractor shall furnish the appropriate tools for that piece of equipment (i.e., special filter removal hooks, valve wrenches, etc.).

1.34 DEMOLITION

- A. All required demolition work shall be performed by the Contractor. All demolition work shall be performed in a neat and orderly fashion.
- B. Demolition work, if indicated on the drawings, is intended for general information only and is not intended to describe the full extent of demolition work required under this Contract. All existing mechanical work and systems, including but not limited to piping, equipment,

ductwork, wiring, controls, hangers, and supports, made obsolete by this project, shall be removed in their entirety under this Contract, unless noted otherwise.

- C. After piping, ductwork, equipment, etc., has been removed, neatly cap remaining ductwork and piping, and insulate caps to match the existing adjacent ductwork and piping. In finished areas, all ductwork and piping shall be cut back to a concealed location, i.e., within walls, above ceilings, etc., before capping.
- D. Before submitting his Bid, the Contractor shall visit the site with the Contract Documents in hand, and shall inspect all existing systems to determine the extent of demolition work involved. Particular attention is drawn to the removal of existing walls or portions of existing walls. In those areas, all exposed and concealed piping, ductwork, equipment, etc., running across or through affected areas shall be removed as required. Piping and ductwork shall then be either capped, or, if required for the proper continuing operation of an existing system to remain, piping and ductwork shall be rerouted around the affected areas and reconnected as required.
- E. In general, it shall be the responsibility of the Contractor to remove demolished equipment, piping, ductwork, etc., from the site and properly dispose of it. If the Owner shall so request, however, the Contractor shall turn over demolished equipment, etc., to the Owner for the Owner's use. Unless otherwise noted, demolished work shall not be abandoned in place. Contractor shall make safe all utilities pertaining to this section.

1.35 AIR ELIMINATION

- A. The Contractor shall be responsible for bleeding all air from closed hydronic piping systems after the system has been filled, and thereafter rebleeding as often as required to completely eliminate all air from the system.
- B. Where work on an existing piping system has allowed air to enter that system, the Contractor shall also bleed that system even if no piping work was done in the area where air has developed.
- C. Where air cannot be bled from any piping due to the absence of an air vent, the Contractor shall install a manual air vent in locations required to successfully bleed such air.
- D. Where the piping layout would require an air vent in an inaccessible location, the Contractor shall install an extended 1/4-inch copper bleed line and petcock to an accessible location such as a closet, mechanical room, above lay-in ceiling, etc.

1.36 LUBRICATION

- A. All equipment installed under this Contract having moving parts and requiring lubrication shall be properly lubricated according to manufacturer's recommendations prior to testing and operation. Any such equipment discovered to have been operated before lubrication by the Contractor is subject to rejection and replacement at no additional cost to the Owner. Units furnished with sealed bearings are exempted.

- B. The Contractor shall furnish and install, as appropriate on all equipment requiring lubrication, Zerk pressure gun grease fittings or sight gravity-feed oilers equipped with shutoff and needle valve adjustment. Units furnished with sealed bearings and lifetime lubrication are exempted. All fittings and oilers are to be fully accessible for lubrication with equipment which does not require special adapters. Where fittings would be otherwise inaccessible, furnish and install extended grease lines.

1.37 CLEANING

- A. The Contractor shall be responsible for keeping the jobsite clean, safe and neat throughout the duration of construction. The Contractor shall clean up his own debris daily and shall coordinate removal of rubbish and debris with the General Contractor/Construction Manager.
- B. No debris, construction materials, cigarette butts, coffee cups, etc., shall be left above suspended ceilings.
- C. Terminal equipment and plumbing fixtures shall cleaned at substantial completion.
- D. If any part of a system should be stopped or damaged by any foreign matter after being placed in operation, the system shall be disconnected, cleaned and reconnected wherever necessary to locate and/or remove obstructions. Any work damaged in the course of removing obstructions shall be repaired or replaced when the system is reconnected at no additional cost to the Owner.
- E. During the course of construction, all ducts and pipes shall be capped in an acceptable manner to insure adequate protection against the entrance of foreign matter.
- F. Upon completion of all work under the Contract, the Contractor shall remove from the premises all rubbish, debris and excess materials left over from his work. Any oil or grease stains on floor areas caused by the Contractor shall be removed and floor areas left clean.

1.38 OPERATING INSTRUCTIONS

- A. Upon completion of all work and tests, the Contractor shall furnish the necessary skilled labor and helpers for operating his system and equipment for a period of 4 hours unless specified otherwise under each applicable Section of this Division. During this period, he shall fully instruct the Owner or the Owner's representative in the operation, adjustment and maintenance of all equipment furnished. The Contractor shall give at least 72 hours notice to the Owner and the Engineer in advance of this period.
- B. The Contractor shall formally submit for delivery to the Engineer three (3) complete bound sets of typewritten or blueprinted instructions for operating and maintaining all systems and equipment included in this Division. All instructions shall be submitted in draft for review prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instruction.
- C. The Contractor, in the above-mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this Division.

- D. The appropriate Contractor shall physically demonstrate procedures for all routine maintenance of all equipment furnished under each respective Section to assure accessibility to all devices.
- E. An authorized manufacturer's representative shall attest in writing that the equipment has been properly installed prior to startup of any major equipment. The following equipment will require this inspection: pumps; air conditioning equipment, controls, air handling equipment, boilers. These letters will be bound into the operating and maintenance books.
- F. Refer to individual trade Sections for any other particular requirements related to operating instructions.

1.39 ADJUSTING AND TESTING

- A. After all the equipment and accessories to be furnished are in place, they shall be put in final adjustment and subjected to such operating tests so as to assure the Engineer that they are in proper adjustment, the control operate as described in the sequence of operation and all systems are in satisfactory, permanent operating condition.
- B. Where requested by the Engineer, a factory-trained service engineering representative shall inspect the installation and assist in the initial startup and adjustment to the equipment. The period of these services shall be for such time as necessary to secure proper installation and adjustments. After the equipment is placed in permanent operation, the service engineering representative shall supervise the initial operation of the equipment and instruct the personnel responsible for operation and maintenance of the equipment. The service engineering representative shall notify the Contractor in writing that the equipment was installed according to manufacturer's recommendations and is operating as intended by the manufacturer.

1.40 COMMISSIONING

- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service.
- B. Complete installation, startup checks and functional tests according to manufacturers written instructions.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start up procedure.
- D. Verify that equipment is installed and commissioned as per manufacturers written instructions/requirements.
- E. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- F. Contractor shall replace all damaged components and components that failed the inspections at no additional charge.

- G. Inspections by the Commissioning Agent shall be on “spot check basis”. Commissioning process does not reduce responsibility of installing contractors to provide a finished and fully functioning product.
- H. This section shall in no way diminish the responsibility of the Contractors, Sub-contractors and Suppliers in performing all aspects of work and testing as outlined in the Contract Documents. Any requirements outlined in this section are in addition to requirements outlined in related specifications.

1.41 GUARANTEES

- A. The Contractor shall guarantee all equipment, material and workmanship under these Specifications and the Contract for a period of one (1) year from the date of final acceptance by Owner, unless otherwise noted.
- B. All refrigeration compressors shall have five (5) year guarantee from the date of final acceptance by the Owner unless otherwise noted.
- C. During this guarantee period, all defects developing through faulty equipment, materials or workmanship shall be corrected or replaced immediately by the Contractor without expense to the Owner. Such repairs or replacements shall be made to the Engineer's satisfaction.

1.42 RESTRICTIONS

- A. Mechanical equipment provided under this Division may not be used for temporary heating/cooling requirements due to premature wear and dirt/dust infiltration. Equipment shall be protected from dust and debris during construction. Duct opening shall be protected during construction to prevent dust and debris from being transported through ductwork to equipment or other spaces and to ensure ductwork is clean and ready for use at the time of equipment start-up. Written approval may be obtained from the Owner only after submission of a written cleaning plan and guarantee/warranty extension.
- B. Piping shall not be run in any concrete floor slab. Written approval from the Structural Engineer may be obtained only after submission and approval of a layout shop drawing.

PART 2 PRODUCTS - NOT USED.

PART 3 EXECUTION - NOT USED.

END OF SECTION 23 05 00

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SECTION 23 05 05 - MECHANICAL DEMOLITION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Removal and disposal of existing heating and cooling systems as shown on the Drawings.
- B. Demolition shall include the removal of all hangers, supports and concrete pads, anchors and other items not required for the new work.

1.3 SEQUENCING AND SCHEDULING OF WORK

- A. All piping to be completely drained prior to commencing demolition.
- B. All power to equipment being removed shall be disconnected by electrical contractor prior to commencing demolition.
- C. Schedule and coordinate demolition with new construction to minimize frequency and duration of work in occupied areas.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching and extending work: As specified in individual sections.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify existing conditions in the field. Note which items are to remain and which items are to be removed as indicated on drawings.
- B. Verify that abandoned wiring and equipment serve only abandoned facilities.
- C. Demolition drawings are based on casual field observation and existing record documents.
- D. Report discrepancies to Engineer before disturbing existing installation.
- E. Where asbestos materials are deemed to be part of the equipment, the abatement contractor shall be responsible for demolition and proper removal and disposal of equipment.
- F. Beginning of demolition means installer accepts existing conditions.

3.2 PREPARATION

- A. Disconnect electrical systems in walls, floors, and ceilings to be removed.
- B. Drain systems to be removed.
- C. Provide temporary piping, ductwork, control wiring, and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or piping, coordinate shut-down time with owner.
- D. Existing Domestic Cold Water System: Maintain existing systems in service. Disable systems only to make switchovers and/or connections. Minimize outage duration.
 - 1. Obtain permission from Owner at least 24 hours before partially or completely disabling system.

3.3 DEMOLITION AND EXTENSION OF EXISTING MECHANICAL WORK

- A. All demolition work shall be scheduled and coordinated in order to accommodate construction phasing schedule.
- B. Remove, relocate, and extend existing installations to accommodate new construction.
- C. Remove abandoned piping to source of supply, provide isolation valve and cap at mains.
- D. Contractor shall make safe all work associated with this division.
- E. Disconnect and remove mechanical piping and fittings serving equipment that has been removed .
- F. Disconnect and remove existing equipment, piping and fittings as indicated on the drawings.
- G. Premature or excessive demolition or failure to retain components of the existing heating and plumbing systems shall result in the Contractor providing replacement at no additional cost to Owner.

3.4 CLEANING AND REPAIR

- A. Clean and repair existing materials and equipment which remain or are to be reused in accordance with manufacturer's recommended maintenance procedures.

END OF SECTION 23 05 05

SECTION 23 05 16 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Flexible pipe connectors.
- B. Flexible- hose packless expansion joints.
- C. Alignment guides and anchors.
- D. Expansion joints and compensators.
- E. Pipe loops, offsets, and swing joints.

1.3 RELATED REQUIREMENTS

- A. Section 230548 - Vibration and Seismic Controls for HVAC Systems.
- B. Section 23 21 13 - Hydronic Piping.

1.4 REFERENCE STANDARDS

- A. ASTM A269/A269M - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service 2015a (Reapproved 2019).
- B. EJMA (STDS) - EJMA Standards Tenth Edition.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: For each type of product indicated.
 - 1. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
- C. Delegated Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for the preparation.
 - 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.

2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
- D. Manufacturer's Instructions: Indicate manufacturer's installation instructions, special procedures, and external controls.
- E. Project Record Documents: Record installed locations of flexible pipe connectors, expansion joints, anchors, and guides.
- F. Maintenance Data: Include adjustment instructions.

1.6 WARRANTY

- A. 3 Year full replacement warranty from the date of final acceptance by Owner, unless otherwise noted. .

PART 2 PRODUCTS

2.1 FLEXIBLE PIPE CONNECTORS - STEEL PIPING

- A. Manufacturers:
1. Flex-hose, Inc. : www.flexhose.com
 2. The Metraflex Company: www.metraflex.com
 3. Victaulic Company: www.victaulic.com
 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. General: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by center section of flexible hose.
- C. Flexible Hose: Corrugated stainless steel (or bronze) close-pitch hose with stainless steel (or bronze) overbraid.
- D. Pressure Rating: Design for testing to 1.5 times the maximum rated working pressure and a minimum 4:1 (burst to working) safety factor.
- E. Rating: Operating temperatures up to 850 Deg. F for stainless steel and 400 Deg. F for bronze.
- F. Size: Use pipe sized units.
- G. Three Victaulic flexible type couplings may be used in lieu of a flexible connector for vibration attenuation at equipment connections. The couplings shall be placed in close proximity to the source of the vibration.

2.2 ACCESSORIES

- A. Pipe alignment guides and anchors as required by manufacturer.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install flexible pipe connectors on pipes connected to vibration isolated equipment. Provide line size flexible connectors.
- C. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.
- D. Anchor pipe to building structure where required. Provide pipe guides so movement is directed along axis of pipe only. Erect piping such that strain and weight is not on cast connections or apparatus.
- E. Provide support and equipment required to control expansion and contraction of piping. Provide loops, pipe offsets, and swing joints, or expansion joints where required.

END OF SECTION 230516 23 05 16

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SECTION 23 05 17 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Pipe sleeves.
- B. Pipe-sleeve seals.

1.3 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.
- B. Section 09 91 13 - Exterior Painting: Preparation and painting of exterior piping systems.
- C. Section 09 91 23 - Interior Painting: Preparation and painting of interior piping systems.
- D. Section 23 05 53 - Identification for HVAC Piping and Equipment: Piping identification.
- E. Section 23 07 16 - HVAC Equipment Insulation.
- F. Section 23 07 19 - HVAC Piping Insulation.

1.4 REFERENCE STANDARDS

- A. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type) 2016.
- B. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems 2013a (Reapproved 2017).

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements for submittal procedures.
- B. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.
 - 2. Extra Valve Stem Packings: Two for each type and size of valve.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Installer Qualifications: Company specializing in performing work of the type specified this section.
 - 1. Minimum three years experience.
 - 2. Approved by manufacturer.
- C. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store sleeve and sleeve seals in shipping containers, with labeling in place.
- B. Provide temporary protective coating on cast iron and steel sleeves if shipped loose.

1.8 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a five year period after Date of Substantial Completion.

PART 2 PRODUCTS

2.1 PIPE SLEEVES

- A. Manufacturers:
 - 1. Flexicraft Industries; Pipe Wall Sleeve: www.flexicraft.com/#sle.
 - 2. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Vertical Piping:
 - 1. Sleeve Length: 1 inch above finished floor.
 - 2. Provide sealant for watertight joint.
 - 3. Blocked Out Floor Openings: Provide 1-1/2 inch angle set in silicon adhesive around opening.
 - 4. Drilled Penetrations: Provide 1-1/2 inch angle ring or square set in silicone adhesive around penetration.
- C. Plastic or Sheet Metal: Pipe passing through interior walls, partitions, and floors, unless steel or brass sleeves are specified below.

- D. Pipe Passing Through Below Grade Exterior Walls:
 - 1. Zinc coated or cast iron pipe.
 - 2. Provide watertight space with link rubber or modular seal between sleeve and pipe on both pipe ends.
- E. Pipe Passing Through Concrete Beam Flanges, except where Brass Pipe Sleeves are Specified:
 - 1. Galvanized steel pipe or black iron pipe with asphalt coating.
 - 2. Connect sleeve with floor plate except in mechanical rooms.
- F. Pipe Passing Through Mechanical, Laundry, and Animal Room Floors above Basement:
 - 1. Galvanized steel pipe or black iron pipe with asphalt coating.
 - 2. Connect sleeve with floor plate except in mechanical rooms.
- G. Penetrations in concrete beam flanges are permitted but are prohibited through ribs or beams without prior approval from the Engineer.
- H. Clearances:
 - 1. Provide allowance for insulated piping.
 - 2. Wall, Floor, Partitions, and Beam Flanges: 1 inch greater than external pipe diameter.
 - 3. All Rated Openings: Caulked tight with fire stopping material in compliance with ASTM E814 in accordance with Section 07 84 00 to prevent the spread of fire, smoke, and gases.

2.2 PIPE-SLEEVE SEALS

- A. Manufacturers:
 - 1. Flexicraft Industries; PipeSeal: www.flexicraft.com/#sle.
 - 2. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Modular Mechanical Sleeve-Seal:
 - 1. Elastomer-based interlocking links continuously fill annular space between pipe and wall-sleeve, wall or casing opening.
 - 2. Watertight seal between pipe and wall-sleeve, wall or casing opening.
 - 3. Size and select seal component materials in accordance with service requirements.
 - 4. Glass-reinforced plastic pressure end plates.

PART 3 EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and foreign material, from inside and outside, before assembly.

3.2 INSTALLATION

- A. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- B. Install piping to conserve building space, to not interfere with use of space and other work.
- C. Install piping and pipe sleeves to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- D. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- E. Structural Considerations:
 - 1. Do not penetrate building structural members unless indicated.
- F. Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
 - 1. Underground Piping: Caulk pipe sleeve watertight with lead and oakum or mechanically expandable chloroprene inserts with bitumen sealed metal components.
 - 2. Aboveground Piping:
 - a. Pack solid using mineral fiber in compliance with ASTM C592.
 - b. Fill space with an elastomer caulk to a depth of 0.50 inch where penetrations occur between conditioned and unconditioned spaces.
 - 3. All Rated Openings: Caulk tight with fire stopping material in compliance with ASTM E814 in accordance with Section 07 84 00 to prevent the spread of fire, smoke, and gases.

4. Caulk exterior wall sleeves watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed components.

G. Manufactured Sleeve-Seal Systems:

1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
3. Locate piping in center of sleeve or penetration.
4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
5. Tighten bolting for a water-tight seal.
6. Install in accordance with manufacturer's recommendations.

- H. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

3.3 CLEANING

- A. Upon completion of work, clean all parts of the installation.
- B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.
- C. See Section 01 74 19 - Construction Waste Management and Disposal, for additional requirements.

END OF SECTION 23 05 17

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SECTION 23 05 19 - METERS AND GAUGES FOR HVAC PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Pressure gauges and pressure gauge taps.
- B. Thermometers and thermometer wells.
- C. Test plugs.

1.3 RELATED REQUIREMENTS

- A. Section 23 09 23 - Direct-Digital Control System for HVAC.
- B. Section 23 21 13 - Hydronic Piping.

1.4 REFERENCE STANDARDS

- A. ASME B40.100 - Pressure Gauges and Gauge Attachments 2013.
- B. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers 2014 (Reapproved 2020).
- C. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers 2014 (Reapproved 2021).

1.5 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for submittal procedures.
- B. Product Data: Provide list that indicates use, operating range, total range and location for manufactured components.
- C. Project Record Documents: Record actual locations of components and instrumentation.

1.6 FIELD CONDITIONS

- A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 PRODUCTS

2.1 PRESSURE GAUGES

A. Manufacturers:

1. Terice: www.terice.com
2. Winters Instruments: www.winters.com
3. Ashcroft: www.ashcroft.com
4. Substitutions: See Section 01 60 00 - Product Requirements.

B. Gage: ASME B40.100, cast aluminum steel case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.

1. Window: clear glass.
2. Size: 4-1/2 inch diameter.
3. Mid-Scale Accuracy: +/- 1 %.
4. Units of measure: Psi

2.2 PRESSURE GAUGE TAPPINGS

- A. Gauge Cock: Tee or lever handle, brass for maximum 150 psi.
- B. Needle Valve: Brass, 1/4 inch NPT for minimum 150 psi.
- C. Pulsation Damper: Pressure snubber, brass with 1/4 inch connections.

2.3 STEM TYPE THERMOMETERS

A. Manufacturers:

1. Winters Instruments: www.winters.com
2. Terice: www.terice.com
3. Weiss Instruments: www.weissinstruments.com
4. Substitutions: See Section 01 60 00 - Product Requirements.

B. Thermometer: ASTM E 1, adjustable angle, red appearing non-toxic liquid fill, lens front tube, cast aluminum case with enamel finish or impact resistance valox polyester case, cast aluminum adjustable joint with positive locking device.

1. Size: 9 inch scale.
2. Window: Clear glass.

3. Stem: 3/4 inch NPT brass.
4. Accuracy: +/- 1 percent, per ASTM E 77.
5. Units of measure: Degree F.

2.4 THERMOMETER SUPPORTS

- A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.

2.5 TEST PLUGS

- A. Test Plug: 1/4 inch or 1/2 inch brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with Nordel core for temperatures up to 350 degrees F.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide one pressure gage per pump, installing taps before strainers and on suction and discharge of pump.
- C. Install pressure gauges with pulsation dampers. Provide gauge cock to isolate each gauge. Provide siphon on gauges in steam systems. Extend nipples and siphons to allow clearance from insulation.
- D. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- E. Install thermometer sockets adjacent to controls system thermostat, transmitter, or sensor sockets. Refer to Section 23 09 43. Where thermometers are provided on local panels, duct or pipe mounted thermometers are not required.
- F. Provide instruments with scale ranges selected according to service with largest appropriate scale.
- G. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- H. Locate test plugs adjacent thermometers and thermometer sockets.

END OF SECTION 23 05 19

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SECTION 23 05 48 - VIBRATION AND SEISMIC CONTROLS FOR HVAC SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Inertia bases.
- B. Vibration isolators.
- C. Seismic restraint/expansion.

1.3 RELATED SECTIONS

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 23 05 00 - Mechanical General Conditions.

1.4 RELATED WORK

- A. Housekeeping Pads
 - 1. Housekeeping pad reinforcement and monolithic pad attachment to the structure details and design shall be prepared by the restraint vendor.
 - 2. Housekeeping pads shall be coordinated with restraint vendor and sized to provide a minimum edge distance of ten (10) bolt diameters all around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embedment.
- B. Supplementary Support Steel
 - 1. Contractor shall supply supplementary support steel for all equipment, piping, ductwork, etc. including roof-mounted equipment, as required or specified.
- C. Attachments
 - 1. Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double-sided beam clamps, etc. in accordance with the requirements of the vibration vendor's calculations.

1.5 DESCRIPTION

- A. Work of this Section includes furnishing and installing vibration isolation equipment and/or seismic restraint/expansion for mechanical equipment and piping systems and ductwork furnished under this Division.
- B. Vibration isolators shall be provided for motor driven equipment over 0.5 HP, including connected piping, ductwork and raceways.
- C. Mechanical equipment and raceway systems shall be seismically restrained as required by Section 1621 of the currently applicable IBC building code and the Connecticut Supplement.

1.6 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for submittal procedures.
- B. Product Data: Provide schedule of vibration isolator type with location and load on each.
 - 1. Horsepower of each motor, and lowest operating RPM of both driven and driver, in each supported unit.
 - 2. Calculated static load of each isolator, in pounds.
 - 3. Scheduled deflection of each isolator. Identification of each isolator selected by number and spring color.
 - 4. For spring isolators: Spring diameters, deflections, compressed height, and solid spring height.
- C. Shop Drawings: Locate vibration isolators, with static and dynamic load on each. Indicate seismic control measures.
 - 1. Calculate total lateral and longitudinal forces, in pounds for each pipe or ductwork segment and piece of equipment. The total lateral force is defined in IBC 2003, Section 1621.1.4
 - 2. For seismic restraints: published data or certified drawings showing construction details, capacities and calculated force acting in all directions at each point of attachment, or California OSHPD pre-approved "R" numbers, certifying G force capabilities.
- D. Seismic calculations shall be submitted with the seal of a professional engineer who is legally qualified to practice in the jurisdiction where the Project is located and who is experienced in providing engineering services of the kind indicated.
- E. Coordination Drawings:
 - 1. Drawings showing equipment base construction for each machine, including dimensions, structural member sizes and support point locations.

2. Drawings showing methods of suspension, support guides for conduit, piping and ductwork.
3. Drawings showing methods for isolation of conduits, pipes and ductwork penetrating walls and floor slabs.
4. Concrete and steel details for bases including anchor bolt locations.
5. Number and location of seismic restraint/expansion and anchors for each piece of equipment and piping system. Coordination drawings shall be reviewed by the seismic engineer of record, detailing restraint/expansion locations. Each coordination drawing shall bear the seismic engineer's stamp certifying review of the designed systems.
6. Specific details of restraint/expansion including anchor bolts for mounting and maximum loading at each location, for each piece of equipment and/or raceway.
7. Submitted drawings shall detail location and construction details of raceway expansion fittings at building seismic joints to accomodate 4" displacement.
8. Refer to the Architectural and/or Structural drawings for locations of seismic joints.

F. Manufacturer's Instructions: Indicate installation instructions with special procedures and setting dimensions.

1.7 COMMISSIONING

- A. Engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 500000 - Commissioning Requirements.
- B. Complete installation and startup checks and functional tests according to Section 500000 - Commissioning Requirements.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start up procedure.
- D. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- E. Contractor shall replace all damaged components and components that failed the inspections at no additional charge.
- F. Inspections by the Commissioning Agent shall be on "spot check basis". Commissioning process does not reduce responsibility of installing contractors to provide a finished and fully functioning product.
- G. This section shall in no way diminish the responsibility of the Contractors, Sub-contractors and Suppliers in performing all aspects of work and testing as outlined in the Contract Documents. Any requirements outlined in this section are in addition to requirements outlined in related

specifications.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Amber/Booth: www.amberbooth.com
- B. Kinetics Noise Control, Inc: www.kineticsnoise.com.
- C. Mason Industries: www.mason-ind.com. (Reference Standard)
- D. Substitutions: See Section 01 6000 - Product Requirements.

2.2 INERTIA BASES

- A. Structural Bases:
 - 1. Construction: Welded structural steel with gusseted brackets, to support equipment and motor, with motor slide rails.
 - 2. Design: Sufficiently rigid to prevent misalignment or undue stress on machine, and to transmit design loads to isolators and snubbers.
- B. Concrete Inertia Bases:
 - 1. Construction: Structural steel channel perimeter frame, with gusseted brackets and anchor bolts, reinforcing; concrete filled.
 - 2. Mass: Minimum of 1.5 times weight of isolated equipment.
 - 3. Connecting Point: Reinforced to connect isolators and snubbers to base.
 - 4. Concrete: Minimum 3000 psi concrete.

2.3 VIBRATION ISOLATORS

- A. Spring Hanger:
 - 1. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection. Color code springs for load carrying capacity.
 - 2. Housings: Incorporate neoprene isolation element meeting requirements for neoprene mount isolators.
 - 3. Misalignment: Capable of 30 degree hanger rod misalignment.
- B. Neoprene Pad Isolators:
 - 1. Rubber or neoprene waffle pads.

- a. Hardness: 50 durometer.
 - b. Thickness: Minimum 3/4 inch.
 - c. Maximum Loading: 50 psi.
 - d. Rib Height: Maximum 0.7 times width.
2. Configuration: Single layer.
- C. Bridge bearing neoprene mountings shall have a minimum static deflection of 0.2" and all directional seismic capability. The mount shall consist of a ductile iron casting containing two separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge bearing specifications. Mountings shall have an Anchorage Pre approval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be Type BR as manufactured by Mason Industries, Inc.
- D. Sheet metal panels shall be bolted to the walls or supporting structure by assemblies consisting of a neoprene bushing cushioned between 2 steel sleeves. The outer sleeve prevents the sheet metal from cutting into the neoprene. Enlarge panel holes as required. Neoprene elements pass over the bushing to cushion the back panel horizontally. A steel disc covers the inside neoprene element and the inner steel sleeve is elongated to act as a stop so tightening the anchor bolts does not interfere with panel isolation in 3 planes. Bushing assemblies can be applied to the ends of steel cross members where applicable. All neoprene shall be bridge-bearing quality. Bushing assemblies shall be type PB as manufactured by Mason Industries, Inc.
- E. A one piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal-to-metal contact. Neoprene bushings shall be type HG as manufactured by Mason Industries, Inc.
- F. Flexible spherical expansion joints shall employ peroxide cured EPDM in the covers, liners and Dacron tire cord frictioning. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2" and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron or steel flanges with hooked or similar interlocks. 14" and smaller connectors shall be rated at 250 psi up to 190 F with a uniform drop in allowable pressure to 190 psi at 250 F. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5-minute factory test at twice the rated pressure. Concentric reducers to the above specifications may be substituted for equal ended expansion joints. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have 1/2" thick Neoprene washer bushings large enough in area to take the thrust at 1000 psi maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ as manufactured by Mason Industries, Inc.

- G. Flexible hose shall have bronze braid and copper solder ends. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be type CPSB as manufactured by Mason Industries, Inc.
- H. Three Victaulic flexible type couplings may be used in lieu of a flexible connector for vibration attenuation at equipment connections in applicable piping systems. The couplings shall be placed in close proximity to the source of the vibration.

2.4 SEISMIC RESTRAINTS

- A. Suspended Equipment and Pipe and Ductwork:
 - 1. Mechanical equipment, pipe and ductwork requiring seismic bracing shall be supported by structure designed to withstand the lateral and longitudinal forces as determined in the current applicable Building Code.
 - 2. Seismic bracing for mechanical equipment, pipe and ductwork shall be a seismic restraint system type SCB as manufactured by Mason Industries or rigid member system as manufactured by Tolco.
 - 3. Suspended equipment utilizing vibration isolating elements as part of the suspending structure shall incorporate seismic restraint cables at all mounting points (minimum of four points). Cables shall be installed at 45 degree angle to vertical and 45 degree angles to equipment longitudinal axes. Seismic restraint cables shall be type SCB as manufactured by Mason Industries.
- B. Female wedge anchors are preferred in floor locations so isolators or equipment can be slid into place after the anchors are installed. Anchors shall be manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female wedge anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying to its allowable loads. Drill-in female wedge anchors shall be type SAB as manufactured by Mason Industries, Inc.

PART 3 EXECUTION

3.1 GENERAL

- A. Furnish all labor, materials, tools, appliances, and equipment and perform all operations necessary for the complete execution of the installation of noise and vibration isolation devices and seismic restraints specified in this section.
- B. All piping and ductwork to be isolated according to this section of the specification shall freely pass through walls and floors with out rigid connections. Penetration points shall be sleeved or otherwise formed to allow passage of piping or ductwork, and maintain a minimum of 3/4" and maximum of 1-1/4" clearance around the outside surfaces. This clearance space shall be tightly packed with 1.50 PCF fiberglass, and caulked airtight, after installation of piping and ductwork.
- C. The isolation materials manufacturer shall be responsible for the proper selection of springs to accomplish the specified minimum static deflections, for all isolators, based on the weight

distribution of equipment to be isolated.

- D. Installation of all vibration isolation material specified herein shall be accomplished following the manufacturer's written instructions.
- E. Upon completion of installation of all vibration isolation and seismic restraint devices, the seismic Engineer of record shall visit the site and inspect the installation. Upon completion of inspection, the engineer shall provide a stamped letter of compliance certifying that all components have been installed and adjusted properly.

3.2 PIPING

- A. All piping in the building which are connected to vibration isolated equipment shall be noise isolated at connections to the building structure per the Schedule at the end of this section.
- B. Horizontal Piping: Where required raceway shall incorporate seismic restraint cables at all changes of direction and at interval not to exceed those in the table below.
- C. Vertical Piping: Riser clamps shall be anchored at each floor to provide seismic restraint.
- D. Maximum Lateral Restraint spacing for Piping:
- E. Size Threaded & Mech Joined Copper (Nominal) Flanged Steel (Grooved) Steel
- F. 2" & Under 24' 16' 20'
- G. 2.5" - 6" 36' 24' 20'
- H. Provide longitudinal restraints at interval of double the lateral spacing but never to exceed 80 feet.

3.3 INSTALLATION

- A. Install neoprene pad isolators in accordance with the manufacturer's instructions.
- B. Bases:
 - 1. Set steel bases for one inch clearance between housekeeping pad and base.
 - 2. Set concrete inertia bases for 2 inches clearance between housekeeping pad and base.
 - 3. Adjust equipment level.
- C. Hangers shall be suspended from and restrained by substantial structural members, not the slab diaphragm, unless specifically approved by the Architect.
- D. Isolators shall be installed with the hanger box as close to the structure as possible. Hanger rods shall be aligned so as to clear the hanger box.
- E. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.

1. The installation or use of vibration isolators shall not cause any change of position of equipment or piping that will result in stresses in the pipe connections or misalignment of shafts or bearings. In order to meet this objective, equipment and piping shall be maintained in a rigid position during installation. The load shall not be transferred to the isolator until the installation is complete and under full operational load.
- F. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.
- G. Seismic restraints shall be installed after equipment is in operating position to assure design clearances are maintained.
- H. Support piping connections to equipment mounted on isolators using isolators or resilient hangers for scheduled distance.
 1. Up to 4 Inches Pipe Size: First three points of support.
 2. 5 to 8 Inches Pipe Size: First four points of support.

3.4 FIELD QUALITY CONTROL

- A. Inspect isolated equipment after installation and submit report. Include static deflections.

3.5 SCHEDULES

- A. Pipe Isolation Schedule.
 1. 1 Inch Pipe Size: Isolate 120 diameters from equipment.
 2. 2 Inch Pipe Size: Isolate 90 diameters from equipment.
 3. 3 Inch Pipe Size: Isolate 80 diameters from equipment.
 4. 4 Inch Pipe Size: Isolate 75 diameters from equipment.

END OF SECTION 23 05 48

SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Pipe markers.
- D. Ceiling tacks.

1.3 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems 2020.

1.4 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for submittal procedures.
- B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Product Data: Provide manufacturers catalog literature for each product required.
- E. Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

- A. Air Handling Units: Nameplates.
- B. Air Terminal Units: Tags.
- C. Automatic Controls: Tags. Key to control schematic.
- D. Control Panels: Nameplates.
- E. Ductwork: Nameplates.

- F. Heat Transfer Equipment: Nameplates.
- G. Instrumentation: Tags.
- H. Major Control Components: Nameplates.
- I. Piping: Tags.
- J. Pumps: Nameplates.
- K. Small-sized Equipment: Tags.
- L. Tanks: Nameplates.
- M. Water Treatment Devices: Nameplates.

2.2 MANUFACTURERS

- A. Brady Corporation: www.bradycorp.com.
- B. Champion America, Inc: www.Champion-America.com.
- C. Seton Identification Products: www.seton.com/aec.
- D. Substitutions: See Section 01 6000 - Product Requirements.

2.3 NAMEPLATES

- A. Description: Laminated three-layer plastic with engraved letters.
 - 1. Letter Color: White.
 - 2. Letter Height: 1/4 inch.
 - 3. Background Color: Black.

2.4 TAGS

- A. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.
- B. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

2.5 PIPE MARKERS

- A. Color: Comply with ASME A13.1.
- B. Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

- C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure-sensitive adhesive backing and printed markings.
- D. Underground Plastic Pipe Markers: Bright-colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil, 0.004 inch thick, manufactured for direct burial service.

2.6 CEILING TACKS

- A. Description: Steel with 3/4 inch diameter color coded head.
- B. Color code as follows:
 - 1. HVAC Equipment: Yellow.
 - 2. Fire Dampers and Smoke Dampers: Red.
 - 3. Heating/Cooling Valves: Blue.

PART 3 EXECUTION

3.1 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic pipe markers in accordance with manufacturer's instructions.
- D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- E. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.
- F. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
- G. Identify control panels and major control components outside panels with plastic nameplates.
- H. Identify thermostats relating to terminal boxes or valves with nameplates.
- I. Identify valves in main and branch piping with tags.
- J. Identify air terminal units and radiator valves with numbered tags.
- K. Tag automatic controls, instruments, and relays. Key to control schematic.

- L. Identify piping, concealed or exposed, with plastic pipe markers. Use tags on piping 3/4 inch diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- M. Install ductwork with plastic nameplates. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.
- N. Locate ceiling tacks to locate VAV boxes above lay-in panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION 23 05 53

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Testing, adjustment, and balancing of air systems.
- B. Testing, adjustment, and balancing of hydronic systems.
- C. Measurement of final operating condition of HVAC systems.
- D. Commissioning activities.

1.3 RELATED REQUIREMENTS

- A. Section 01 91 13 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.
- B. Section 23 08 00 - Commissioning of HVAC.

1.4 REFERENCE STANDARDS

- A. AABC (NSTSB) - AABC National Standards for Total System Balance, 7th Edition 2016.
- B. AABC MN-1 - AABC National Standards for Total System Balance; Associated Air Balance Council; 2002.
- C. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems 2008, with Errata (2019).
- D. NEBB (TAB) - Procedural Standards for Testing Adjusting and Balancing of Environmental Systems 2015, with Errata (2017).
- E. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing 2002.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
 - 1. Include at least the following in the plan:

- a. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
- b. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
- c. Identification and types of measurement instruments to be used and their most recent calibration date.
- d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
- e. Final test report forms to be used.
- f. Detailed step-by-step procedures for TAB work for each system and issue, including:
 - 1) Terminal flow calibration (for each terminal type).
 - 2) Diffuser proportioning.
 - 3) Branch/submain proportioning.
 - 4) Total flow calculations.
 - 5) Rechecking.
 - 6) Diversity issues.
- g. Expected problems and solutions, etc.
- h. Criteria for using air flow straighteners or relocating flow stations and sensors; analogous explanations for the water side.
- i. Details of how TOTAL flow will be determined; for example:
 - 1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
 - 2) Water: Pump curves, circuit setter, flow station, ultrasonic, etc.
- j. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and methods to verify this.
- k. Confirmation of understanding of the outside air ventilation criteria under all conditions.
- l. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).

- m. Method of checking building static and exhaust fan and/or relief damper capacity.
 - n. Proposed selection points for sound measurements and sound measurement methods.
 - o. Methods for making coil or other system plant capacity measurements, if specified.
 - p. Time schedule for TAB work to be done in phases (by floor, etc.).
 - q. Description of TAB work for areas to be built out later, if any.
 - r. Time schedule for deferred or seasonal TAB work, if specified.
 - s. False loading of systems to complete TAB work, if specified.
 - t. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.
 - u. Interstitial cavity differential pressure measurements and calculations, if specified.
 - v. Procedures for field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
 - w. Procedures for formal progress reports, including scope and frequency.
 - x. Procedures for formal deficiency reports, including scope, frequency and distribution.
- C. Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect, or could affect, the control system setup and operation.
- D. Progress Reports.
- E. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
- 1. Revise TAB plan to reflect actual procedures and submit as part of final report.
 - 2. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Engineer and for inclusion in operating and maintenance manuals.
 - 3. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
 - 4. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
 - 5. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.

6. Units of Measure: Report data in I-P (inch-pound) units only.
7. Include the following on the title page of each report:
 - a. Name of Testing, Adjusting, and Balancing Agency.
 - b. Address of Testing, Adjusting, and Balancing Agency.
 - c. Telephone number of Testing, Adjusting, and Balancing Agency.
 - d. Project name.
 - e. Project location.
 - f. Project Contractor.
 - g. Report date.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Perform total system balance in accordance with one of the following:
 1. AABC (NSTSB), AABC National Standards for Total System Balance.
 2. ASHRAE Std 111, Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.
 3. NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems.
 4. SMACNA (TAB).
 5. Maintain at least one copy of the standard to be used at project site at all times.
- B. This will be a phased project. TAB Agency shall begin work after completion of systems to be tested, adjusted, or balanced and shall complete work prior to Substantial Completion of the project or phase of the project.
- C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.
- D. TAB Agency Qualifications:
 1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
 2. Having minimum of five years documented documented experience.

3. Certified by one of the following:
 - a. AABC, Associated Air Balance Council: www.aabc.com/#sle; upon completion submit AABC National Performance Guaranty.
 - b. NEBB, National Environmental Balancing Bureau: www.nebb.org/#sle.
 - c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org/#sle.
- E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.2 EXAMINATION

- A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
 1. Systems are started and operating in a safe and normal condition.
 2. Temperature control systems are installed complete and operable.
 3. Proper thermal overload protection is in place for electrical equipment.
 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 5. Duct systems are clean of debris.
 6. Fans are rotating correctly.
 7. Fire and volume dampers are in place and open.
 8. Air coil fins are cleaned and combed.
 9. Access doors are closed and duct end caps are in place.
 10. Air outlets are installed and connected.
 11. Duct system leakage is minimized.
 12. Hydronic systems are flushed, filled, and vented.
 13. Pumps are rotating correctly.
 14. Proper strainer baskets are clean and in place.
 15. Service and balance valves are open.
- B. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

- A. Hold a pre-balancing meeting at least one week prior to starting TAB work.
 - 1. Require attendance by all installers whose work will be tested, adjusted, or balanced.
- B. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Engineer to facilitate spot checks during testing.
- C. Provide additional balancing devices as required.

3.4 ADJUSTMENT TOLERANCES

- A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.
- B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
- C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.5 RECORDING AND ADJUSTING

- A. Field Logs: Maintain written logs including:
 - 1. Running log of events and issues.
 - 2. Discrepancies, deficient or uncompleted work by others.
 - 3. Contract interpretation requests.
 - 4. Lists of completed tests.
- B. Ensure recorded data represents actual measured or observed conditions.
- C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- D. Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.
- E. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.6 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Measure air quantities at air inlets and outlets.
- D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- K. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.
- L. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.
- M. For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

3.7 WATER SYSTEM PROCEDURE

- A. Adjust water systems to provide required or design quantities.
- B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
- C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

- D. Effect system balance with automatic control valves fully open to heat transfer elements.
- E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
- F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.8 COMMISSIONING

- A. See Sections 01 91 13 - General Commissioning Requirements and 23 08 00 for additional requirements.
- B. Perform prerequisites prior to starting commissioning activities.
- C. Fill out Prefunctional Checklists for:
 - 1. Air side systems.
 - 2. Water side systems.
- D. Furnish to the Commissioning Authority, upon request, any data gathered but not shown in the final TAB report.
- E. Re-check minimum outdoor air intake flows and maximum and intermediate total airflow rates for 5 percent of the air handlers plus a random sample equivalent to 10 percent of the final TAB report data as directed by Commissioning Authority.
 - 1. Original TAB agency shall execute the re-checks, witnessed by the Commissioning Authority.
 - 2. Use the same test instruments as used in the original TAB work.
 - 3. Failure of more than 10 percent of the re-checked items of a given system shall result in the rejection of the system TAB report; rebalance the system, provide a new system TAB report, and repeat random re-checks.
 - 4. For purposes of re-check, failure is defined as follows:
 - a. Air Flow of Supply and Return: Deviation of more than 10 percent of instrument reading.
 - b. Minimum Outside Air Flow: Deviation of more than 20 percent of instrument reading; for inlet vane or VFD OSA compensation system using linear proportional control, deviation of more than 30 percent at intermediate supply flow.
 - c. Temperatures: Deviation of more than one degree F.
 - d. Air and Water Pressures: Deviation of more than 10 percent of full scale of test instrument reading.

- e. Sound Pressures: Deviation of more than 3 decibels, with consideration for variations in background noise.

F. In the presence of the Commissioning Authority, verify that:

1. Final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked.
2. The air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all terminal units taking off downstream of the static pressure sensor, the terminal unit on the critical leg has its damper 90 percent or more open.
3. The water system is being controlled to the lowest possible pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from the pump to the coil having all balancing valves wide open and that during full cooling the cooling coil valve of that leg is 90 percent or more open.

3.9 SCOPE

A. Test, adjust, and balance the following:

1. HVAC Pumps.
2. Condensing Boilers
3. Air Cooled Water Chillers.
4. Air Cooled Refrigerant Condensers.
5. Packaged Roof Top Heating/Cooling Units.
6. Packaged Terminal Air Conditioning Units.
7. Terminal Heat Transfer Units.
8. Air Handling Units.
9. Fans.
10. Air Filters.
11. Air Terminal Units.
12. Air Inlets and Outlets.

3.10 MINIMUM DATA TO BE REPORTED

A. Electric Motors:

1. Manufacturer.
2. Model/Frame.
3. HP/BHP.
4. Phase, voltage, amperage; nameplate, actual, no load.
5. RPM.
6. Service factor.
7. Starter size, rating, heater elements.
8. Sheave Make/Size/Bore.

B. V-Belt Drives:

1. Identification/location.
2. Required driven RPM.
3. Driven sheave, diameter and RPM.
4. Belt, size and quantity.
5. Motor sheave diameter and RPM.
6. Center to center distance, maximum, minimum, and actual.

C. Pumps:

1. Identification/number.
2. Manufacturer.
3. Size/model.
4. Impeller.
5. Service.
6. Design flow rate, pressure drop, BHP.
7. Actual flow rate, pressure drop, BHP.
8. Discharge pressure.
9. Suction pressure.

10. Total operating head pressure.
11. Shut off, discharge and suction pressures.
12. Shut off, total head pressure.

D. Combustion Equipment:

1. Boiler manufacturer.
2. Model number.
3. Serial number.
4. Gas flow rate.
5. Heat input.
6. Percent carbon monoxide (CO).
7. Flue gas temperature at outlet.
8. Ambient temperature.
9. Percent combustion efficiency.
10. Heat output.

E. Air Cooled Condensers:

1. Identification/number.
2. Location.
3. Manufacturer.
4. Model number.
5. Serial number.
6. Number of compressors.

F. Heat Exchangers:

1. Identification/number.
2. Location.
3. Service.
4. Manufacturer.
5. Model number.

6. Serial number.
7. Steam pressure, design and actual.
8. Primary water entering temperature, design and actual.
9. Primary water leaving temperature, design and actual.
10. Primary water flow, design and actual.
11. Primary water pressure drop, design and actual.
12. Secondary water leaving temperature, design and actual.
13. Secondary water leaving temperature, design and actual
14. Secondary water flow, design and actual.
15. Secondary water pressure drop, design and actual.

G. Air Moving Equipment:

1. Location.
2. Manufacturer.
3. Model number.
4. Serial number.
5. Arrangement/Class/Discharge.
6. Air flow, specified and actual.
7. Return air flow, specified and actual.
8. Outside air flow, specified and actual.
9. Total static pressure (total external), specified and actual.
10. Inlet pressure.
11. Discharge pressure.
12. Sheave Make/Size/Bore.
13. Number of Belts/Make/Size.
14. Fan RPM.

H. Exhaust Fans:

1. Location.

2. Manufacturer.
3. Model number.
4. Serial number.
5. Air flow, specified and actual.
6. Total static pressure (total external), specified and actual.
7. Inlet pressure.
8. Discharge pressure.
9. Sheave Make/Size/Bore.
10. Number of Belts/Make/Size.
11. Fan RPM.

I. Duct Traverses:

1. System zone/branch.
2. Duct size.
3. Area.
4. Design velocity.
5. Design air flow.
6. Test velocity.
7. Test air flow.
8. Duct static pressure.
9. Air temperature.
10. Air correction factor.

J. Air Monitoring Stations:

1. Identification/location.
2. System.
3. Size.
4. Area.
5. Design air flow.

6. Test velocity.

7. Test air flow.

K. Flow Measuring Stations:

1. Identification/number.

2. Location.

3. Size.

4. Manufacturer.

5. Model number.

6. Serial number.

7. Design Flow rate.

8. Design pressure drop.

9. Actual/final pressure drop.

10. Actual/final flow rate.

11. Station calibrated setting.

L. Terminal Unit Data:

1. Manufacturer.

2. Type, constant, variable, single, dual duct.

3. Identification/number.

4. Location.

5. Model number.

6. Size.

7. Minimum static pressure.

8. Minimum design air flow.

9. Maximum design air flow.

10. Maximum actual air flow.

11. Inlet static pressure.

M. Air Distribution Tests:

1. Air terminal number.
2. Room number/location.
3. Terminal type.
4. Terminal size.
5. Area factor.
6. Design velocity.
7. Design air flow.
8. Test (final) velocity.
9. Test (final) air flow.
10. Percent of design air flow.

END OF SECTION 23 05 93

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SECTION 23 07 13 - DUCT INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Duct insulation.
- B. Duct liner.
- C. Jacketing and accessories.
- D. Fire-rated Insulation Systems

1.3 RELATED REQUIREMENTS

- A. Section 23 3100 - HVAC Ducts and Casings: Metal and non-metal ducts.

1.4 REFERENCE STANDARDS

- A. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus 2021.
- B. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications 2013 (Reapproved 2019).
- C. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation 2014 (Reapproved 2019).
- D. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation 2020.
- E. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material) 2019.
- F. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials 2016.
- G. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials; National Fire Protection Association; 2006.
- H. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2020.
- I. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.5 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section, documented experience and approved by manufacturer and approved by manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.8 FIELD CONDITIONS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.2 GLASS FIBER, FLEXIBLE

- A. Manufacturer:
 - 1. Knauf Insulation: www.knaufusa.com.
 - 2. Johns Manville: www.jm.com/#sle.
 - 3. Owens Corning Corporation: www.ocbuildingspec.com/#sle.

4. Substitutions: See Section 01 60 00 - Product Requirements.
 - B. Insulation: ASTM C 553; flexible, formaldehyde-free, noncombustible blanket, Greenguard Certified.
 1. K value: 0.36 at 75 degrees F, when tested in accordance with ASTM C518.
 2. Maximum Water Vapor Absorption: 5.0 percent by weight.
 3. Density: 0.75 lb/cuft.
 4. Equal to Johns Manville Microlite XG.
 - C. Vapor Barrier Jacket:
 1. Kraft paper with glass fiber yarn and bonded to aluminized film.
 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 3. Secure with pressure-sensitive tape.
 - D. Vapor Barrier Tape:
 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film with pressure-sensitive rubber-based adhesive.
 - E. Tie Wire: Annealed steel, 16 gauge, 0.0508 inch diameter.
- 2.3 OUTDOOR DUCT INSULATION
- A. Closed cell expanded polystyrene foam insulation (minimum R-value of 12 per inch thickness) covered with self-adhering modified bitumen weather barrier.
- 2.4 DUCT LINER
- A. Insulation: Incombustible glass fiber complying with ASTM C 1071; GREENGUARD certified, flexible blanket; impregnated surface and edges coated with poly vinyl acetate polymer or acrylic polymer shown to be fungus and bacteria resistant by testing to ASTM G 21 and G22. Equal to Johns Manville Linacoustic RC.
 1. Apparent Thermal Conductivity: Maximum of 0.31 at 75 degrees F.
 2. Service Temperature: Up to 250 degrees F.
 3. Rated Velocity on Coated Air Side for Air Erosion: 6,000 fpm, minimum.
 4. Thickness: 1.5 inches.
 - B. Adhesive: Waterproof, fire-retardant type, ASTM C916.

- C. Liner Fasteners: Galvanized steel, self-adhesive pad or welded with integral head.
- D. Any internal liners shall be none porous type either elastomeric foam or film lined fiberglass.

2.5 FIRE-RATED INSULATION SYSTEMS

- A. Manufacturers
 - 1. Fyre Wrap: www.firewrap.com
 - 2. Fire Master Duct Wrap: www.thermalceramics.com
 - 3. Johns Manville; Firetemp-wrap: www.jm.com
- B. High temperature, flexible blanket insulation with FSK jacket, 1-1/2" thick, 6 pcf, tested and certified to provide a 1 hour fire rating and zero clearance to combustible material.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Test ductwork for design pressure prior to applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Insulated Ducts Conveying Air Below Ambient Temperature:
 - 1. Provide insulation with vapor barrier jackets.
 - 2. Finish with tape and vapor barrier jacket.
 - 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - 4. Insulate entire system, including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- D. Insulated Ducts Conveying Air Above Ambient Temperature:
 - 1. Provide with or without standard vapor barrier jacket.
 - 2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- E. External Duct Insulation Application:

1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
2. Secure insulation without vapor barrier with staples, tape, or wires.
3. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

F. Duct and Plenum Liner Application:

1. Adhere insulation with adhesive for 100 percent coverage.
2. Secure insulation with mechanical liner fasteners. Refer to SMACNA (DCS) for spacing.
3. Seal and smooth joints. Seal and coat transverse joints.
4. Seal liner surface penetrations with adhesive.
5. Duct dimensions indicated are net inside dimensions required for air-flow. Increase duct size to allow for insulation thickness.

3.3 DUCT INSULATION SCHEDULE

- A. Supply and Return Ducts: 2" (fiberglass - minimum installed R-6)
- B. DOAS & ERU Supply and Exhaust Ducts: 2" (fiberglass - minimum installed R-6)
- C. Exposed Ducts Within Space Served: 0"
- D. Supply and Return Ducts exposed to Outdoors: 2" (polystyrene - minimum installed R-12)
- E. Exhaust Fan Ducts: 0"
- F. Kitchen Hood Grease Duct: 1-1/2" (fire-rated insulation), two layers

END OF SECTION 23 07 13

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SECTION 23 07 16 - HVAC EQUIPMENT INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Equipment insulation.
- B. Jacketing and accessories.

1.3 RELATED REQUIREMENTS

- A. Section 23 05 53 - Identification for HVAC Piping and Equipment.
- B. Section 23 21 13 - Hydronic Piping: Placement of hangers and hanger inserts.
- C. Section 23 21 14 - Hydronic Specialties.

1.4 REFERENCE STANDARDS

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus 2019.
- B. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus 2021.
- C. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation 2017.
- D. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications 2013 (Reapproved 2019).
- E. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type) 2016.
- F. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation 2014 (Reapproved 2019).
- G. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials 2016.
- H. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials; National Fire Protection Association; 2006.
- I. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.5 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for equipment scheduled.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with not less than three years of documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.8 FIELD CONDITIONS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.2 GLASS FIBER, RIGID

- A. Manufacturer:
 - 1. Knauf Insulation: www.knaufusa.com.
 - 2. Johns Manville Corporation: www.jm.com.
 - 3. Owens Corning Corp: www.owenscorning.com/#sle.
 - 4. CertainTeed Corporation: www.certainteed.com.
 - 5. Substitutions: See Section 01 60 00 - Product Requirements.

- B. Insulation: ASTM C612 or ASTM C592; rigid, noncombustible.
 - 1. K Value: 0.25 at 75 degrees F, when tested in accordance with ASTM C177 or ASTM C518.
 - 2. Maximum Service Temperature: 1,200 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
 - 4. Maximum Density: 8.0 pcf.
- C. Vapor Barrier Jacket:
 - 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
 - 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 - 3. Secure with self-sealing longitudinal laps and butt strips.
- D. Facing: 1 inch galvanized steel hexagonal wire mesh stitched on one face of insulation.
- E. Vapor Barrier Lap Adhesive: Compatible with insulation.
 - 1. Compatible with insulation.
- F. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.
 - 1. ASTM C195; hydraulic setting on mineral wool.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that equipment has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Factory Insulated Equipment: Do not insulate.
- C. Exposed Equipment: Locate insulation and cover seams in least visible locations.
- D. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
- E. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.

- F. Insulated equipment containing fluids below ambient temperature; insulate entire system.
- G. Fiber glass insulated equipment containing fluids below ambient temperature; provide vapor barrier jackets, factory-applied or field-applied. Finish with glass cloth and vapor barrier adhesive.
- H. Fiber glass insulated equipment containing fluids above ambient temperature; provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Finish with glass cloth and adhesive.
- I. Inserts and Shields:
 - 1. Application: Equipment 1-1/2 inches diameter or larger.
 - 2. Shields: Galvanized steel between hangers and inserts.
 - 3. Insert Location: Between support shield and equipment and under the finish jacket.
 - 4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - 5. Insert Material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- J. Finish insulation at supports, protrusions, and interruptions.
- K. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.
- L. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.

3.3 SCHEDULE

- A. Heating Systems:
 - 1. Heat Exchangers/Converters:
 - 2. Air Separators: 2" Glass Fiber.
 - 3. Variable Volume Terminal Reheat Coils: 2" Glass Fiber.
 - 4. Expansion Tanks: 2" Glass Fiber.

END OF SECTION 23 07 16

SECTION 23 07 19 - HVAC PIPING INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Piping insulation.
- B. Flexible removable and reusable blanket insulation.
- C. Jacketing and accessories.

1.3 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.
- B. Section 23 21 13 - Hydronic Piping: Placement of hangers and hanger inserts.
- C. Section 23 23 00 - Refrigerant Piping: Placement of inserts.

1.4 REFERENCE STANDARDS

- A. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus 2019.
- B. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus 2019.
- C. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement 2007 (Reapproved 2019).
- D. ASTM C449 - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement 2007 (Reapproved 2019).
- E. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus 2021.
- F. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation 2017.
- G. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form 2020a.
- H. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation 2019.

- I. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel 2008 (Reapproved 2018).
- J. ASTM D610 - Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces 2008 (Reapproved 2019).
- K. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials 2016.

1.5 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.8 FIELD CONDITIONS

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.2 GLASS FIBER, RIGID

- A. Manufacturers:
 - 1. Knauf Insulation: www.knaufusa.com.
 - 2. Johns Manville Corporation: www.jm.com.
 - 3. Owens Corning Corp: www.owenscorning.com.

4. CertainTeed Corporation: www.certainteed.com.
 - B. Insulation: ASTM C 547 and ASTM C 795; rigid molded, noncombustible, GREENGUARD certified.
 1. K Value: ASTM C177, 0.24 at 75 degrees F.
 2. Maximum Service Temperature: 850 degrees F.
 3. Maximum Moisture Absorption: 0.2 percent by volume.
 4. Equal to Johns Manville Micro-Lok HP.
 - C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.
 - D. Vapor Barrier Lap Adhesive/Mastic:
 1. Compatible with insulation.
- 2.3 FLEXIBLE ELASTOMERIC CELLULAR INSULATION
- A. Manufacturers:
 1. Aeroflex USA, Inc; Aerocel Stay-Seal with Protape (SSPT): www.aeroflexusa.com/#sle.
 2. Armacell LLC; ArmaFlex Ultra with FlameDefense: www.armacell.us/#sle.
 3. K-Flex USA LLC; K-Flex Titan: www.kflexusa.com/#sle.
 4. Substitutions: See Section 01 60 00 - Product Requirements.
 - B. Insulation: Closed cell flexible elastomeric pipe (tube) insulation complying with ASTM C 534 Type I, tubular Grade 1, GREENGUARD certified
 1. Minimum Service Temperature: -297 degrees F.
 2. Maximum Service Temperature: +220 degrees F.
 3. Connection: Waterproof vapor barrier adhesive.
 4. Equal to AP Armaflex.
 - C. Elastomeric Foam Adhesive: Air dried, Low V.O.C. contact adhesive, compatible with insulation equal to Armaflex 520 BLV.
 - D. For insulation thickness greater than 1", provide two layers of insulation in accordance with manufacturer's recommendations for multi-layering.
 - E. For insulation exposed to weather, apply Armaflex WB finish.

2.4 JACKETING AND ACCESSORIES

A. PVC Plastic.

1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
 - a. Minimum Service Temperature: 0 degrees F.
 - b. Maximum Service Temperature: 150 degrees F.
 - c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
 - d. Thickness: 10 mil, 0.010 inch.
 - e. Connections: Brush on welding adhesive.
 - f. Equal to Johns Manville Zeston 2000.
2. Covering Adhesive Mastic: Compatible with insulation.
 - a. Compatible with insulation.

2.5 ACCESSORIES

A. General Requirements:

1. Provide required accessories in accordance with and subject to the recommendations of the insulation manufacturer.
2. Furnish compatible materials which do not contribute to corrosion, soften, or otherwise attack surfaces to which applied, in either the wet or dry state.
3. Comply with ASTM C795 requirements for materials to be used on stainless steel surfaces.
4. Supply materials that are asbestos free.

B. Corrosion Inhibitors:

1. Corrosion Control Gel:
 - a. Corrosion Protection: Comply with ASTM B117 and ASTM D610.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Test piping for design pressure, liquid tightness, and continuity prior to applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Exposed Piping: Locate insulation and cover seams in least visible locations.
- D. Pipes conveying fluids below ambient temperature: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- E. Glass Fiber Insulated Pipes Conveying Fluids Below Ambient Temperature:
 - 1. Provide vapor barrier jackets, factory-applied or field-applied; secure with self-sealing longitudinal laps and butt strips with pressure-sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
 - 2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor barrier adhesive or PVC fitting covers.
- F. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- G. Glass Fiber Insulated Pipes Conveying Fluids Above Ambient Temperature:
 - 1. Provide standard jackets, with or without vapor barrier, factory-applied, or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure-sensitive adhesive. Secure with outward clinch expanding staples.
 - 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
- H. Inserts and Shields:
 - 1. Application: Piping 1-1/2 inches diameter or larger.
 - 2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - 3. Insert location: Between support shield and piping and under the finish jacket.
 - 4. Insert configuration: Minimum 12 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - 5. Insert Material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- I. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, see Section 07 84 00.
- J. Exterior Applications: Provide two coats of UV resistant finish for flexible elastomeric cellular insulation without jacketing.

3.3 SCHEDULE

A. Heating Systems:

1. Heating Water/Glycol Supply and Return (Glass Fiber Insulation):
 - a. 1-1/2" pipe size or less: 1-1/2" insulation thickness
 - b. 2" pipe size or larger: 2" insulation thickness

B. Cooling Systems (Flexible Elastomeric Cellular Insulation):

1. Condensate Drains from Cooling Coils:
 - a. 1/2" insulation thickness
2. Refrigerant Low Pressure Vapor (+40 degrees F to +90 degrees F)
 - a. 1-1/2" pipe size or less: 1" insulation thickness
3. Refrigerant High Pressure Vapor (+95 degrees F to +220 degrees F)
 - a. 1-1/2" pipe size or less: 1-1/2" insulation thickness
4. Refrigerant Liquid (+75 degrees F ambient to +118 degrees F ambient):
 - a. 1-1/2" pipe size or less: 1" insulation thickness

END OF SECTION 23 07 19

SECTION 230800 - COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SUMMARY

- A. This section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements.
- C. In addition, provide the following:
 - 1. Certificates of readiness
 - 2. Certificates of completion of installation, prestart, and startup activities.
 - 3. O&M manuals
 - 4. Test reports
- D. Control Drawings Submittal
 - 1. The control drawings shall have a key to all abbreviations.

2. The control drawings shall contain graphic schematic depictions of the systems and each component.
3. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
4. Provide a full points list with at least the following included for each point:
 - a. Controlled system
 - b. Point abbreviation
 - c. Point description
 - d. Display unit
 - e. Control point or set point
 - f. Monitoring point
 - g. Intermediate point
 - h. Calculated point

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC&R system and controls system in Division 23, except for equipment specific to and used by TAB in their commissioning responsibilities. A sufficient quantity of two-way radios shall be provided by each subcontractor.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in

the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

- D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.
- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems
- B. Red-lined Drawings:
 - 1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
 - 2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
 - 3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
 - 4. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. Operation and Maintenance Data:
 - 1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
 - 2. The CxA will review the O&M literature once for conformance to project requirements.
 - 3. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.
- D. Demonstration and Training:
 - 1. Contractor will provide demonstration and training as required by the specifications.
 - 2. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training.
 - 3. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.

4. The CxA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CxA and Owner's representative. A copy of the test record shall be provided to the CxA, Owner, and Architect.
 5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
 6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
 7. Review data in O&M Manuals.
- E. Systems manual requirements:
1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.
 2. The GC shall include final approved versions of the following information for the Systems Manual:
 - a. As-Built System Schematics
 - b. Verified Record Drawings
 - c. Test Results (not otherwise included in Cx Record)
 - d. Periodic Maintenance Information for computer maintenance management system
 - e. Recommendations for recalibration frequency of sensors and actuators
 - f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
 - g. Training Records, Information on training provided, attendees list, and any on-going training
 3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.
 4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors of Division 23 are as follows (all references apply to commissioned equipment only):
- B. Perform commissioning tests at the direction of the CxA.
- C. Attend construction phase controls coordination meetings.
- D. Attend testing, adjusting, and balancing review and coordination meetings.
- E. Participate in HVAC&R 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. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- H. Prepare preliminary schedule for Mechanical system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.
- I. Update schedule as required throughout the construction period.
- J. During the startup and initial checkout process, execute the related portions of the prefunctional checklists for all commissioned equipment.
- K. Assist the CxA in all verification and functional performance tests.
- 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. Gather operation and maintenance literature on all equipment and assemble in binders as required by the specifications. Submit to CxA (45) days after submittal acceptance.
- N. Coordinate with the CxA to provide (48) hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- O. Notify the CxA a minimum of (2) weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.
- P. Participate in, and schedule vendors and contractors to participate in the training sessions.
- Q. Provide written notification to the CM/GC and CxA Authority that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 - 1. HVAC&R equipment including all fans, air handling units, ductwork, dampers, terminals, and all other equipment furnished under this Division.
 - 2. Fire stopping in the fire rated construction, including fire and smoke damper installation, caulking, gasketing and sealing of smoke barriers.
 - 3. Fire detection and smoke detection devices furnished under other divisions of the specification.
- R. The equipment supplier shall document the performance of his equipment.
- S. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- T. Test, Adjust and Balance Contractor
 - 1. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.

2. Submit the site-specific testing and balancing plan to the CxA and AE for review and acceptance.
 3. Attend the testing and balancing review meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in testing, adjusting, and balancing the HVAC&R system.
 4. At the completion of the testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R contractor and the CM/GC.
 5. At the completion of testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R Contractor and the CM/GC.
 6. Participate in verification of the testing and balancing report, which will consist of repeating measurements contained in the testing and balancing reports. Assist in diagnostic purposes when directed.
- U. Provide training of the Owner's operating staff using expert qualified personnel, as specified.
- V. Equipment Suppliers
1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 2. Assist in equipment testing per agreements with contractors.
 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- W. Refer to Division 01 Section "General Commissioning Requirements" for additional contractor responsibilities.

3.3 OWNER'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Design Professional's Responsibilities.

3.5 CxA'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

3.6 TESTING PREPARATION

- A. Certify in writing to the CxA that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

- B. Certify in writing to the CxA that HVAC&R 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 in writing that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Place 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 identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 TESTING, ADJUSTING AND BALANCING VERIFICATION

- A. Prior to performance of Testing, Adjusting and balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- B. Notify the CxA at least ten (10) days in advance of testing and balancing Work and provide access for the CxA to witness testing and balancing Work.
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.
 - 1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
 - 2. The testing and balancing 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.

3.8 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

- B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.
- 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 HVAC&R contractor, testing and balancing Subcontractor, and HVAC&R Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. 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.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. 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.
- I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.9 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 23 sections. Provide submittals, test data, inspector record, and certifications to the CxA.
- B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in *Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."* Assist the CxA with preparation of testing plans.
- C. Pipe system cleaning, flushing, hydrostatic tests and chemical treatment: Test requirements are specified in Division 23 piping Sections. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 2. Description of equipment for flushing operations.
 3. Minimum flushing water velocity.
 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
- D. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, 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.
- E. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.
- F. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.
- G. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. Air Coil
2. Air Cooled Condensing Unit
3. Air Handling Unit
4. Air Handling Unit – Ventilation
5. Air Terminal
6. Blower Coil Unit
7. Boiler
8. Building Automation System
9. Cabinet Unit Heater
10. Chemical Treatment
11. Computer Room AC
12. Ductwork
13. Exhaust Fan
14. Fan
15. Fan Powered Box
16. Finned Tube Radiation
17. Fire and Smoke Damper
18. Fume Hood
19. Glycol Make-up System
20. Heat Exchanger
21. Hot Water System
22. Piping
23. Pump

24. Roof Top Unit
25. Self Contained AC Unit
26. Terminal Box
27. Terminal Unit
28. Testing, Adjusting and Balancing
29. VAV Terminal Unit/Box
30. VFD
31. Water Treatment

1. Boiler - B-1, B-2, B-3
2. Cabinet Unit Heater – CUH-ABC
3. DOAS -1 & DOAS-2
4. Electric Unit Heater – EUH & EUH-A
5. Exhaust Fan – Kitchen – KEF-1
6. Pump – P1A/B
7. Radon Exhaust Fan – REF-1 & REF-2
8. Rooftop Unit - Café
9. Rooftop Unit - Gym
10. Split System AC Unit - AC-1-1, 1-2, 2-1, & 2-2
11. Split System Outdoor Unit - CU-1-1, 1-2, 2-1, & 2-2
12. Unit Heater – UH-A
13. VRF Indoor – VRF- A,B,C,D,E,F,G,H
14. VRF Outdoor – CU-1,2,3,4,5,6,7

3.10 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.11 APPROVAL

- A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.12 DEFERRED TESTING

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.13 OPERATION AND MAINTENANCE MANUALS

- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

- B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.
- C. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.

3.14 TRAINING OF OWNER PERSONNEL

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.
- B. Mechanical Contractor. The mechanical contractor shall have the following training responsibilities:
 - 1. Provide the CxA with a training plan two weeks before the planned training.
 - 2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, all HVAC equipment (ex. pumps, heat exchangers, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, etc.)
 - 3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
 - 4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
 - 5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
 - 6. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
 - 7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
 - 8. Training shall include:
 - a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
 - b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts

- inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
- c. Discussion of relevant health and safety issues and concerns.
 - d. Discussion of warranties and guarantees.
 - e. Common troubleshooting problems and solutions.
 - f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
 - g. Discussion of any peculiarities of equipment installation or operation.
 - h. The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1-2007, is recommended.
9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
 10. The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
 11. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.
- C. Controls Contractor. The controls contractor shall have the following training responsibilities:
1. Provide the CxA and AE with a training plan four weeks before the planned training.
 2. The controls contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.
 3. Training manuals. The standard operating manual for the system and any special training manuals will be provided for each trainee, with three extra copies left for the O&M manuals. In addition, copies of the system technical manual will be demonstrated during training and three copies submitted with the O&M manuals. Manuals shall include detailed description of the subject matter for each session. The manuals will cover all control sequences and have a definitions section that fully describes all relevant words used in the manuals and in all software displays. Manuals will be approved by the CxA and AE. Copies of audiovisuals shall be delivered to the Owner.
 4. The trainings will be tailored to the needs and skill-level of the trainees.
 5. The trainers will be knowledgeable on the system and its use in buildings. For the on-site sessions, the most qualified trainer(s) will be used. The Owner shall approve the instructor prior to scheduling the training.
 6. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
 7. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

8. There shall be three (3) training sessions:
 - a. Training I. Control System. The first training shall consist of 8 hours of actual training. This training may be held on-site or in the supplier's facility. If held off-site, the training may occur prior to final completion of the system installation. Upon completion, each student, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
 - b. Training II. Building Systems. The second session shall be held on-site for a period of 8 hours of actual hands-on training after the completion of system commissioning. The session shall include instruction on:
 - 1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls and any interface with security and communication systems.
 - 2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing set points and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
 - 3) All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.
 - 4) Every screen shall be completely discussed, allowing time for questions.
 - 5) Use of keypad or plug-in laptop computer at the zone level.
 - 6) Use of remote access to the system via phone lines or networks.
 - 7) Setting up and changing an air terminal unit controller.
 - 8) Graphics generation
 - 9) Point database entry and modifications
 - 10) Understanding DDC field panel operating programming (when applicable)
 - c. Training III. The third training will be conducted on-site six months after occupancy and consist of 8 hours of training. The session will be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the system.

D. TAB. The TAB contractor shall have the following training responsibilities:

1. TAB shall meet for 4 hours with facility staff after completion of TAB and instruct them on the following:

- a. Go over the final TAB report, explaining the layout and meanings of each data type.
- b. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
- c. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
- d. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
- e. Other salient information that may be useful for facility operations, relative to TAB.

END OF SECTION 23 08 00

SECTION 23 09 00 - DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Building Management System (BMS), utilizing direct digital controls.

1.3 RELATED WORK SPECIFIED ELSEWHERE

- A. Products Supplied But Not Installed Under This Section:
 - 1. Control valves.
 - 2. Flow switches.
 - 3. Wells, sockets and other inline hardware for water sensors (temperature, pressure, flow).
- B. Work Required Under Other Divisions Related to This Section:
 - 1. Power wiring to line side of motor starters, disconnects or variable frequency drives.
 - 2. Provision and wiring of smoke detectors and other devices relating to fire alarm system.
 - 3. Campus LAN (Ethernet) connection adjacent to JACE network management controller.

1.4 RELATED SECTIONS

- A. Section 23 05 00 - Basic Mechanical Materials and Methods: Performance and reference standards for products and materials required for the Project.

1.5 SYSTEM DESCRIPTION

- A. This project requires the installation of a new Integrated Automation System constructed using with BACnet Field Level Devices.
- B. The Contractor will be required to perform the following:
 - 1. Furnish, install, configure and commission a new Niagara Framework with BACnet fully programmable and application specific DDC controllers for the equipment shown including all components, software and applications required to meet the sequence of operation and the design/performance intent of the systems.
 - 2. Provide fully programmable field controllers as specified herein and as indicated on the drawings. Provide I/O and ancillary devices as specified herein, as indicated on the

drawings, and as necessary to perform the sequences of operation.

3. Application Specific or "Configurable" controllers will not be accepted.
4. Provide BACnet BTL AWS (Advanced Work Station) certification for the Control System Server (CSS). All Network Controllers (NCs) shall be BTL BBC certified.
5. Furnish and install all low voltage step-down transformers with associated low voltage connections, power supplies and power/communication/input/output cabling necessary for the control system.
6. Furnish and install conduit, junction boxes, fittings, panels, enclosures, and hardware as specified in these specifications, on the drawings and as required by Code.
7. Provide Graphical User Interface Development for all of the devices identified above.
8. It is the contractor's responsibility to review all of the design documents and specifications and report any discrepancies to the owner.

1.6 SUBMITTALS

- A. Submit under provisions of Section 01 30 00.
- B. Product Data: Manufacturer's data sheets on each product to be used, including:
 1. Preparation instructions and recommendations.
 2. Storage and handling requirements and recommendations.
 3. Installation methods.
- C. Submit documentation of contractor qualifications, including those indicated in "Quality Assurance" if requested by the A-E.
- D. 4 copies of shop drawings of the entire control system shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers' catalog data sheets and installation instructions. Submit in printed electronic format. Samples of written Controller Checkout Sheets and Performance Verification Procedures for applications similar in scope shall be included for approval.
- E. Shop drawings shall also contain complete wiring and schematic diagrams, sequences of operation, control system bus layout and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.
- F. Upon completion of the work, provide x complete sets of 'as-built' drawings and other project-specific documentation in 3-ring hard-backed binders and on Flash media.
- G. Any deviations from these specifications or the work indicated on the drawings shall be clearly identified in the Submittals.

1.7 QUALITY ASSURANCE

- A. The Control System Contractor shall have a full service DDC office within 50 miles of the job site. This office shall be staffed with sales engineering and support, applications engineers, software engineers and field technicians. This office shall maintain parts inventory and shall have all testing and diagnostic equipment necessary to support this work, as well as staff trained in the use of this equipment. BMS vendors that do not utilize local engineering and sales support personnel for this project in a branch office within 50 miles of the jobsite shall not be acceptable under any circumstances.
- B. Single Source Responsibility of Supplier: The Control System Contractor shall be responsible for the complete installation and proper operation of the control system. The Control System Contractor shall exclusively be in the regular and customary business of design, installation and service of computerized building management systems similar in size and complexity to the system specified. The Control System Contractor shall be the manufacturer of the primary DDC system components or shall have been the authorized representative for the primary DDC components manufacturer for at least 5 years.
- C. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in the production and installation of HVAC control systems. Products shall be manufacturer's latest standard design and have been tested and proven in actual use.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Maintain integrity of shipping cartons for each piece of equipment and control device through shipping, storage and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.9 JOB CONDITIONS

- A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers and structural and architectural features.

1.10 SEQUENCING

- A. Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress.

PART 1 PRODUCTS

2.1 MANUFACTURERS

- A. Base Bid: Alerton provided by Automated Building Systems – Glastonbury – Drew Appleton (860) 657-9257 or dappleton@absddc.com

2.2 ALTERNATE ADD /DEDUCT BY ONE OF THE FOLLOWING:

- A. Shneider Electric by ESC.....Add/Deduct \$ _____
- B. Schneider Electric by SNE Building Systems..... Add /Deduct \$ _____
- C. Substitutions: Not permitted.

2.3 GENERAL

- A. The Building Management System (BMS) shall be comprised of a network of interoperable, stand-alone digital controllers, a network area controller, graphics and programming and other control devices for a complete system as specified herein.
- B. The installed system shall provide secure password access to all features, functions and data contained in the overall BMS.

2.4 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURE

- A. The system provided shall incorporate hardware and software resources sufficient to meet the functional requirements of these Specifications. The Facility Local Area Network (FAC LAN) and Device Level Network (DLN) shall be based on industry standard open platforms as specified herein and utilize commonly available operation, management and application software. All software packages and databases shall be licensed to the Owner to allow unrestricted maintenance and operation of the IAS. Contractor shall include all items not specifically itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these Specifications.
- B. The system architecture shall implement a new building IAS Framework and consists of an Ethernet-based, wide area network (WAN), a single Local Area Network (LAN) that supports NCs, PCUs, ASCs, Operator Workstations (OWS), Smart Devices (SD), and Remote Communication Devices (RCDs) as applicable.
- C. Facility Local Area Network (FAC LAN): The FAC LAN shall be an Ethernet-based, 10/100/1000 Ethernet LAN connecting Local NCs, IAS Server and OWSs. The FAC LAN serves as the backbone for the NCs communications path. Contractor shall provide a FAC LAN as a dedicated LAN for the control system. LAN shall be IEEE 802.3 Ethernet over Fiber or Category 6 cable with switches and routers that support 1000base-T gigabit Ethernet throughput.
- D. Device Level Network (DLN): Network used to connect PCUs and ASCs. These shall be Peer to Peer devices as defined in the BTL standard. Network speed shall be 78K bits per second.
- E. ARCnet and/or Token-Ring based FAC LANs and DLNs shall not be acceptable.
- F. Remote Data Access: The system shall support the Internet Browser-based remote access to the building data. The IAS contractor shall coordinate with the Owner's IT department to insure all remote browser access (if desired by the owner) is protected with the latest Software updates and a VPN (Virtual Private Network) must be installed to protect the owner's network from

cyber attacks.

- G. Browser-based access: A remote/local user using a standard browser will be able access all control system facilities and graphics via the WAN or direct connection, with proper username and password. Only native Internet browser-based user interfaces (HTML5 , XML, CCS3, etc.) that do not require plug-ins (thin clients) are acceptable. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™, Firefox™ or Chrome™.
- H. The communication speed between the controllers, LAN interface devices, CSS, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition.
- I. Systems Configuration Database: The system architecture shall support maintaining the systems configuration database on a server that resides on the FAC LAN. User tools for DLN and FAC LAN management shall be provided and licensed to the Owner and shall allow unrestricted configuring, updating, maintaining, and expanding of all current devices, configurations and settings.
- J. Database Schema shall be published and provided to the Owner to facilitate easy access to DLN and FAC LAN data.

2.5 OPERATOR WORKSTATION (COMPASS)

- A. Structure of Workstation Interaction: Client/server relationship. Embedded web server for browser access. Server to archive data and store system. Operator Workstations to support operation. Virtualized server environment. Web clients may access archive server data.
 - 1. Single Server License Shall:
 - a. Maximum Devices to be Connected: 3000.
 - b. Maximum Devices to be Connected: As indicated on Drawings.
 - c. Not restrict system size based on point count (BACnet or Integration).
- B. Operator Workstation: General purpose, commercially available, personal computer.
 - 1. Processor: Minimum speed of 2.5 GHz.
 - a. Quad core processor.
 - b. Eight core processor.
 - c. Processor core as indicated on Drawings.
 - d. RAM: 4 GB.
 - e. RAM: 16 GB.

- f. RAM: As indicated on Drawings.
 - g. Hard Drive: Minimum of 1 TB.
 - h. Network Interface Card: 10 Mbs.
 - i. Network Interface Card: 100 Mbs.
 - j. Network Interface Card: 1000 Mbs.
 - k. Provide more memory and/or a faster processor if necessary to perform the functions described in this specification.
- C. Sufficient storage to accommodate fully configured point databases, application databases, graphics files, user-defined reports, and historical data archived as specified.
- D. Graphic Based Displays: For each system.
 - 1. Operator Workstation: Point data for each system. Update every 30 seconds.
 - 2. Dynamically update data any action by user.
 - 3. Graphic Displays: Iconic graphic representations of mechanical equipment. Display graphic files, text, trendlog, and dynamic object data displays including animation.
 - 4. Graphic Displays: "Drill Down" capability from main display to more specific system displays or navigation tree for building equipment and system diagnostic centric display organization.
 - a. Tree Navigation Contents: Customizable per-user and per-group basis.
 - 5. Systems with Terminal Unit Controls: Building floor plan with dynamic temperatures, drillable for more specific terminal information.
 - 6. Points on graphics allow user to change field-resident Operator Workstation functions associated with project, including setpoints, weekly and exception schedules, from any screen, whether screen shows text or graphic display. Do without reference to object addresses or other numeric/mnemonic indications.
 - 7. Protect display views unless operator credentials have proper access level. Assign access levels to each display/system object. Menu labels not to appear on graphic if operator does not have appropriate security level.
 - 8. Analog objects: Displayed with operator modifiable units. Input objects may be displayed as graphic items on display screen as an overlay to the system graphic.
 - 9. Information: Labeled with descriptors and shown with appropriate engineering units.
 - 10. DDCs system must provide graphic displays and files. Systems requiring graphics development or logic programming are prohibited. Graphic Files: JPG, GIF or PNG.

11. Submit graphic displays to Owner for review and approval. Approved graphics to be in place prior to commissioning.
 12. Operator Workstation: Supply graphics library, to use unaltered or modified. Include library to assemble custom graphics. System to allow creation of new graphics.
 13. Data Displays: Ability to link to content outside of BAS system. Content to include, but not limited to launching external files in their native applications.
- E. Omnigraphics: Graphics with custom geometry offering color gradient shading and variable opacity in scale to system variables; analog and digital, and color range settings.
1. Omnigraphics Must Support:
 - a. Displaying current values in the geometric shapes.
 - b. Geometric shapes to be clickable allowing another graphic display.
 - c. Color Scale: Support using AV's to define the color scale ranges.
- F. The Operator Interface: Support the following functions.
1. Mouse-over tooltip information of graphic items or data points; can be turned off.
 2. Right click capability to access system functionality such as Schedule, Trendlogs, and Alarms associated with display object selected.
 3. Automatic zooming to screen size to maximize display to display area. Can be enabled or disabled. Background color, flood fills remaining screen background.
 4. Support user configurable embedded Data Viewer for a persistent trend log data view to accompany system data and graphic information on a single display.
- G. Password Protection: Preventing unauthorized use unless operator is logged on.
1. Limits operator to assigned functions when logged on. Includes displays as outlined.
 2. Users: Individual User IDs, User Names, and Passwords. Case sensitive alphanumeric character entry except for User ID. User ID, User Name, and Password will enforce minimum of 8 characters and stored in encrypted format.
 3. Each user to be allowed individual assignment of control functions, menu items, navigation tree, and user-specific system start display, and restricted access to discrete BACnet devices to which user requires access.
 4. Passwords, user names, and access assignments: Adjustable via Compass. Password adjustable via web client.
 5. Users to have set access levels, which define access to displays and individual objects user may control. System to have 10 distinct access levels for assignment.

6. Operator Workstation and Web Client: Auto logout feature when no keyboard or mouse activity is detected for time period, adjustable by system administrator. Enabled and disabled by system administrator. Screen message notifying log out.
 7. Permit effective date range, and effective time of day, User are permitted access.
 8. Operator Workstation: Support LDAP integration enforcing strong password policies.
- H. Operator Activity Log: Tracks operator changes and activities.
1. Included in Operator Workstation. A log of what changed, who made the change, date and time of system activity, and value of change before and after. Operator may display activity, sort changes by user or operation and print Operator Activity Log.
 2. Activity log to be gathered and archived to MSDB as needed. Log to be able to exportable for spreadsheet display and sorting.
 3. User option to record commenting in Operator Activity Log upon system point change.
 4. Accessible via Web Client for viewing, sorting, filtering, and printing.
- I. Scheduling:
1. Information to be in easy-to-read daily format including calendar of this month and next. Schedules to show actual ON/OFF times for day based on scheduling priority. Priority for Scheduling: Events, holidays and daily, with events being the highest.
 2. Holiday and Special Event Schedules: Display data in calendar format. Be able to schedule holidays and special events directly from these calendars.
 3. Operator to be able to change information for a given weekly or exception schedule if logged on with appropriate access privileges.
 4. Schedule Wizard for schedules set up. Walks user through schedule generation. Have its own pull-down selection for startup or may be started by right-clicking on value displayed on graphic and then selecting Schedule.
 5. Scheduling: Include optimum start based on outside air temperature, current heating/cooling setpoints, indoor temperature and previous starts history. Individual zones to have optimum start time calculated based on parameters listed. Operators to input schedules to set time that occupied setpoint is to be attained. Optimum start feature must calculate the startup time needed to match zone temperature to setpoint. Operators to be able to set a limit for maximum startup time allowed.
 6. List show currently defined schedules. Includes standard, holiday and event schedules. User to be able to select a list showing scheduled points and zones.
 7. Display of schedules must show ON times for standard, holiday and event schedules in different colors on a given day. OFF times must also be shown in additional colors.

Operators may select from a calendar what days are to be scheduled and show points and zones affected. Operators may set time for one day and then match it to days of the week to be affected as a recurrence of same schedule.

8. Any displayed data that is changeable by operator may be selected using the right mouse button and schedule selectable on screen. Selection of schedule using this method allows viewing of assigned schedule and allows the point to be scheduled.
9. Schedule Support Functions: Drag-n-drop events and holidays on schedule calendar.
 - a. Drag-n-drop events default to two-hour period; can operator adjusted.
 - b. Drag-n-drop holidays default for OFF all day; edit for multiple-day holidays.
 - c. View affected zones when adding or editing timed events of a schedule.
10. Web Client: A search list of scheduled points and zones to access schedule calendar.
11. Schedule Time Blocks: Present schedule detail via mouse-over information.

J. Advanced Scheduling:

1. Each resource shall have its own unique schedule object.
2. Both analog and binary points shall be scheduled.
3. Holiday schedules shall support perpetual holidays
4. Calendar Events Set to be Reoccurring Events: Daily, weekly, monthly and annually as well as a non-pattern occurrence by selecting groups of days so they can be edited on one occurrence.

K. Alarm Indication and Handling: Visual, printed, and email means of alarm indication.

1. Printout of Alarms: Sent to assigned terminal and port. May be filtered based on User ID's authorization level.
2. Web Client: Display persistent alarm state for system regardless of data view including points in alarm but not acknowledged, and points that have gone into alarm and returned to normal without being acknowledged.
3. Recorded and archive at the Operator Workstation:
 - a. Description of event and equipment initiating alarm. 256 characters in length.
 - b. Time and date of alarm occurrence.
 - c. Time and date of object state return to normal.
 - d. Time and date of alarm acknowledgment

- e. Identification of operator acknowledging alarm.
- 4. Alarm messages: User-definable text, English or other specified language, and delivered to operator's terminal, client, or remote communication using email; authenticated SMTP supported.
- 5. Allow for set up of alarms. User interface will walk user through steps necessary.
- 6. Alarm annunciation includes navigation link to a user-selected display or URL.
- 7. Displayed data changeable by operator is right mouse button selectable. Alarm is then selectable on screen allowing view of alarm history or allow new alarm creation.
- L. Trendlog Information: Display trendlog records in standard engineering units.
 - 1. Periodically gather data stored in building controllers and store information in system database. Append stored records with new data. Overwriting records is not allowed unless file size is limited. System database capable of storing 50 million records before archiving data. Samples viewable at Web Client.
 - a. Capable of trending on interval determined by polling rate, or change-of-value.
 - 2. Add and edit trendlogs and setup information including the following:
 - a. The interval at which it is to be logged.
 - b. Operations shall be password protected.
 - c. Accessed directly from graphics on which a trended object is displayed.
 - 3. Trendlog Wizard: Setup of multiple trend logs simultaneously. Walk users through necessary steps. Have a pull-down selection for startup, or by right-clicking on value displayed on graphic, and then selecting Trendlogs from displayed menu.
 - 4. Trendlog Data: Viewable on Datalogger accessible via Web Browser. Trend logs of any point on a graphic must be initiated by performing a right mouse click on the point.
- M. DataViewer access via Web Browser: Capable of graphing trend-logged object data.
 - 1. Access and ability to create, edit and view are restricted by user account credentials
 - 2. Specific and repeatable URL defines trendlog views for browser bookmarking and email compatibility.
 - 3. Call out of trendlog value at intersection of trend line and mouse-over vertical axis.
 - 4. Trendlog or Energy log and companion logs configurable to display on one of two independent vertical scales embedded in display.
 - 5. Click zoom for control of data set viewed along either graph axis.

6. User-specifiable start and end dates and fast scroll features supporting click zoom of macro scale view of data for quickly finding data set based on visual signature.
 7. User export of the viewed data set to MS Excel.
 8. Optional min/max ranges (Upper Control Limits, Lower Control Limits) for each value.
- N. Energy Log Information: Display information in standard engineering units.
1. Periodically gather energy log data in field controller and archive information. Append files with new data. Overwriting archived data is not allowed unless file size is limited.
 2. Store data in database format for use by third-party programs. System operation to stay online during graphing operations.
 3. Operators to be able to change energy log setup information. Includes meters, meter pulse value, and type of energy units. Meters monitored by system may be logged. Support using flow and temperature sensors for BTU monitoring.
 4. Web Client: Display data in tabular and graphical formats. Display in hourly, daily, weekly, monthly and yearly formats. Be able to select specific data periods to view.
- O. Demand Limiting: Sheds and restores equipment based on energy usage when compared to shed and restore settings.
1. Shedding: Implemented independently on each zone or piece of system equipment.
 2. Binary Shedding: 5 priority levels. Loads in a given priority level to be shed before any loads in a higher priority level are shed. Load shedding within a given priority level includes two methods; a "first off-first on" mode, and a "first off-last on" linear mode.
 3. Analog Shedding: Program generated ramp used by individual zones or control algorithm to raise and lower cooling and heating settings reducing energy usage.
 4. Status of each program to be displayed with description of each load on Web Client.
- P. Tenant Activity: A program monitoring after-hours overrides by tenants, logs data, and generates bill based on usage and rate charged for each tenant space.
1. Tenant after-hours override usage is logged in Operator Workstation database.
 2. Include entry of following information for use in logging and billing.
 - a. Tenant's contact name and address.
 - b. One or multiple tenant zones making up a total tenant space, including separate billing rate for each separate zone.
 - c. Minimum and maximum values an event duration and event limit.
 - d. Property management information.

- e. Overall billing rate.
 - f. Seasonal adjustments or surcharge to billing rate.
 - g. Billing notification type including, but not limited to printer, file and email.
 - h. Billing form template.
3. Logging: Include recording the following information for each and every tenant event.
- a. Zone description.
 - b. Time the event begins.
 - c. Total override time.
 - d. Limits shall be applied to override time.
4. A Tenant Bill: Generated for a specific period using entered configuration data and logged data. User with appropriate security level will be able to view and override billing information. User to be able to select a billing period to view and be able to delete events from billing and edit a selected tenant activity event's override time.
- Q. Reports: Capable of producing the following reports. Deliverable Format: CSV.
- 1. Trendlog configurations.
 - 2. Alarm configurations.
 - 3. Tenant activity configurations.
 - 4. Device summary.
 - 5. Energy log configurations.
 - 6. Schedule configurations.
 - 7. Deliverable Format: CSV files.
- R. Field Engineering Tools: For programming controllers supplied.
- 1. Database Application Manager: Include controller logic files and associated graphics.
 - 2. Device Manager: Detect devices connected on BACnet network by scanning. Display device instance, network ID, model, and description. Record and display software file loaded in each controller. Store file copies in project folder on computer's hard drive.
 - 3. Audit when device not in database is added to network.
 - 4. Backup/restore function for system to selected medium. System to be capable of restoring systems and creating a backup for instantiating a new client PC.

5. A means to scan, detect, interrogate, and edit third-party BACnet devices and BACnet objects within those devices.
- S. Web Interface: System software based upon server/thin client architecture, designed around open standards of web technology.
1. Communicate using Ethernet and TCP. Access server using a web browser across Owner's intranet and remotely via the Internet. Support 200 users with single license.
 2. Web Browser: Microsoft Internet Explorer v11 or later, Firefox 70 or later, Chrome 78 or later, and Safari 13 or later. No special vendor-supplied software to be required. Display data in real-time. Update automatically without user interaction.
 3. Web Pages: Automatically generated with HTML5 from data display files on Operator Workstation. Do not use systems requiring an HTML editor for web page generation.
 4. Launching Web Browser on Operator Workstation presents a login page requiring a login name and password. Navigation and system adjustments dependent upon operators assigned privileges. User activity reports will show activity of operators, whether changes were made using a web client or Operator Workstation.
 5. User Session Management including ability to view connected user sessions to the web client, see how long they have been active/inactive for each unique session, and force log-out for any or all sessions.
- T. Context Menu Navigation: Web Browser: Support Context Menu Navigation via a right mouse click on a data point.
1. Operations to be dependent upon logged in user privileges and include:
 - a. View and setup Alarms.
 - b. View and setup Trend Logs.
 - c. Display the BACnet properties for the selected Object.
 - d. View and setup Schedules.
 - e. View System activity for the selected Object.
- U. Summary Pages:
1. Present system data in tabular form. Data to be from multiple devices. Points presented horizontally and devices listed on left side of table.
 2. Built using spreadsheet that can be imported into Operator Workstation.
 3. Data in summary pages to be live. Configure each object to be read only or writeable.
 4. Both analog and binary data shall be supported.

5. Summary page, when populated, captured for archiving and review for analysis.
6. The data shall be sortable by clicking on the column headings.

V. Advance Scheduling (EASE): Managed and arranged in multi-tier hierarchy.

1. Access through hierarchy to be controlled via login credentials.
2. Configured for MS SQL 2014/17/19 Enterprise.
3. The Advanced Schedule Application:
 - a. Apply conflict resolution logic for effective scheduling.
 - b. Assign Work, Week and Holiday schedules for multiple resources.
 - c. Create schedules with analog and binary resources.
 - d. Create events for parent resources or children using inheritance.
 - e. Customize event recurrence.
 - f. Use Resource Picker to search and select resources.
 - g. Create custom templates to hold the resource and event time.
 - h. Schedule Operations Status: Use notification banner. Verify changes in resource tree.
 - i. Verify event type applied to resource with indication given by resource hierarchy/tree.

2.6 BUILDING CONTROLLER (ACM)

A. General Requirements:

1. BACnet Conformance: Approved by BTL as meeting BACnet Building Controller requirements.
 - a. Refer to ANSI/ASHREA 135, for a complete list of the services that must be directly supported to provide each of the functional groups listed above.
 - b. Proprietary services, if used, document and provide as part of submittal data. Provide tools for working with proprietary information.
2. Scalable: Number of trunks and protocols selectable to fit project requirements
3. Capable of panel-mounting on DIN rail and/or mounting screws.
4. Global control strategies based on information from any objects in system, regardless if object is directly monitored by building controller module or by another controller.

5. Capable of running 6 independent control strategies simultaneously. Modification of one control strategy does not interrupt function or runtime others.
6. Software implementing DDC strategies to be completely flexible and user-definable.
7. Software Programming Tools: Provide as part of project software. Factory pre-programmed global strategies not modifiable by field personnel are not acceptable. Changing global strategies via firmware changes is also unacceptable.
8. Programming: Object-oriented control function blocks and support DDC functions. Flowcharts: Generated and automatically downloaded to controller. Programming tool to be resident on workstation. used same tool for controllers.
9. Graphically view inputs and outputs to each program block in real-time as program is executing. Function may be performed using operator's workstation or field computer.
10. Controller: 6,000 Analog Values and 6,000 Binary Values.
11. Controller IP configuration: Via direct USB connect or field computer.
12. Quad Core 996 Ghz processor to ensure fast processing speeds.
13. Execute control algorithms and automated control functions with 64-bit processor.
14. Minimum of 1 GB of DDR3 SDRAM on a 533 Mhz bus to ensure high speed data recording, large data storage capacity and reliability.
15. Support 2 on-board EIA-485 ports capable of supporting various EIA-485 protocols including, but not limited to BACnet MS/TP and Modbus. Ports capable of supporting EIA-485 protocols including, to BACnet MS/TP and Modbus.
16. Support 2 ports-each of gigabit speed-Ethernet (10/100/1000) ports. Ports are capable of supporting Ethernet protocols including, BACnet IP, FOX, and Modbus.
17. Ports capable of having protocols assigned to utilize port's physical connection.
18. Minimum 4 onboard inputs, 2 universal inputs and 2 binary inputs.
19. Schedules:
 - a. Normal seven-day scheduling, holiday scheduling and event scheduling.
 - b. Support 380 BACnet Schedule Objects and 380 BACnet Calendar Objects.
20. Logging Capabilities:
 - a. Log 2,000 objects at 15-minute intervals. Any object in system may be logged. Sample time interval adjustable at operator's workstation.
 - b. Viewed logs on-site or off-site using WAN or remote communication.

- c. Periodically upload trended data to operator's workstation for archiving. Archived data available for use in spreadsheet or database programs.
- 21. Alarm Generation: Within the system for any object change of value or state, includes analog and binary object state changes, and controller communication failures.
 - a. Each alarm may be dialed out as noted elsewhere.
 - b. Provide alarm log for alarm viewing. Log may be viewed on-site at operator's terminal or off-site using remote communications.
 - c. Handle up to 2,000 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.
- 22. Demand Limiting of Energy: Built-in, user-configurable function.
 - a. Controller modules support shedding up to 1,200 loads.
 - b. Load shedding programs to operate as defined herein.
- 23. Tenant Activity Logging: Supported by a building controller module. Each independent module to support a 380 zones.
 - a. Tenant Activity logging to function as defined herein.
- B. BACnet MS/TP:
 - 1. BACnet MS/TP LAN must be software-configurable from 9.6 to 115.4 Kbps
 - a. Each BACnet MS/TP LAN shall support 64 BACnet devices at a minimum.
 - b. Proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
- C. BACnet IP:
 - 1. The building controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the local area network (LAN).
 - 2. Must support interoperability on WANs and campus area networks (CANs), and function as a BACnet Broadcast Management Device (BBMD).
 - 3. Each controller shall support at a minimum 128 BBMD entries.
 - 4. BBMD management architecture shall support 3,000 subnets at a minimum.
 - 5. Shall support BACnet Network Address Translation.

6. Proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.

D. Expansion Ports:

1. Controller shall support two (2) expansion ports.
 - a. Combining the two on-board EIA-458 ports with fully loaded expansion ports, the controller shall support six (6) EIA-485 trunks simultaneously.
2. Expansion Cards: Mate to the expansion ports, shall include the following.
 - a. Dual port EIA-485 card.
 - b. 78 kbps FTT10A LON network card.

E. Modbus Protocol Support:

1. Controller shall support reading from and writing to TCP Slaves and Serial Connections (RTU or ASCII over either EIA-485 or EIA-232).
 - a. Shall be capable of mapping Modbus register coil data to BACnet AV, BV, MV, AI, BI, and MI object types.
 - b. Support a minimum of 6000 Mapped Modbus points.
2. Support up to 384 virtual groupings of Modbus points where each grouping is represented as a single virtual BACnet device.
 - a. Virtual BACnet devices support BACnet Change Of Value (COV) notifications
 - b. Each Virtual device has diagnostic information for troubleshooting Modbus point mapping. Diagnostic point should include the following.
 - 1) Number of points mapped.
 - 2) Number of messages Transmitted and Received.
 - 3) Modbus Exception Counts.
 - 4) Display of last exception message.
 - 5) Serial Setting (Baud rate, Parity, Stop Bits).
3. Integration Performance: Data age of integrated point shall be capable of 1 second for 5000 points.

F. Niagara Framework:

1. Controller shall utilize the Tridium Niagara Framework.

- a. Niagara licensing shall be stored on a removable MicroSD card for fast in-field replacement of controller.
 2. The Niagara License for the controllers shall be an open license.
 - a. The controller shall be programmable via Niagara Workplace programming tool.
 - b. The controller shall be programmable via a Niagara embedded Workplace programming tool.
 - G. Power Supply:
 1. Input for power: Accept between 17 and 30 VAC, 47 and 63 Hz.
 2. Rechargeable Battery: For controller shutdown including flash memory data storage.
 3. On-board capacitor ensuring continuous operation of real-time clocks for 14 days.
 - H. Controller: Shall be in compliance with the following.
 1. UL 916 for open energy management.
 2. FCC Class B.
 3. RoHS Compliant.
 4. IEC 60703.
 5. C-Tick Listed.
 6. CE(EN 60730-1).
 - I. Controller: Operate in the following environmental conditions.
 1. Without Battery: Minus 4 to 149 degrees F (Minus 20 to 65 degrees C).
 2. With Battery: 32 to 122 degrees F (0 to 50 degrees C).
 3. Relative Humidity: 0 to 95 percent, non-condensing.
- 2.7 CENTRAL PLANT AND AIR HANDLER APPLICATION CONTROLLERS
- A. Provide one or more native BACnet application controllers for each air handler and provide native BACnet application controllers as needed for central plant control that adequately cover all objects listed in object list. All controllers shall interface to building controller through either MS/TP LAN using BACnet protocol, or Ethernet LAN using BACnet over Ethernet or BACnet TCP/IP. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable using graphical programming blocks. Programming tool shall be resident on operator workstation and be the same tool as used for the building controller. No auxiliary or non-BACnet controllers shall be used.

B. BACnet Conformance

1. Application controllers shall be approved by the BTL as meeting the BACnet Advanced Application Controller requirements.
2. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Multi-state Values, Device, File, and Program object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. Application controllers shall include universal inputs with 12-bit resolution that accept 3K and 10K thermistors, 0–10VDC, Platinum 1000 ohm RTD, 0–5VDC, 4–20mA and dry contact signals. Any input on a controller may be either analog or digital with a minimum of three inputs that accept pulses. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall include binary and analog outputs on board. Analog outputs with 12-bit resolution shall support either 0–10VDC or 0–20mA. Binary outputs shall have LED indication of status. Software shall include scaling features for analog outputs. Application controller shall include 20VDC voltage supply for use as power supply to external sensors.

1. All outputs must have onboard Hand-Off-Auto (HOA) switches and a status indicator light. HOA switch position shall be monitored. Each analog output shall include a potentiometer for manually adjusting the output when the HOA switch is in the Hand position.
2. The position of each and every HOA switch shall be available system wide as a BACnet object property.

D. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller up to 20 times per second (minimum of 10 times per second) and capable of multiple PID loops for control of multiple devices. All calculations shall be completed using floating-point math and system shall support display of all information in floating-point nomenclature at operator's terminal.

1. The following control blocks shall be supported:
 - a. Natural Log
 - b. Exponential

- c. Log base 10
 - d. X to the power of Y
 - e. Nth square root of X
 - f. 5th Order Polynomial Equations
 - g. Astronomical Clock (sunrise/sunset calculation)
 - h. Time based schedules
- E. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely using modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using programming tools as described in operator's terminal section.
- F. Application controller shall include support for intelligent room sensor (see Section 2.10.B.) Display on intelligent room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode, based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.
- G. Schedules
- 1. The controller shall support a minimum of 3 BACnet Schedule Objects and have a real time clock on board with battery backup to maintain time through a power loss.
- H. Logging Capabilities
- 1. Controller shall support a minimum of 50 trendlogs. Any object in the controller (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
 - 2. Controller shall periodically upload trended data to system server for long-term archiving if desired. Archived data stored in (MS Jet Database or SQL) database form and shall be available for use in third-party spreadsheet or database programs.
- I. Alarm Generation
- 1. Alarms may be generated within the controller for any object change of value or state (either real or calculated). This includes things such as analog object value changes, and binary object state changes.
 - 2. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.

3. Controller must be able to handle up to 25 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.

J. The controller processor shall be a 32-bit processor.

K. The packaging of the controller shall provide operable doors to cover the terminals once installation is complete. The housing of the controller shall provide for DIN rail mounting and also fully enclose circuit board.

1. TERMINAL UNIT APPLICATION CONTROLLERS

L. Provide one native BACnet fully programmable field controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.

M. BACnet Conformance

1. Application controllers shall, as a minimum, support MS/TP BACnet LAN types. They shall communicate directly using this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be approved by the BTL as meeting the BACnet Application Specific Controller requirements and support all BACnet services necessary to provide the following BACnet functional groups:
 - a. Files Functional Group
 - b. Reinitialize Functional Group
 - c. Device Communications Functional Group
2. Please refer to Section 22.2, BACnet Functional Groups in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

N. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5VDC, 4–20mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.

- O. All program sequences shall be stored on board controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely through modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.
- P. Application controller shall include support for intelligent room sensor (see Section 2.10.B.) Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

2.8 OTHER CONTROL SYSTEM HARDWARE

- A. Motorized control dampers that will not be integral to the equipment shall be furnished by the Control System Contractor. Control damper frames shall be constructed of galvanized steel, formed into channels and welded or riveted. Dampers shall be galvanized, with nylon bearings. Blade edge seals shall be vinyl. Blade edge and tip seals shall be included for all dampers. Blades shall be 16-gauge minimum and 6 inches wide maximum and frame shall be of welded channel iron. Damper leakage shall not exceed 10 CFM per square foot, at 1.5 inches water gauge static pressure.
- B. Control damper actuators shall be furnished by the Control System Contractor. Two-position or proportional electric actuators shall be direct-mount type sized to provide a minimum of 5 in-lb torque per square foot of damper area. Damper actuators shall be spring return type. Operators shall be heavy-duty electronic type for positioning automatic dampers in response to a control signal. Motor shall be of sufficient size to operate damper positively and smoothly to obtain correct sequence as indicated. All applications requiring proportional operation shall utilize truly proportional electric actuators.
- C. Control Valves: Control valves shall be 2-way or 3-way pattern as shown and constructed for tight shutoff at the pump shut-off head or steam relief valve pressure. Control valves shall operate satisfactorily against system pressures and differentials. Two-position valves shall be 'line' size. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (unless otherwise noted or scheduled on the drawings). Valves with sizes up to and including 2 inches (51 mm) shall be "screwed" configuration and 2-1/2 inches (63.5 mm) and larger valves shall be "flanged" configuration. All control valves, including terminal unit valves, less than 2 inches (51 mm) shall be globe valves. Electrically-actuated control valves shall include spring return type actuators sized for tight shut-off against system pressures (as specified above) and, when specified, shall be furnished with integral switches for indication of valve position (open-closed).

- D. Control Valve Actuators: Actuators for VAV terminal unit heating coils shall be "drive-open; drive-closed" type. All actuators shall have inherent current limiting motor protection. Valve actuators shall be 24-volt, electronic type, modulating or two-position as required for the correct operating sequence. Actuators on valves needing 'fail-safe' operation shall have spring return to Normal position. Modulating valves shall be positive positioning in response to the signal. All valve actuators shall be UL listed.
- E. All control valves 2-1/2 inches (63.5 mm) or larger shall have position indication. All hot water control valves shall be Normally-Open arrangement; all chilled water control valves shall be Normally-Closed arrangement.
- F. Wall Mount Room Temperature sensors: Each room temperature sensor shall provide temperature indication to the digital controller, provide the capability for a software-limited occupant set point adjustment (warmer-cooler slider bar or switch) and limited operation override capability. Room Temperature Sensors shall be 10,000-ohm thermistor type with a temperature range of -40 to 140 degrees F (-38 to 60 degrees C). The sensor shall be complete with a decorative cover and suitable for mounting over a standard electrical utility box. These devices shall have an accuracy of 0.5 degrees F (.024 degrees C) over the entire range.
- G. Duct-mounted and Outside Air Temperature Sensors: 10,000-ohm thermistor temperature sensors with an accuracy of ± 0.2 degrees C. Outside air sensors shall include an integral sun shield. Duct-mounted sensors shall have an insertion measuring probe of a length appropriate for the duct size, with a temperature range of -40 to 160 degrees F (-38 to 71 degrees C) The sensor shall include a utility box and a gasket to prevent air leakage and vibration noise. For all mixed air and preheat air applications, install bendable averaging duct sensors with a minimum 8 feet (2438 mm) long sensor element. These devices shall have accuracy of 0.5 degrees F (.024 degrees C) over the entire range.
- H. Humidity sensors shall be thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2%) at 0 to 90% RH, 12 - 30 VDC input voltage, analog output (0 - 10 VDC or 4 - 20mA output). Operating range shall be 0 to 100% RH and 32 to 140 degrees F (0 to 60 degrees C). Sensors shall be selected for wall, duct or outdoor type installation as appropriate.
- I. Carbon Dioxide Sensors (CO₂): Sensors shall utilize Non-dispersive infrared technology (N.D.I.R.), repeatable to plus or minus 20 PPM. Sensor range shall be 0 - 2000 PPM. Accuracy shall be plus or minus five percent (5%) or 75 PPM, whichever is greater. Response shall be less than one minute. Input voltage shall be 20 to 30 VAC or DC. Output shall be 0 - 10 VDC. Sensor shall be wall or duct mounted type, as appropriate for the application, housed in a high impact plastic enclosure.
- J. Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point. Current switch to include an integral LED for indication of trip condition and a current level below trip set point.

- K. Differential Analog (duct) Static Pressure Transmitters Provide a pressure transmitter with integral capacitance type sensing and solid-state circuitry. Accuracy shall be plus or minus 1% of full range; range shall be selected for the specific application. Provide zero and span adjustment capability. Device shall have integral static pickup tube.
- L. Differential Air Pressure Switches: Provide SPDT type, UL-approved, and selected for the appropriate operating range where applied. Switches shall have adjustable setpoints and barbed pressure tips.
- M. Water Flow Switches: Provide a SPST type contact switch with bronze paddle blade, sized for the actual pipe size at the location. If installed outdoors, provide a NEMA-4 enclosure. Flow switch shall be UL listed.
- N. Temperature Control Panels: Furnish temperature control panels of code gauge steel with locking doors for mounting all devices as shown. All electrical devices within a control panel shall be factory wired. A complete set of 'as-built' control drawings (relating to the controls within that panel) shall be furnished within each control panel.
- O. Pipe and Duct Temperature sensing elements: 10,000-ohm thermistor temperature sensors with and accuracy of $\pm 1\%$ accuracy. Their range shall be -5 to 250 degrees F (-20 to 121 degrees C). Limited range sensors shall be acceptable provided they are capable of sensing the range expected for the point at the specified accuracy. Thermal wells with heat conductive gel shall be included.
- P. Low Air Temperature Sensors: Provide SPST type switch, with 15 to 55 degrees F (-9 to 13 degrees C), range, vapor-charged temperature sensor. Honeywell model L482A, or approved equivalent.
- Q. Relays: Start/stop relay model shall provide either momentary or maintained switching action as appropriate for the motor being started. All relays shall be plugged in, interchangeable, mounted on a subbase and wired to numbered terminals strips. Relays installed in panels shall all be DPDT with indicating lamp. Relays installed outside of controlled devices shall be enclosed in a NEMA enclosure suitable for the location. Relays shall be labeled with UR symbol. RIB-style relays are acceptable for remote enable/disable.
- R. Transducers: Differential pressure transducers shall be electronic with a 4-20 mA output signal compatible to the Direct Digital Controller. Wetted parts shall be stainless steel. Unit shall be designed to operate in the pressure ranges involved.
- S. Control Power Transformers: Provide step-down transformers for all DDC controllers and devices as required. Transformers shall be sized for the load, but shall be sized for 50 watts, minimum. Transformers shall be UL listed Class 2 type, for 120 VAC/24 VAC operation.
- T. Water Flow Metering:
 - 1. Inline Electromagnetic
 - 2. Carbon Steel body, PTFE liner, ANSI Class 150 flange

3. Pressure rating: 580 psig minimum
4. Temp Rating: 400 deg. Minimum
5. Display: remote mounted electronics, visual instantaneous rate of flow (GPM)
6. Accuracy: +/- 2-1/2 percent
 - a. Subject to compliance with requirements by one of the following.
 - 1) ONICON INCORPORATE, F-3100 SERIES
 - 2) SEAMETRICS INC.
 - 3) THERMO MEASUREMENT LTD.
 - 4) VENTURE MEASUREMENT.
 - A. Glycol Metering: Provide MISCO IRIS+
 1. Inline Sensor is a completely self-contained
 2. The modular design including a flow-through adapter with two push-to-connect I/O ports and an integrated mounting bracket.
 3. Detachable “smart-sensor” can be removed from the adapter without tools, for cleaning or maintenance, with just a quarter-turn.
 4. Sensor outputs a 4 to 20 mA or 0 to 10 volt signal that can be directly connected to the BMS system.
 - B. Air Flow Monitoring: Provide combination airflow and air temperature devices where indicated on the plans.
 - a. Each measuring device shall consist of multi-point sensors in one or more probe assemblies per location, and a single remotely mounted microprocessor-based transmitter for each measurement location. Each transmitter shall operate on 24 VAC and be fused and protected from over voltage, over current and power surges. All integrated circuitry shall be temperature rated as 'industrial-grade'. No electronic components other than the sensor elements shall be located at the sensing node. Each ducted sensor probe shall have an integral, U.L. Listed, plenum rated cable. Conductor insulation for internal probe wiring shall be made from Kynar.
 - b. Each sensing point shall independently determine the airflow rate and temperature at each node, which shall be equally weighted in calculations by the transmitter prior to output as the cross-sectional average. Devices which average multiple non-linear variables are not acceptable. Pitot arrays are not acceptable. Devices using chip-in-glass, epoxy-coated or diode-case chip thermistors are not acceptable. Vortex-shedding devices are not acceptable.

- c. Each independent airflow sensor node shall have a laboratory accuracy of $\pm 2\%$ of Reading over the entire calibrated airflow range of 0 to 5,000 fpm (25.4 m/s) for ducted or plenum mounted probes, or not less than 0 to 10,000 fpm (50.8 m/s) for fan inlet mounted sensors. All sensor nodes shall be wind tunnel calibrated or field-verified against air velocity standards that are traceable to NIST.
- d. Devices whose accuracy is the combined and independent accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the calibrated range.
- e. Each independent temperature sensor node shall have a calibrated accuracy of $\pm 0.14^\circ\text{F}$ (0.08°C) over the entire operating temperature range of -20°F to 160°F (-28.9°C to 71°C), and be calibrated or field-verified against temperature standards that are traceable to NIST.
- f. Airflow/Temperature measuring devices shall be UL Listed as an entire assembly. Devices in UL-labeled enclosures are not equivalent and are not acceptable without a UL Listing.
- g. Where fan inlet measurement is required, mounting styles shall be indicated on the plans as either "face mounting" or "throat mounting." Face mounting shall provide no mechanical fastening in the throat or on the surface of the inlet cone and shall be used on all performance-sensitive plenum-type or plug fans.
- h. Acceptable Manufacturers: EBTRON, Inc. (basis of design) or equal by Air Monitor Corporation.

6.2 WEB BROWSER GRAPHICAL USER INTERFACE

- A. Web Browser Navigation: The web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus for operator access, reports and reporting actions for events.
- B. Login: On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and password. Navigation in the system shall be dependent on the operator's role privileges and geographic area of responsibility.
- C. Navigation: Navigation through the GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control like Microsoft's Explorer program) and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment and view the corresponding graphic. The navigation tree

shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.

1. Geographic View shall display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and objects.
 2. Groups View shall display Scheduled Groups and custom reports.
 3. Configuration View shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).
- D. Action Pane: The Action Pane shall provide several functional views for each HVAC or mechanical/electrical subsystem specified. A functional view shall be accessed by clicking on the corresponding button:
1. Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic setpoint controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.
 2. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an 'accept/cancel' button.
 3. Schedules: Shall be used to create, modify/edit and view schedules based on the systems geographical hierarchy (using the navigation tree).
 4. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
 5. Trends: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling.
 6. Logic - Live Graphic Programs: Shall be used to display 'live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.
 7. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.
- E. Color Graphics: The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to set points and comfort. Animated.gifs or .jpg, vector scalable, active setpoint graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:
1. Display Size: The GUI workstation software shall graphically display in a minimum of 1024 by 768 pixels 24 bit True Color.

2. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.
 3. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set points. The colors shall be updated dynamically as a zone's actual comfort condition changes.
 4. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability. .
 5. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
 - a. Each piece of equipment monitored or controlled including each terminal unit.
 - b. Each building.
 - c. Each floor and zone controlled.
- F. Hierarchical Schedules: Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with password access) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room, or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day ' Holiday' for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further operator intervention would be required and every control module in the system with would be automatically downloaded with the ' Independence Day' Holiday. All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.
1. Schedules: Schedules shall comply with BACnet standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
 - a. Types of schedule shall be Normal, Holiday or Override.
 - b. A specific date,.
 - c. A range of dates,.
 - d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
 - e. Wildcard (example, allow combinations like second Tuesday of every month).

2. **Schedule Categories:** The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.
 3. **Schedule Groups:** In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an 'individual tenant' group - who may occupy different areas within a building or buildings. Schedules applied to the 'tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the 'tenant group'.
 4. **Intelligent Scheduling:** The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.
 5. **Partial Day Exceptions:** Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).
 6. **Schedule Summary Graph:** The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.
- G. **Alarms:** Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an 'Alarms' view. Alarms, and reporting actions shall have the following capabilities:
1. **Alarms View:** Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address and other pertinent information. An operator shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.
 2. **Alarm Categories:** The operator shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.
 3. **Alarm Templates:** Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out

of range information.

4. Alarm Areas: Alarm Areas enable an operator to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.
5. Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.
6. Alarm Configuration: Operators shall be able to define the type of Alarm generated per object. A 'network' view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.
7. Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement and total number of Alarms in the BAS Server database.
8. Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an operator defined period.
9. Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:
 - a. Print: Alarm information shall be printed to the BAS server's PC or a networked printer.
 - b. Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts. Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.
 - c. File Write: The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
 - d. Write Property: The write property reporting action updates a property value in a hardware module.
 - e. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.

- f. Run External Program: The Run External Program reporting action launches specified program in response to an event.
- H. Trends: As system is engineered, all points shall be enabled to trend. Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.
 1. Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.
 2. Local Trends: Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and periodically uploaded to the BAS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.
 3. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis.
 4. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.
 5. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.
 6. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.
 7. Copy/Paste. The operator shall have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).
 8. Trending data shall include the following features:
 - a. Software that is capable of graphing the trend-logged object data shall be included.
 - b. Access and ability to create, edit and view are restricted to users by user account credentials
 - c. Specific and repeatable URL defines the trendlog(s) views for browser bookmarking and email compatibility.
 - d. Call out of trendlog value at intersection of trend line and mouse-over vertical axis.
 - e. Trendlog or Energy log and companion logs can be configured to display on one of two independent vertical scales embedded in the display.

- f. Click zoom for control of data set viewed along either graph axis.
- g. User-specifiable start and end dates as well as a fast scroll features that supports click zoom of macro scale view of the data for quickly finding data set based on visual signature.
- h. User export of the viewed data set to MS Excel.
- i. Web browser-based help.
- j. Optional min/max ranges (Upper Control Limits, Lower Control Limits) for each value.

I. Energy Log Information

- 1. AWS shall be capable of periodically gathering energy log data stored in the field equipment and archive the information. Archive files shall be appended with new data, allowing data to be accumulated. Systems that write over archived data shall not be allowed unless limited file size is specified. Display all energy log information in standard engineering units.
- 2. All data shall be stored in database file format for direct use by third-party programs. Operation of system shall stay completely online during all graphing operations.
- 3. AWS operator shall be able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All meters monitored by the system may be logged. System shall support using flow and temperature sensors for BTU monitoring.
- 4. AWS shall display data in tabular format form for both consumption and peak values. Data shall be shown in hourly, daily, weekly, monthly and yearly formats. In each format, the user shall be able to select a specific period of data to view.
- 5. Web client shall display data in tabular format and graphical format. Data shall be shown in hourly, daily, weekly, monthly and yearly formats. In each format, the user shall be able to select a specific period of data to view.

J. Demand Limiting

- 1. AWS shall include demand limiting program that includes two types of load shedding. One type of load shedding shall shed/restore equipment in binary fashion based on energy usage when compared to shed and restore settings. The other type of shedding shall adjust operator-selected control setpoints in an analog fashion based on energy usage when compared to shed and restore settings. Shedding may be implemented independently on each and every zone or piece of equipment connected to system.
- 2. Binary shedding shall include minimum of five (5) priority levels of equipment shedding. All loads in a given priority level shall be shed before any loads in a higher priority level are shed. Load shedding within a given priority level shall include two methods. In one,

the loads shall be shed/restored in a “first off-first on” mode, and in the other the loads are just shed/restored in a “first off-last on” (linear) fashion.

3. Analog shed program shall generate a ramp that is independently used by each individual zone or individual control algorithm to raise the appropriate cooling setting and lower appropriate heating setting to reduce energy usage.
4. AWS shall be able to display the status of each and every load shed program. Status of each load assigned to an individual shed program shall be displayed along with English description of each load.

K. Reports

1. AWS shall be capable of periodically producing reports of trendlogs, alarm history, tenant activities, device summary, energy logs, and override points. The frequency, content, and delivery are to be user adjustable.
2. All reports shall be capable of being delivered in multiple formats including text- and comma-separated value (CSV) files. The files can be printed, emailed, or saved to a folder, either on the server hard drive or on any network drive location.

L. Security Access: Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Password. Access to different areas of the BAS system shall be defined in terms of Roles, Privileges and geographic area of responsibility as specified:

1. Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of 'easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function Privileges.
 - a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.
 - b. Edit Privileges shall comprise: Setpoint, Tuning and Logic, Manual Override, and Point Assignment Parameters.
 - c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print and Alarm/Event Maintenance.
2. Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.

M. Workstation Hardware and Accessories:

1. Provide one (1) operator's workstation in Boiler Room or other location(s) noted on the plans.

2. AWS Server Minimum Requirements

- a. 64-bit OS
- b. Windows 10 or Windows Server 2012
- c. 2 GHz (or better), eight-core processors
- d. 4 GB RAM or higher
- e. 32 GB of hard drive space required for base installation without application data
- f. Minimum 1 TB hard drive (also see criteria in Part 3 - Execution below).
- g. Network interface card (10/100/1000 Mbps)
- h. Wireless keyboard and mouse
- i. 27" LCD monitor.
- j. Wireless network card.

3. Printer

- a. A separate Laser jet type printer shall be provided for hard copy data and alarm printouts. All change of state reporting system logs, information summaries, system malfunctions and alarms shall be printed at this terminal.
- b. The minimum acceptable print speed shall be 300 characters per second. The printer shall have a line length of at least 80 characters and the character set shall be the standard 191 character ASCII upper case subset.
- c. The printer shall be interfaced to the system by standard USB port.

N. Software

- 1. At the conclusion of the project, contractor shall leave with owner an electronic copy that includes the complete software operation system and project graphics, setpoints, system parameters, etc. This backup shall allow the owner to completely restore the system in the case of a computer malfunction.

PART 1 EXECUTION

7.1 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

7.2 PREPARATION

- A. Clean surfaces thoroughly prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

7.3 GENERAL

- A. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.
- B. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by the Control System Contractor in accordance with these specifications.
- C. Equipment furnished by the Mechanical Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by the Control System Contractor.
- D. All control devices mounted on the face of control panels shall be clearly identified as to function and system served with permanently engraved phenolic labels.

7.4 WIRING

- A. All electrical control wiring to the control panels shall be the responsibility of the Control System Contractor.
- B. All wiring shall be in accordance with the Project Electrical Specifications (Division 16), the National Electrical Code and any applicable local codes. All control wiring shall be installed in raceways.
- C. Excess wire shall not be looped or coiled in the controller cabinet.
- D. Incorporate electrical noise suppression techniques in relay control circuits.
- E. There shall be no drilling on the controller cabinet after the controls are mounted inside.
- F. Careful stripping of wire while inside the cabinet is required to ensure that no wire strand fragments land on circuit boards.
- G. Use manufacturer-specified wire for all network connections.
- H. Use approved optical isolation and lightning protection when penetrating building envelope.
- I. Read installation instructions carefully. Any unavoidable deviations shall be approved by owner's rep prior to installation.

7.5 ACCEPTANCE TESTING

- A. Upon completion of the installation, the Control System Contractor shall load all system software and start-up the system. The Control System Contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to insure that the system is functioning in full accordance with these specifications.
- B. The Control System Contractor shall perform tests to verify proper performance of components, routines and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation.
- C. System Acceptance: Satisfactory completion is when the Control System Contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

7.6 OPERATOR TRAINING

- A. During system commissioning and at such time acceptable performance of the Control System hardware and software has been established, the Control System Contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction shall be done during normal working hours and shall be performed by a competent representative familiar with the system hardware, software and accessories.
- B. The Control System Contractor shall provide 16 total hours of comprehensive training for system orientation, product maintenance and troubleshooting, programming and engineering, if not provided under a previous contract at the site using the same brand and type of controllers within the previous 3 years.

7.7 WARRANTY PERIOD SERVICES

- A. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of one year from the time of system acceptance.
- B. Within this period, upon notice by the Owner, any defects in the BMS due to faulty materials, methods of installation or workmanship shall be promptly repaired or replaced by the Control System Contractor at no expense to the Owner.
- C. Maintenance of Computer Software Programs: The Control System Contractor shall maintain all software during the warranty period. In addition, all factory or sub-vendor upgrades to software shall be added to the systems, when they become available, at no additional cost. New products are not considered upgrades in this context.
- D. Maintenance of Control Hardware: The Control System Contractor shall inspect, repair, replace, adjust, and calibrate, as required, the controllers, control devices and associated peripheral units during the warranty period. The Control System Contractor shall then furnish a

report describing the status of the equipment, problem areas (if any) noticed during service work, and description of the corrective actions taken. The report shall clearly certify that all software is functioning correctly.

- E. Service Period: Calls for service by the Owner shall be honored within 24 hours and are not to be considered as part of routine maintenance.
- F. Service Documentation: A copy of the service report associated with each owner-initiated service call shall be provided to the owner.

7.8 WARRANTY ACCESS

- A. The Owner shall grant to the Control System Contractor reasonable access to the BMS during the warranty period. Remote access to the BMS (for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period) will be allowed.

7.9 OPERATION & MAINTENANCE MANUALS

- A. See Division 1 for requirements. O&M manuals shall include the following elements, as a minimum:
 - 1. As-built control drawings for all equipment.
 - 2. As-built Network Communications Diagram.
 - 3. General description and specifications for all components.
 - 4. Completed Performance Verification sheets.
 - 5. Completed Controller Checkout/Calibration Sheets.

7.10 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair or replace damaged products before Substantial Completion.

7.11 CLOSEOUTS

- A. See Section 017800-Closeout Submittals, for closeout submittals.
- B. See Section 017900-Demonstration and Training, for additional requirements.
- C. Provide minimum 8 hours of training.

END OF SECTION 23 09 00

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SECTION 23 09 93 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."
- B. Division 01, Section 019113 "General Commissioning Requirements" for commissioning and testing requirements related to this section.

1.2 SUMMARY

- A. This Section includes control sequences for HVAC systems, subsystems, and equipment.
- B. Related Sections include the following:
 - 1. Section 230900 "Instrumentation and Control for HVAC" for control equipment and devices and for submittal requirements.

1.3 DEFINITIONS

- A. DDC: Direct digital control.
- B. VAV: Variable air volume.
- C. ATC: Automatic temperature control.
- D. BAS: Building Automation System

1.4 GENERAL

- A. Unless noted otherwise herein, all control functions described in this sequence of operation shall be accomplished by the Building Automation System (BAS), and all equipment shall be started, stopped and positioned (if a modulating device) by the BAS. All hardware necessary to accomplish the control functions shall be provided by the ATC contractor, unless noted otherwise. The BAS contractor shall coordinate the quantity of required final drive devices (damper motors, control valves, etc.) and sensors with the mechanical equipment vendor's products.
- B. All setpoints described in this sequence of operation shall be fully adjustable throughout the entire range of the sensors being used to measure the variable being controlled. All controlled variables identified in the following sequence of operation shall be maintained at setpoint using proportional-integral control algorithms, in order to ensure that no error exists between the controlled variable and its setpoint at steady-state conditions. Proportional-integral-derivative algorithms shall be used if the process so warrants, at the discretion of the control software programmer.

- C. Point Lists, if provided in the Sequence, are a Minimum and should be used as a guideline. All points listed are required. Any additional points required to meet the sequence of operations or the specification or the intent of the specification will be included.
- D. Alarms will be set up initially by the ATC contractor. The system will be capable of unlimited alarms, but the selected alarms will not be the left for the customer to set. Any alarms that the customer requests to be set up will be done by the Contractor at no additional charge.
- E. Trending. At a minimum, all points of physical control shall be trended and stored for a minimum of one (1) year. Digital points shall be trended on change of value. Analog points shall be trended in 15-minute intervals.
- F. ATC Contractor shall provide all necessary points and sensors for monitoring and controlling the sequence of operations as well as all points shown on the DDC schematics in the contract documents.
- G. All points shall be alarmed at the DDC workstation if found to be deviating from their normal operating conditions.

1.5 HYDRONIC HEATING BOILERS (TOTAL 2 BOILERS)

- A. The hydronic gas-fired boiler/burner units shall be controlled by a microprocessor based pre-engineered and programmed control system furnished by the boiler manufacturer. The Building Automation System will communicate with boiler provided controls via BACnet. All boiler/burner control wiring from burner control panels to multiple boiler control system shall be provided by the Automatic Temperature Control Contractor per manufacturer's instructions. The factory boiler control system shall be furnished with supply water temperature sensor, outdoor air sensors, and automatic isolation valve (provided by the ATC contractor) will be wired directly to the factory panel by the Automatic Temperature Control Contractor. Primary hot water pumps will be enabled and controlled by the controller furnished by the boiler manufacturer
- B. Boiler controller shall be set to achieve supply water temperature reset indicated below while optimizing the energy consumption of the plant. Boiler controller shall initiate respective boiler automatic isolation valve prior to firing respective boiler.
- C. The DDC shall monitor the boilers via BACnet, but as a minimum interface must allow user to view all operating points, firing rates, energy consumptions, etc.
- D. Boilers system shall be enabled when the system pumps are on and the system is in the heating mode. In general, the boiler plant shall be enabled at outdoor temperatures below 65°F (adj.). Factory boiler control system shall modulate as required to maintain supply water temperature. Based on the following outdoor air schedule, the hot water supply temperature shall be reset. The reset schedule range shall be linear.
 - 1. O.A. Temp Supply Temp.
 - 2. 0°F 150°F

3. 60°F 130°F

- E. The hot water supply from each boiler will be monitored.
- F. The system hot water temperature supplied to the building heat (i.e. radiation) loop and from the building will be monitored.
- G. Provide two (2) remote shutoff switches for the boiler room. One (1) switch shall be located just outside the interior door to the boiler room. Switch must be located in a break glass or equal tamper resistant enclosure properly labeled. The second switch should be located just inside the boiler room exterior door properly labeled as to its service. Switches must be wired and programmed so that when either switch is placed in the off position a disable signal shall be immediately sent to all the heating boilers and domestic hot water heaters.

1.6 HOT WATER SECONDARY VARIABLE PUMPING SYSTEM

- A. Pumps shall be enabled by the BAS based on outside air temperature.
- B. Once the outside temperature falls below 65 °F (adj.), the pumps shall be enabled as follows:
 - 1. Start the primary hot water pump(s). The controller shall monitor pump status. If pump status does not match the commanded value, an alarm shall be generated at the Operator Workstation.
 - 2. The pumps shall slowly ramp up and down in speed to maintain system pressure control setpoint.
 - 3. The Hot Water System shall be controlled to maintain the design pressure setpoint for the system as determined by the TAB. As the system pressure drop increases, the BAS will command the hot water pumps VFD to decrease its output. As the system pressure drop decreases, the BAS will command the hot water pump VFD to increase its output. VFD output will be monitored by the BAS
 - 4. If the primary hot water pump cannot maintain the system pressure setpoint, the second hot water pump will be enabled to run. The second primary pump will modulate to maintain the system pressure setpoint. Both pumps will operate at the same speed.
 - 5. If either primary pump fails to operate, the third pump will be enabled and operate in the sequence to replace the failed pump.
 - 6. The lead pump / lag pump rotation will rotate weekly.

1.7 HOT WATER BY-PASS VALVE

- A. By-pass valve is provided for low flow conditions, during shoulder seasons and during construction.
- B. The hot water supply temperature and hot water return temperature in and out of the loop will be monitored and displayed,

- C. The hot water pressure in and out of the loop will be monitored and displayed.

1.8 GLYCOL SYSTEM

- A. The glycol concentration will be monitored in the condenser water loop and the hot water loop. If the concentration of either loop falls below the setpoint, an alarm will be issued at the workstation.
- B. The BAS will monitor the Glycol Make Up control package controller.
 - 1. If the controller has an alarm, the BAS will generate an alarm at the workstation.
 - 2. The Make Up Pump will be monitored directly by the BMS via a current switch.
 - 3. The Glycol level will be monitored from the manufacturers control panel.

1.9 WATER TREATMENT

- A. The water treatment panel will be monitored for operation status and alarm. If the panel has an alarm status, the BAS system will generate an alarm at the operator workstation.

1.10 DOAS CONTROL

- A. Enabling: RTU will be controlled by the building automation system (BAS) as provided by the ATC. BAS unit controller to operate in occupied mode or unoccupied mode if any of the following devices are not activated.
 - 1. Internal safety devices.
 - a. Fans shall be off.
 - b. OA and EA dampers shall be closed.
 - c. Issue alarm to operator's work station.
 - 2. Fire Alarm Control Panel.
 - a. Fans shall be off.
 - b. OA and EA dampers shall be closed.
 - c. Issue alarm to operator's work station.
 - 3. Low temperature limit.
 - a. Fans shall be off.
 - b. Gas valves shall be modulated open.
 - c. OA and EA dampers shall be closed.
 - d. Issue alarm to operator's work station.

4. High static.
 - a. Fans shall be off.
 - b. OA and EA dampers shall be closed.
 - c. Issue alarm to operator's work station.

B. General Conditions:

1. Control dampers and actuators are provided with unit. ATC to wire actuators.
2. Outdoor airflow station to be provided by the unit manufacturer.
3. All other airflow stations provided by ATC. Airflow reading monitored at operation's work station.
4. Static pressure sensor is to be installed 2/3 of the distance in the effectively longest duct run downstream from the supply fan.

C. Supply Air Temperature Reset:

1. Supply air temperature reset shall be enabled when the supply fan is operating.
2. When enabled, initial discharge air temperature set point shall be 60 F.
3. Discharge air temperature range shall be between 65 F and 54 F.
4. If any space temperature zone is in heating mode and none are in cooling mode, the discharge air temperature set point shall be reset 2 degrees higher every 15 minutes until the heating zone temperature set point is achieved or the upper discharge air temperature set point is reached.
5. If any space temperature zone is in cooling mode and none are in heating mode, the discharge air temperature set point shall be reset 2 degrees lower every 15 minutes until the cooling zone temperature set point is achieved or the lower discharge air temperature set point is reached.

D. Unoccupied Damper Control and Energy Recovery Wheel Control:

1. Outside air damper shall be fully closed unless unoccupied economizer mode is enabled.
2. Exhaust air damper shall be fully closed unless unoccupied economizer mode is enabled.
3. Supply air energy wheel bypass damper shall be fully closed unless unoccupied economizer mode is enabled.
4. Exhaust air energy wheel bypass damper shall be fully closed unless unoccupied economizer mode is enabled.
5. Energy wheel shall be off.

- E. Economizer Unoccupied Cooling Control:
1. BMS will allow economizer cycles to be activated based on outside air conditions if the average space temperature and enthalpy is greater than the outside air temperature and enthalpy with a hysteresis of 5°F, the outside air enthalpy is less than 22 Btu/lb with a hysteresis of 2 Btu/lb, the outside air temperature is less than 65°F with a hysteresis of 2°F, and the outside air readings are valid.
 2. When economizer unoccupied mode is enabled:
 - a. Outside air and Exhaust air damper shall fully open.
 - b. Supply air energy wheel bypass damper shall be fully open.
 - c. Exhaust air energy wheel bypass damper shall be fully open.
- F. Unoccupied Heating:
1. The units will be off during this mode. Heating will be provided by the hot water system.
- G. Unoccupied Mechanical Cooling:
1. The units will be off during this mode. Cooling if required will be provided by the VRF system.
- H. Unoccupied Dehumidification: When the space dew point temperature rises above dew point unoccupied set point, BAS will initiate dehumidification unoccupied mode as follows:
1. Supply Fan will cycle on.
 2. Initiate compressor to maintain unoccupied space dehumidification set point. Compressor shall not operate if supply fan current relay is activated
 3. Modulate hot gas reheat coil to maintain discharge air temperature setpoint (68 °F) adjustable.
- I. Occupied Damper Control:
1. Outside air damper shall open 100%
 2. Exhaust air damper shall open 100%
 3. Mixed air damper shall be closed.
 4. Supply air energy wheel bypass damper shall be fully closed unless in Economizer Mode.
 5. Exhaust air energy wheel bypass damper shall be fully closed unless in Economizer Mode.
 6. Damper positions shall be monitored via hard wired feedback from the damper actuators to the DDC field controller.

J. Occupied Economizer Cooling Control:

1. BMS will allow economizer cycles to be activated based on outside air conditions if the average space temperature and enthalpy is greater than the outside air temperature and enthalpy with a hysteresis of 5°F, the outside air enthalpy is less than 22 Btu/lb with a hysteresis of 2 Btu/lb, the outside air temperature is less than 65°F with a hysteresis of 2°F, and the outside air readings are valid.
2. If the supply air temperature remains lower than 45°F for 5 minutes with a 5°F hysteresis and alarm will be generated. This alarm will not be enabled until the supply fan has been running for 30 minutes.
3. DX cooling and dehumidification mode shall be locked out.
4. Energy wheel bypass dampers will be open.
5. Energy wheel will be off.
6. Relief air fan shall be enabled.
7. The relief fan VFD speed shall modulate to maintain the relief CFM offset setpoint from the Outdoor air CFM.

K. Occupied Economizer Cooling Control:

1. BMS will allow economizer cycles to be activated based on outside air conditions if the return air temperature and enthalpy is greater than the outside air temperature and enthalpy with a hysteresis of 5°F, the outside air enthalpy is less than 22 Btu/lb with a hysteresis of 2 Btu/lb, the outside air temperature is less than 65°F with a hysteresis of 2°F, and the outside air readings are valid.
2. DX cooling and dehumidification mode shall be locked out.
3. Outside air damper and return air damper shall be open
4. Energy wheel bypass dampers will be open.
5. Energy wheel will be off.
6. Relief air fan shall be on and run to track the supply fan speed.

L. Occupied Energy Wheel Control:

1. Energy wheel shall operate unless in economizer mode or defrost mode.
2. In economizer or defrost mode, energy wheel shall not rotate.
3. Defrost Control: When the differential pressure across the wheel exceeds the recommended setpoint, the wheel will be stopped to defrost a portion of the wheel. The wheel will then be jogged ON and the stopped at another section, the defrost cycle will

continue until the differential pressures indicate the wheel has been defrosted.

M. Occupied Fan Control:

1. Supply fan VFD shall modulate the supply fan speed to maintain “reset” duct static pressure setpoint. As the system pressure increases, the BAS will command the supply fan VFD to decrease its output. As the system pressure drop decreases, the BAS will command the supply fan VFD to increase its output. VFD output will be monitored by the BAS.
2. The relief fan will be on whenever the supply fan is running. The relief fan VFD speed shall track the supply fan speed with a ten percent (10%) or as set by the balancer.

N. Unoccupied Fan Control:

1. The supply and exhaust fans will be off.

O. Occupied Heat Control:

1. Economizer mode and cooling mode will be locked out.
2. The gas heating will be enabled. The gas valve will modulate to maintain the discharge air temperature setpoint.

P. Occupied DX Cooling Control

1. When discharge air temperature increases above set point and the outdoor enthalpy is above 25 degrees BTUH, DX cooling mode shall be enabled.
2. Dehumidification mode and economizer cooling mode shall be locked out.
3. Reset outside air and mixed air damper to minimum position.
4. Initiate DX compressor(s). Modulating compressors shall operate as the first cooling stage. If the modulating compressor cannot maintain the discharge air temperature setpoint, the second modulating compressor will be enabled and modulated to maintain the discharge air temperature setpoint. Compressors, once enabled will be on until the minimum run time has elapsed. Compressor shall not operate if supply fan current relay is not activated or condensate pan water detection is activated or compressor high pressure is activated. Roof top equipment manufacture shall take control of the condenser fan operation.
5. The suction pressure transmitter will be monitored for the modulating compressor.

Q. Occupied Dehumidification Control:

1. When the discharge dew point temperature rises above the set point and cooling mode is not enabled, dehumidification mode shall be enabled.

2. Initiate DX compressor(s). Modulating compressors shall operate as the first dehumidification stage and run at 100% capacity. Compressor shall not operate if supply fan current relay is not activated or condensate pan water detection is activated or compressor high pressure is activated. Roof top equipment manufacture shall take control of the condenser fan operation.
3. Enable and Modulate the hot gas reheat valve to maintain the last discharge air temperature setpoint.

R. UV Filtering:

1. The units will be supplied with UV filtering
2. The UV will be monitored for run status
3. The run time will be tracked. Once the run hours have reached the “Change UV Bulb” hours, a message will be generated at the operator workstation.

1.11 ENERGY RECOVERY UNIT

A. Enabling: RTU will be controlled by the building automation system (BAS) as provided by the ATC. BAS unit controller to operate in occupied mode or unoccupied mode if any of the following devices are not activated.

1. Internal safety devices.
 - a. Fans shall be off.
 - b. OA and EA dampers shall be closed.
 - c. MA damper shall be full open.
 - d. Issue alarm to operator’s work station.
2. Fire Alarm Control Panel.
 - a. Fans shall be off.
 - b. OA and EA dampers shall be closed.
 - c. MA damper shall be full open.
 - d. Issue alarm to operator’s work station.
3. Low temperature limit.
 - a. Fans shall be off.
 - b. Gas valves shall be modulated open.
 - c. OA and EA dampers shall be closed.

- d. MA damper shall be full open.
- e. Issue alarm to operator's work station.
- 4. High static.
 - a. Fans shall be off.
 - b. OA and EA dampers shall be closed.
 - c. MA damper shall be full open.
 - d. Issue alarm to operator's work station.

B. General Conditions:

- 1. Control dampers and actuators are provided with unit. ATC to wire actuators.
- 2. Damper position feedback on Air Handling Units shall be hardwired from the actuator to the DDC field controller.
- 3. Outdoor air Flow Stations provided by the unit manufacturer shall be monitored at the operator's workstation.
- 4. Airflow station provided by ATC. Airflow reading monitored at operation's work station.

C. General Conditions:

- 1. Control dampers and actuators are provided with unit. ATC to wire actuators.
- 2. Outdoor Airflow station provided by unit manufacturer. All other Airflow stations are provided by the ATC. Airflow reading monitored at operation's work station.

D. Supply Air Temperature Reset:

- 1. Supply air temperature reset shall be enabled when the supply fan is operating.
- 2. When enabled, initial discharge air temperature set point shall be 60 °F.
- 3. Discharge air temperature range shall be between 68 °F and 54 °F.
- 4. If the space temperature zone is in heating mode, the discharge air temperature set point shall be reset 2 degrees higher every 15 minutes until the heating zone temperature set point is achieved or the upper discharge air temperature set point is reached.
- 5. If the space temperature zone is in cooling mode, the discharge air temperature set point shall be reset 2 degrees lower every 15 minutes until the cooling zone temperature set point is achieved or the lower discharge air temperature set point is reached.
- 6. If the unit is in cooling mode and the discharge air temperature reset setpoint is at its maximum and the space temperature is approaching the space temperature setpoint, the

supply fan speed will begin to modulate to a slower speed. The fan speed will continue to modulate slower until the fan minimum speed is reached or the space temperature begins to rise.

7. If the unit is in heating mode, the discharge air temperature setpoint will reset until it reaches the maximum setpoint. Once the fan reaches the maximum setpoint, and the space temperature approaches the space temperature setpoint, the fan speed will modulate to a slower speed until it reaches its minimum speed setpoint or the space temperature begins to drop below the space temperature setpoint.

E. Morning Warmup:

1. Outside air damper shall be fully closed.
2. Exhaust air damper shall be fully closed.
3. Mixed air damper shall be fully open.
4. Supply air energy wheel bypass damper shall be fully closed.
5. Exhaust air energy wheel bypass damper shall be fully closed.
6. Energy wheel shall be off.
7. The supply fan and return shall run continuously.
8. The heat pump will be in "heat mode" and the compressors shall stage and modulate until the return air temperature reaches the "occupied" average space temperature set point.

F. Morning Cool down:

1. Outside air damper shall be fully closed
2. Exhaust air damper shall be fully closed.
3. Mixed air damper shall be fully open.
4. Supply air energy wheel bypass damper shall be fully closed.
5. Exhaust air energy wheel bypass damper shall be fully closed.
6. Energy wheel shall be off.
7. The supply fan and return shall run continuously.
8. The DX compressors will stage / modulate to maintain 55 degrees supply air temperature.

G. Supply Air Temperature Reset:

1. Supply air temperature reset shall be enabled when the supply fan is operating.

2. When enabled, initial discharge air temperature set point shall be 60°F.
3. Discharge air temperature range shall be between 65°F and 54°F.
4. If any space temperature zone is in heating mode and none are in cooling mode, the discharge air temperature set point shall be reset 2 degrees higher every 15 minutes until the heating zone temperature set point is achieved or the upper discharge air temperature set point is reached.
5. If any space temperature zone is in cooling mode and none are in heating mode, the discharge air temperature set point shall be reset 2 degrees lower every 15 minutes until the cooling zone temperature set point is achieved or the lower discharge air temperature set point is reached.

H. Unoccupied Damper Control and Energy Recovery Wheel Control:

1. Outside air damper shall be fully closed unless unoccupied economizer mode is enabled.
2. Exhaust air damper shall be fully closed unless unoccupied economizer mode is enabled.
3. Mixed air damper shall be fully open unless unoccupied economizer mode is enabled.
4. Supply air energy wheel bypass damper shall be fully closed unless unoccupied economizer mode is enabled.
5. Exhaust air energy wheel bypass damper shall be fully closed unless unoccupied economizer mode is enabled.
6. Energy wheel shall be off.
7. If the exhaust temperature drops below 38 degrees (adj.) the energy wheel will be off and alarm will be issued at the operator Workstation.

I. Economizer Unoccupied Cooling Control:

1. Economizer unoccupied cooling mode shall be enabled when the following conditions are true:
 - a. Associated zone requires cooling
 - b. Supply fan is operating.
 - c. Outdoor air is at or less than 25 deg BTUH. (adj.)
 - d. Mixed air temperature is less than the discharge air temperature.
2. When economizer unoccupied mode is enabled:
 - a. Exhaust air damper shall fully open.

- b. Outside air and mixed air damper shall modulate to maintain discharge air temperature setpoint.
 - c. Supply air energy wheel bypass damper shall be fully open.
 - d. Exhaust air energy wheel bypass damper shall be fully open.
- J. Mixed Air Temperature Reset:
 - 1. Mixed air temperature will be the result of the discharge of the energy wheel and the return air. The speed of the energy recovery wheel is a fixed value, so the mixed air temperature is controlled to setpoint by use of modulating the return air damper.
- K. Unoccupied Heating: When the space temperature drops in below heating unoccupied set point, BAS will initiate mechanical heating unoccupied mode as follows:
 - 1. Supply fan shall cycle on.
 - 2. Gas valve shall modulate to maintain discharge temperature set point until unoccupied space temperature set point is satisfied.
- L. Unoccupied Cooling: When an associated space temperature rises above cooling unoccupied set point, BAS will initiate mechanical cooling unoccupied mode as follows:
 - 1. Outdoor air damper will be closed unless Economizer is available.
 - 2. Recirculation damper will be opened.
 - 3. Supply fan will cycle on.
 - 4. Initiate compressors and modulate to maintain Un-occupied space temperature set point. Compressor shall not operate if supply fan current relay is not activated.
 - 5. Enabled compressors will not be allowed to deactivate until the minimum run time has elapsed.
- M. Unoccupied Dehumidification: When the space dew point temperature rises above dew point unoccupied set point, BAS will initiate dehumidification unoccupied mode as follows:
 - 1. Supply Fan will cycle on.
 - 2. Initiate compressor to maintain unoccupied space dehumidification set point. Compressor shall not operate if supply fan current relay is activated
 - 3. Modulate hot gas reheat coil to maintain discharge air temperature setpoint (68 F) adjustable.
- N. Occupied Damper Control:
 - 1. Supply air energy wheel bypass damper shall be fully closed unless in Economizer Mode.

2. Exhaust air energy wheel bypass damper shall be fully closed unless in Economizer Mode.
3. Outside air damper shall open to minimum position as determined by the TAB.
4. Exhaust air damper shall open to minimum position as determined by the TAB.
5. Mixed air damper shall open to minimum position as determined by the TAB.
6. Damper position status will be monitored. If the damper position does not match the damper position setpoint within 5 minutes, and alarm will be generated.

O. Occupied Economizer Cooling Control:

1. BMS will allow economizer cycles to be activated based on outside air conditions if the return air temperature and enthalpy is greater than the outside air temperature and enthalpy with a hysteresis of 5°F, the outside air enthalpy is less than 22 Btu/lb with a hysteresis of 2 Btu/lb, the outside air temperature is less than 65°F with a hysteresis of 2°F, and the outside air readings are valid.
2. If the mixed air temperature drops below 48°F, the AHU controller will begin to close the economizer to protect the coil. The controller will continue to close the damper linearly until the temperature drops to 40°F, when the economizer/ventilation damper will be 100% closed.
3. If the mixed air temperature remains lower than 45°F for 5 minutes with a 5°F hysteresis and alarm will be generated. This alarm will not be enabled until the supply fan has been running for 30 minutes.
4. If the mixed air temperature remains higher than 90°F for 5 minutes with a 5°F hysteresis. This alarm will not be enabled until the supply fan has been running for 30 minutes.
5. DX cooling and dehumidification mode shall be locked out.
6. Outside air damper and return air damper shall modulate to maintain discharge air set point.
7. Energy wheel bypass dampers will be open.
8. Energy wheel will be off.
9. Relief air fan shall be enabled.
10. The relief fan VFD speed shall modulate to maintain the relief CFM offset setpoint from the Outdoor air CFM.

P. Demand Control Ventilation Occupied Damper Control:

1. CO2 damper control shall be enabled when the following conditions are true:
 - a. An associated zone is at or above the zone CO2 level setpoint for 15 minutes or more

- b. The outdoor CO2 level is below the indoor level setpoint.
- 2. When Demand Control Ventilation is enabled:
 - a. Modulate OA damper between scheduled minimum damper position and fully open damper position as required to maintain CO2 level setpoint.
 - b. When all associated zones are within the CO2 level setpoint, the unit will resume in the Occupied Mode.

Q. Occupied Energy Wheel Control:

- 1. Energy wheel shall operate unless in economizer mode or defrost mode.
- 2. In economizer or defrost mode, energy wheel shall not rotate.
- 3. Defrost Control: When the differential pressure across the wheel exceeds the recommended setpoint, the wheel will be stopped to defrost a portion of the wheel. The wheel will then be jogged ON and the stopped at another section, the defrost cycle will continue until the differential pressures indicate the wheel has been defrosted.

R. Occupied Fan Control:

- 1. The Supply fan will start and run continuously. If the fan fails to operate, an alarm will be generated.
- 2. Relief fan shall be enabled to operate whenever the supply fan is enabled. The relief fan VFD speed shall track the supply fan speed with a ten percent (10%) offset. (adj. for balancing)
- 3. If the unit is in cooling mode and the discharge air temperature reset setpoint is at its maximum and the space temperature is approaching the space temperature setpoint, the supply fan speed will begin to modulate to a slower speed. The fan speed will continue to modulate slower until the fan minimum speed is reached or the space temperature begins to rise.
- 4. If the unit is in heating mode, the discharge air temperature setpoint will reset until it reaches the maximum setpoint. Once the fan reaches the maximum setpoint, and the space temperature approaches the space temperature setpoint, the fan speed will modulate to a slower speed until it reaches its minimum speed setpoint or the space temperature begins to drop below the space temperature setpoint.

S. Unoccupied Fan Control:

- 1. The supply and exhaust fans will be off unless;
- 2. One of the associated zones calls for heating or cooling in night setback mode, or one of the associated zones is set into Occupied mode by one of the zone override buttons.

3. If the zone is set into Occupied mode by an override, then the fans will operate as in “Occupied” mode.
4. The Supply fan will start and run continuously. If the fan fails to operate, an alarm will be generated.
5. Relief fan shall be enabled to operate whenever the supply fan is enabled. The relief fan VFD speed shall track the supply fan speed with a ten percent (10%) offset. (adj. for balancing)
6. If the unit is in cooling mode and the discharge air temperature reset setpoint is at its maximum and the space temperature is approaching the space temperature setpoint, the supply fan speed will begin to modulate to a slower speed. The fan speed will continue to modulate slower until the fan minimum speed is reached or the space temperature begins to rise.
7. If the unit is in heating mode, the discharge air temperature setpoint will reset until it reaches the maximum setpoint. Once the fan reaches the maximum setpoint, and the space temperature approaches the space temperature setpoint, the fan speed will modulate to a slower speed until it reaches its minimum speed setpoint or the space temperature begins to drop below the space temperature setpoint.

T. Occupied Heat Control:

1. Economizer mode and cooling mode will be locked out.
2. The gas heating will be enabled. The gas valve will modulate to maintain the discharge air temperature setpoint.

U. Occupied DX Cooling Control

1. Dehumidification mode and economizer cooling mode shall be locked out.
2. Reset outside air and mixed air damper to minimum position.
3. Initiate DX compressor(s). Modulating compressors shall operate as the first cooling stage. If the modulating compressor cannot maintain the discharge air temperature setpoint, the second compressor will be enabled and modulated to maintain the discharge air temperature setpoint. Compressors, once enabled will be on until the minimum run time has elapsed. Compressor shall not operate if supply fan current relay is not activated or condensate pan water detection is activated or compressor high pressure is activated. Roof top equipment manufacture shall take control of the condenser fan operation.

V. Occupied Dehumidification Control:

1. If the return air dewpoint rises above 55°F (adj) = (75°F @ 50%RH) the modulation of the D/X cooling compressors will be overridden to dehumidify the air and the hot gas reheat valve will be modulated to maintain the supply air setpoint.

2. Reset outside air damper to minimum position.
3. Initiate DX compressor(s). Modulating compressors shall operate as the first dehumidification stage and run at 100% capacity. Compressor shall not operate if supply fan current relay is not activated or condensate pan water detection is activated or compressor high pressure is activated. Roof top equipment manufacture shall take control of the condenser fan operation.
4. Enable and Modulate the hot gas reheat valve to maintain the last discharge air temperature setpoint.

W. UV Filtering:

1. The units will be supplied with UV filtering
2. The UV will be monitored for run status
3. The run time will be tracked. Once the run hours have reached the “Change UV Bulb” hours, a message will be generated at the operator workstation.

1.12 CLASSROOM AIR HANDLING UNIT (AHU)

A. General Conditions:

1. The unit will be controlled by the field mounted BMS controller provided by the ATC.
2. Control dampers are provided with unit. ATC to provide, mount and wire actuators.
3. Hot water control valve/ actuator assemblies will be provided by the ATC.

B. Enabling: AHU will be controlled by the building automation system (BAS) as provided by the ATC. BAS unit controller to operate in occupied mode or unoccupied mode if any of the following devices are not activated.

1. Internal safety devices.
 - a. Fans shall be off.
 - b. OA and EA dampers shall be closed.
 - c. RA damper shall be full open.
 - d. Issue alarm to operator’s work station.
2. Low temperature limit.
 - a. Fans shall be off.
 - b. Hot water valves shall be modulated open.
3. OA and EA dampers shall be closed.

- a. RA damper shall be full open.
 - b. Issue alarm to operator's work station.
- C. Unoccupied Damper Control and Energy Recovery Wheel Control:
 1. Outside air damper shall be fully closed unless unoccupied economizer mode is enabled.
 2. Exhaust air damper shall be fully closed unless unoccupied economizer mode is enabled.
 3. Return air damper shall be fully open unless unoccupied economizer mode is enabled.
 4. Energy wheel shall be off.
- D. Economizer Unoccupied Control:
 1. Economizer unoccupied mode shall operate the same as in Occupied Mode.
- E. Unoccupied Heating: When the space temperature drops in below heating unoccupied set point, BAS will initiate mechanical heating unoccupied mode as follows:
 1. Supply fan shall cycle on.
 2. The VRF coil will be in heating mode. The VRF controller will maintain the space temperature setpoint provided by the BMS system.
 3. If the outdoor air temperature is below 40 degrees (adj.) , the hot water valve will modulate to maintain the space temperature setpoint.
- F. Unoccupied Cooling: When an associated space temperature rises above cooling unoccupied set point, BAS will initiate mechanical cooling unoccupied mode as follows:
 1. Outdoor air damper will be closed unless Economizer is available.
 2. Recirculation damper will be opened.
 3. Supply fan will cycle on.
 4. Exhaust Fan will be Off
 5. Energy Wheel will be Off.
 6. The VRF coil will be in Cooling mode. The VRF controller will maintain the space temperature setpoint provided by the BMS system.
- G. Unoccupied Dehumidification: When the space dew point temperature rises above dew point unoccupied set point, BAS will initiate dehumidification unoccupied mode as follows:
 1. Enabled If the zone dewpoint rises above 55°F (adj) = (75°F @ 50%RH)
 2. Supply Fan will cycle on and run at 50% speed (adjustable)

3. The VRF coil will be in Dehumidification mode. The BMS will send the VRF system a cooling setpoint.
 4. If the space humidity cannot be maintained, and reaches 74% RH (adjustable), the VRF system will be put into cooling mode, the fan speed will increase to 100% and the hot water valve will modulate to maintain the space temperature setpoint.
- H. Occupied Damper Control:
1. Outside air damper shall open.
 2. Mixed air damper shall open to minimum position as determined by the TAB.
- I. Occupied Economizer Cooling Control:
1. BMS will allow economizer cycles to be activated based on outside air conditions if the Zone temperature and enthalpy is greater than the outside air temperature and enthalpy with a hysteresis of 5°F, the outside air enthalpy is less than 22 Btu/lb with a hysteresis of 2 Btu/lb, the outside air temperature is less than 65°F with a hysteresis of 2°F, and the outside air readings are valid.
 2. During a call for cooling the recovery damper will be open, the relief fan will ramp to a higher speed and the tilting wheel function will be enabled to by-pass the wheel and allow a higher volume of outside air. The return air will modulate open allowing mixing between the room and the outdoor air to achieve the discharge air setpoint. The discharge air should not drop below 50 deg.
 3. If the mixed air temperature remains lower than 45°F for 5 minutes with a 5°F hysteresis and alarm will be generated. This alarm will not be enabled until the supply fan has been running for 30 minutes.
 4. DX cooling and dehumidification mode shall be locked out.
 5. Energy wheel bypass dampers will be open.
 6. Energy wheel will be off.
 7. Relief air fan shall be enabled.
 8. The relief fan ECM speed shall modulate to maintain the relief CFM offset setpoint from the Outdoor air CFM.
- J. Demand Control Ventilation Occupied Damper Control:
1. CO2 damper control shall be enabled when the following conditions are true:
 - a. Zone is at or above the zone CO2 level setpoint for 15 minutes or more
 - b. The outdoor CO2 level is below the indoor level setpoint.

2. When Demand Control Ventilation is enabled:
 - a. Modulate OA damper between scheduled minimum damper position and fully open damper position as required to maintain CO2 level setpoint.
 - b. The energy wheel tilt function will be enabled to allow air to by-pass the wheel.
 - c. When zones is within the CO2 level setpoint, the unit will resume in the Occupied Mode.

K. Occupied Energy Wheel Control:

1. Energy wheel shall operate unless in economizer mode or defrost mode.
2. ASHRAE cycle II outdoor air requirements will be met through operation of the energy recovery wheel. During all Occupied periods the wheel will be enabled, the incoming recovery damper will be open, the return air damper will modulate to a minimal position allowing air to be drawn through the wheel and the relief fan will be enabled at low speed.
3. In economizer or defrost mode, energy wheel shall by-pass air.
4. Defrost Control: When the differential pressure across the wheel exceeds the recommended setpoint, the wheel will be stopped to defrost a portion of the wheel. The wheel will then be jogged ON and the stopped at another section, the defrost cycle will continue until the differential pressures indicate the wheel has been defrosted.

L. Occupied Fan Control:

1. The Supply fan will start and run continuously. If the fan fails to operate, an alarm will be generated.
2. Relief fan shall be enabled to operate whenever the supply fan is enabled. The relief fan ECM speed shall track the outdoor air damper position.
3. If the unit is in cooling mode and the discharge air temperature reset setpoint is at its maximum and the space temperature is approaching the space temperature setpoint, the supply fan speed will begin to modulate to a slower speed. The fan speed will continue to modulate slower until the fan minimum speed is reached or the space temperature begins to rise.
4. If the unit is in heating mode, the discharge air temperature setpoint will reset until it reaches the maximum setpoint. Once the fan reaches the maximum setpoint, and the space temperature approaches the space temperature setpoint, the fan speed will modulate to a slower speed until it reaches its minimum speed setpoint or the space temperature begins to drop below the space temperature setpoint.

M. Occupied Heat Control:

1. When space temperature drops below set point, heating mode shall be enabled.

2. If the outdoor air temperature is below 40 degrees (adj.) the primary source of heating will be the hot water coil. The hot water valve will modulate to maintain the space temperature setpoint.
3. If the outdoor air temperature is above 40 degrees, the primary source of heat will be the VRF system. The BMS will activate the VRF zone into heating mode.

N. Occupied DX Cooling Control

1. Dehumidification mode and economizer cooling mode shall be locked out.
2. Initiate DX cooling mode through the VRF system interface.
3. The VRF system controller will maintain the space temperature setpoint as set by the BMS system.

O. Occupied Dehumidification Control:

1. Enabled If the zone dewpoint rises above 55°F (adj) = (75°F @ 50%RH)
2. Supply Fan will cycle on and run at 50% speed (adjustable)
3. The VRF coil will be in Dehumidification mode. The BMS will send the VRF system a cooling setpoint.
4. If the space humidity cannot be maintained, and reaches 74% RH (adjustable), the VRF system will be put into cooling mode, the fan speed will increase to 100% and the hot water valve will modulate to maintain the space temperature setpoint.

1.13 VRF SYSTEM

- A. The VRF system will be used for heating and cooling. The VRF modes will be controlled by the BMS system through a BACnet interface.
- B. If the zone requires cooling, as sensed by the BAS provided temperature sensor, the BAS will request the VRF system to be in cooling mode. The VRF controller will compare the BAS setpoint to the VRF supplied temperature sensor reference and control to maintain the zone temperature setpoint.
- C. If the zone requires heating, as sensed by the BAS provided temperature sensor, and the outdoor air temperature is above 45 degrees (adj.) the BAS will request the VRF system to be in heating mode. The VRF controller will compare the BAS setpoint to the VRF supplied temperature sensor reference and control to maintain the zone temperature setpoint.
- D. If the zone requires heating, as sensed by the BAS provided temperature sensor, and the outdoor air temperature is below 45 degrees (adj.) the BAS will request the VRF system to be off. The heating will be provided by the hot water system.
- E. The BAS will communicate to the VRF system global controller via BACnet.

1. System modes, zone temperature setpoints, system alarms, system scheduling will be interfaced.
2. All communications control wiring will be provided by the ATC.
3. Reference sensor (provided by the VRF system manufacturer) will be wired by the ATC.

1.14 HOT WATER PERIMETER RADIANT CEILING PANELS

- A. In Occupied mode, If the zone is below the space temperature setpoint the radiant ceiling panel hot water valve will cycle open to maintain the space temperature setpoint.
- B. In Un-Occupied mode, If the zone is below the night setback space temperature setpoint, the hot water valve will cycle to maintain the night setback space temperature setpoint.
- C. If the zone is satisfied the hot water valve will be closed.

1.15 TOILET EXHAUST FAN CONTROL

- A. Enabling: Exhaust fan will be controlled by the building automation system (BAS). BAS unit controller to operate in occupied mode or unoccupied mode.
- B. Unoccupied Mode:
 1. Damper shall be fully closed.
 2. Fan shall not operate.
- C. Occupied Mode:
 1. Damper shall be fully open.
 2. Fan shall be enabled via damper fully open position status switch. When enabled, fan shall operate continuously.

1.16 KILN ROOM EXHAUST FAN CONTROL

- A. Fan will operate continuously when the Kiln is “On”
- B. The exhaust air control damper shall be closed when the exhaust fan is off and open when the exhaust fan is on. The exhaust fan shall not start until proof (by end switch) that the exhaust air control damper is open.
 1. The space temperature in the room will be monitored. If the space temperature rises above 79 degrees, the damper will open and the fan will start.
 2. If the space temperature rises above 84 degrees, and alarm will be generated at the workstation.

1.17 BOILER ROOM AND ELECTRICAL ROOMS EXHAUST FAN CONTROL

- A. The exhaust air control dampers shall be closed when the exhaust fan is off and open when the exhaust fan is on. The exhaust fan shall not start until proof (by end switch) that the exhaust air control damper is open.
 - 1. The space temperature in the room will be monitored. If the space temperature rises above 79 degrees, the damper will open and the fan will start.
 - 2. If the space temperature rises above 84 degrees, and alarm will be generated at the workstation.

1.18 KITCHEN EXHAUST FAN

- A. Fan will be enabled and disabled by the BAS system for Occupied and Un-Occupied hours.
- B. The fan will be turned on by a wall mounted, manually operated switch.
- C. The fan will be monitored for run status.
- D. If the manual switch is "On" and the fan is in Occupied mode, but does not run as indicated by a current switch, an alarm will be issued at the operator workstation.
- E. Whenever the fan is energized associated make-up unit MAU-1 shall start.

1.19 KITCHEN MAKE UP AIR MAU-1

- A. The Kitchen Make Up Air units will be enabled and disabled by the BAS system for Occupied and Un-Occupied Modes. The units will also be interlocked with the associated exhaust fan.
- B. The Exhaust Fan will be Enabled by the BMS system on a Time of Day Schedule. The fan will however be manually started. If the fan are enabled, and the manual switch is activated and the fan fails to operate, an alarm will be generated.
- C. When the unit is enabled, the outdoor air damper will open and the fan will run continuously. If the fan fails to start, the outdoor air damper will be closed, the heat and cooling will be disabled and an alarm will be generated at the workstation.
- D. The fan speed will be based on which Exhaust fan is operating. The Fan speed will be set to provide 10% more supply air than is being exhausted.
- E. Occupied heating mode: If the outdoor air temperature is lower than the supply air temperature setpoint, the gas heat will be enabled / disabled and modulate to maintain the discharge air temperature setpoint.
- F. Occupied Cooling mode: If the outdoor air temperature is higher than the discharge air temperature setpoint, the cooling will be enabled. The first stage compressor will modulate to maintain the discharge air temperature. If the discharge air temperature setpoint cannot be maintained, the second stage compressor will be enabled.

- G. Occupied Dehumidification mode: The supply air temperature and humidity will be monitored. If the supply air relative humidity rises above 65 percent (adj.), the unit will enable the dehumidification mode. The compressors will be enabled, the hot gas reheat will be enabled and modulate to maintain the discharge air temperature.
- H. At no time will compressors be enabled if the supply fan has not been proven on.
- I. Compressors will not be allowed to shut off before the minimum run time.
- J. During Un-Occupied hours the unit will be de-energized and radiant ceiling panel hot water valve will modulate to maintain space temperature. When radiant ceiling panels cannot maintain space temperature setpoint, the unit will be energized. The outdoor air damper will be closed, and the return air damper will be opened unless in Economizer Cooling mode.
- K. Economizer Unoccupied Cooling Control:
 - 1. Economizer unoccupied cooling mode shall be enabled when the following conditions are true:
 - a. Associated zone requires cooling
 - b. Supply fan is operating.
 - c. Outdoor air is at or less than 25 deg BTUH. (adj.)
 - d. Mixed air temperature is less than the discharge air temperature.
 - 2. When economizer unoccupied mode is enabled:
 - a. Exhaust air damper shall fully open.
 - b. Outside air and mixed air damper shall modulate to maintain discharge air temperature setpoint.

1.20 REFRIGERATOR / FREEZER

- A. DDC system will monitor the temperature of each refrigerator and freezer. If the temperature rises above the alarm setpoint, an alarm will be generated.
- B. Temperature sensor shall be rated for low temperatures and be "liquid bath" type.

1.21 CUH/UH SEQUENCE OF OPERATIONS

- A. When space temperature decreases below setpoint, two-position HW control valve shall fully open. The hot water temperature leaving the coil will be monitored. When the HW temperature reaches 90 degrees, the fan will be enabled. If the fan fails to start, an alarm will be generated.

1.22 SPLIT SYSTEM AIR CONDITIONING UNITS

- A. The split system air conditioning units will be provided with integral controllers and wireless zone sensors by the unit manufacturer. The ATC will provide all network and condensing unit

interlock wiring.

- B. The ATC shall be responsible for providing an additional temperature sensor monitoring purposes.
- C. The split systems will be provided by others with a BACnet (MS/TP) integration board. The BMS will monitor the unit via BACnet.

1.23 CEILING DESTRATIFICATION FANS

- A. BMS will interface to the factory provided controller vis BACnet. All system data available through the interface will be displayed at the operator workstation.
- B. Fans will be enabled to run during Occupied hours and disabled during Un-Occupied hours.
- C. Fan speed will be determined by temperature sensors located at 4' and 18' AFF.
- D. If a fire is detected by the fire alarm system, the fans will shut down immediately.
- E. Alarms:
 - 1. Cautionary alarm when Occupancy is overridden
 - 2. Unit stopped condition
 - 3. Fault / failure

1.24 DOMESTIC HOT WATER HEATING

- A. The domestic hot water system will be enabled /disabled based on a time of day schedule.
- B. The hot water pumps will lead / lag based on lead pump failure and weekly rotation.
- C. If either pump fails to start when commanded On, an alarm will be generated.
- D. The tank temperatures will be monitored.
- E. If the domestic hot water temperature drops 15 degrees below setpoint, an alarm will be generated at the operator workstation.

1.25 BUILDING KWH

- A. The Building KWH meters will be provided by Division 26.
- B. A MODBUS interface to the power monitoring panel will be provided by the ATC. All KWH branches will be displayed at the operator workstation on a single graphic.

1.26 GENERATOR / TRANSFER SWITCH

- A. The Generator will be monitored for all available information through the MODBUS gateway.

- B. The Stand by transfer Switch will be monitored for “Normal” position status and “Stand by Power” status.
- C. While the Stand by transfer switch is in “Stand by”Power mode, the Energy Recovery Units and Pumps will Enabled /Disabled to run in a rotation. All of the ERUs will be part of a rotation list. The rotation of units will be manually selectable from the list. The quantity of units will be dependent on the units selected to not over burden the Generator.
- D. The user will have the ability to cycle ERUs for a period of time and automatically shut down the running units, and rotate to the next set of units.
- E. The units will stagger start: i.e. if (4) ERUs are selected; each ERU will start 3 minutes apart from each other.
- F. MUA-1 will be allowed to operate in Stand-by mode.
- G. Pumps will be allowed to operate in stand-by mode.

1.27

1.28 ALARMS

- A. Safety Alarms: Alarm shall be issued to BAS head end if any internal safety alarms are activated.
- B. Smoke Detector and FACP Alarm: Alarm shall be issued to the BAS head end if duct mounted smoke detector or FACP is activated. Associated unit and fans shall not operate.
- C. Fan Alarm: Alarm shall be issued to BAS head end if current relay is activated when fan does not operate when enabled.
- D. Filter Alarm: Alarm shall be issued to the head end if pressure level is activated.
- E. Damper Position Alarm: Alarm shall be issued to the head end if damper position in not in the correct location during occupied or unoccupied mode. Damper positions will be a result of a hard-wired feedback to the BAS controller from the damper actuator.
- F. Valve Position Alarm: Alarm shall be issued to the head end if valve position in not in the correct location during occupied or unoccupied mode. Valve positions will be a result of a hard-wired feedback to the BAS controller from the damper actuator. Not applicable to perimeter radiation, cabinet unit heaters or unit heaters.
- G. VFD Alarm: Alarm shall be issued to the head end if VFD fault is activated.
- H. Boiler High Temperature Limit: BAS receives signal from boiler control panel via BACnet interface.
- I. Boiler Low Temperature Limit: BAS receives signal from boiler control panel via BACnet interface.

- J. Boiler Low Water Cut-Off: BAS receives signal from boiler control panel via BACnet interface.
- K. Burner Failure: BAS receives signal from boiler control panel via BACnet interface.
- L. Pump Alarm: Alarm shall be issued to BAS head end if current relay is activated when pump does not operate when enabled.
- M. Occupied and Unoccupied Zone Temperature Alarm: If space condition cannot be maintained for a specified time duration, alarm shall be issued to the BAS head end.
- N. Refrigerators / Freezers: If space condition cannot be maintained for a specified time duration, alarm shall be issued to the BAS head end.

1.29 CLOSEOUTS

- A. See Section 017800-Closeout Submittals, for closeout submittals.
- B. See Section 017900-Demonstration and Training, for additional requirements.
- C. Provide minimum 16 hours of training.

END OF SECTION 23 09 93

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SECTION 23 21 13 - HYDRONIC PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Hydronic system requirements.
- B. Heating water/glycol piping, above grade.
- C. Pipe and pipe fittings for:
 - 1. Heating water piping system.
 - 2. Equipment drains and overflows.
- D. Pipe hangers and supports.
- E. Unions, flanges, mechanical couplings, and dielectric connections.
- F. Valves:
 - 1. Globe or angle valves.
 - 2. Ball valves.
 - 3. Butterfly valves.
 - 4. Check valves.
 - 5. Pressure independent temperature control valves and balancing valves.
- G. Flow controls.

1.3 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.
- B. Section 07 84 13 - Penetration Firestopping
- C. Section 08 31 13 - Access Doors and Panels.
- D. Section 23 05 16 - Expansion Fittings and Loops for HVAC Piping.
- E. Section 23 05 48 - Vibration and Seismic Controls for HVAC.

- F. Section 23 05 53 - Identification for HVAC Piping and Equipment.
- G. Section 23 07 19 - HVAC Piping Insulation.
- H. Section 23 21 14 - Hydronic Specialties.
- I. Section 23 25 00 - HVAC Water Treatment: Pipe cleaning.

1.4 REFERENCE STANDARDS

- A. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators 2021.
- B. ASME B16.15 - Cast Copper Alloy Threaded Fittings: Classes 125 and 250 2018.
- C. ASME B16.3 - Malleable Iron Threaded Fittings; The American Society of Mechanical Engineers; 1998 (R2006).
- D. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2018.
- E. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings 2018.
- F. ASME B31.9 - Building Services Piping 2020.
- G. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2001 (R2005).
- H. ASME B31.9 - Building Services Piping; The American Society of Mechanical Engineers; 2008 (ANSI/ASME B31.9).
- I. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless 2020.
- J. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service 2019.
- K. ASTM B32 - Standard Specification for Solder Metal 2020.
- L. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2020.
- M. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2020.
- N. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers 1992, with Editorial Revision (2018).
- O. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications 2007 (Reapproved 2019).
- P. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding 2019.

- Q. ASTM F2165 - Standard Specification for Flexible Preinsulated Piping.
- R. AWWA C606 - Grooved and Shouldered Joints 2015.
- S. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018.

1.5 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for submittal procedures.
- B. Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.
- C. Welders Certificate: Include welders certification of compliance with ASME BPVC-IX.
- D. Product Data:
 - 1. Include data on pipe materials, pipe fittings, valves, and accessories.
 - 2. Provide manufacturers catalog information.
 - 3. Indicate valve data and ratings.
 - 4. Show grooved joint couplings, fittings, valves, and specialties on drawings and product submittals, specifically identified with the manufacturer's style or series designation.
- E. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- F. Project Record Documents: Record actual locations of valves.
- G. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
- H. Grooved joint couplings, fittings, valves, and specialties shall be shown on product submittals and shall be specifically identified with the applicable Victaulic style or series designation.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum 10 years of documented experience.
 - 1. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
 - 2. All castings used for couplings housings, fittings, or valve and specialty bodies shall be date stamped for quality assurance and traceability.
- B. Installer Qualifications: Company specializing in performing work of the type specified in this section with minimum five years of experience.

- C. Provide all grooved joint couplings, fittings, valves, specialties, and grooving tools from a single manufacturer.
- D. Coupling Manufacturer:
 - 1. Perform on-site training by factory-trained representative to the Contractor's field personnel in the proper use of grooving tools and installation of grooved joint products.
- E. Welder Qualifications: Certify in accordance with ASME BPVC-IX.

1.7 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 code for installation of piping system.
- B. Welding Materials and Procedures: Conform to ASME (BPV IX) and applicable state labor regulations.
- C. Provide certificate of compliance from authority having jurisdiction, indicating approval of welders.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary protective coating on cast iron and steel valves.
- C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.9 WARRANTY

- A. The warranty period shall be a non-prorated period of 12 months from date of acceptance by the Owner and completion of commissioning.
- B. Pre-insulated Pipe Manufacturer's Warranty: Submit, for owner's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights owner may have under contract documents.
 - 1. Warranty covers the repair or replacement of any piping or fittings proven defective.
 - 2. Warranty may transfer to subsequent owners.
 - 3. The manufacturer's warranty shall be a minimum of 10 years, non-prorated, on the carrier tubing and 10 years on the fittings, insulation, and cover beginning with the date of final acceptance by the Owner and completion of commissioning.

PART 2 PRODUCTS

2.1 HYDRONIC SYSTEM REQUIREMENTS

- A. Comply with ASME B31.9 and applicable federal, state, and local regulations.
- B. Piping: Provide piping, fittings, hangers, and supports as required, as indicated, and as follows:
 - 1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.
 - 2. Use non-conducting dielectric connections whenever jointing dissimilar metals.
 - 3. Grooved mechanical joints may be used in accessible locations only.
 - a. Accessible locations include those exposed on interior of building, and in mechanical rooms, aboveground outdoors, and as approved by the Architect.
 - b. Do not install grooved piping inside chases.
 - c. Grooved mechanical connections and joints comply with AWWA C606, and ASTM F1476: Standard for Performance of Gasketed Mechanical Couplings in Piping applications.
 - d. Use rigid joints unless otherwise indicated.
 - 4. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.
 - 5. Provide pipe hangers and supports in accordance with ASME B31.9 unless indicated otherwise.
- C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges, unions, or grooved couplings to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.
 - 1. Where grooved joints are used in piping, provide grooved valve/equipment connections if available; if not available, provide flanged ends and grooved flange adapters.
- D. Valves: Provide valves where indicated:
 - 1. Provide drain valves where indicated, and if not indicated provide at least at main shut-off, low points of piping, bases of vertical risers, and at equipment. Use 3/4 inch gate or ballvalves with cap; pipe to nearest floor drain.
 - 2. Isolate equipment using butterfly valves with lug end flanges or grooved mechanical couplings.
 - 3. For throttling, bypass, or manual flow control services, use globe, ball, or butterfly valves.

4. In heating water systems, butterfly valves may be used interchangeably with ball, gate and globe valves.
5. For shut-off and to isolate parts of systems or vertical risers, use gate, ball, or butterfly valves.
6. For throttling service, use plug cocks. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.

2.2 HEATING WATER/GLYCOL PIPING, ABOVE GRADE

- A. Steel Pipe (greater than 2 inch pipe size): ASTM A53/A53M, Schedule 40, black, using one of the following joint types:
 1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1/D1.1M welded.
 2. Threaded Joints: ASME B16.3, cast iron fittings.
 3. Grooved Joints: AWWA C606 grooved pipe, fittings of ASTM A536 ductile iron, ASTM A234 wrought steel, or factory-fabricated from ASTM A53 steel pipe, and mechanical couplings.
 4. Fittings: ASTM B 16.3, cast iron or ASTM A 234/A 234M, wrought steel welding type fittings.
 5. Joints: Threaded, or AWS D1.1 welded.
 - a. 3/4" to 2" - threaded cast iron.
 - b. 2-1/2" and larger - welded or grooved mechanical joint.
 6. Mechanical Joints: Groove pipe per ANSI/AWWA C606. Consisting of two ductile iron housing segments, pressure responsive elastomer gasket, and ASTM A449 compliant bolts and nuts.
 - a. Rigid Type Couplings: Housing cast with offsetting, angle pattern bolt pads to provide rigidity and system support when hanging in accordance with ANSI B31.1 and B31.9. Installation-Ready for complete installation without field disassembly, complete with grade EHP gasket suitable for water service to 250 deg. F. Basis of Design: Victaulic Style 107N.
 - b. Flexible Type Couplings: Used in locations where vibration attenuation and stress relief are required. Installation-Ready Style 177 and Victaulic Style 77
 - c. Flanged Adapters: Flat face, for direct connection to ANSI Class 125 or 150 flanged components. Victaulic Style 741.
- B. Copper Tube (2" pipe size and smaller) : ASTM B 88 (ASTM B 88M), Type L (B), drawn.

1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings.
2. Solder Joints: ASME B16.22 solder wrought copper fittings.
 - a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
 - b. Braze: AWS A5.8M/A5.8 BCuP copper/silver alloy.
3. Mechanical Joints: Copper press fittings as manufactured by Viega or Rigid Tool Co.
 - a. Press fittings: Copper press fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22. O-rings for copper press fittings shall be EPDM.
 - b. Victaulic Installation-Ready™ fittings for 2” through 3” grooved end copper tubing; ductile iron conforming to ASTM A-536, Grade 65-45-12, with Installation-Ready™ ends, complete with PVDF (Poly Vinylidene Fluoride) and Grade “EHP” EPDM-HP [Grade ‘T’ Nitrile] gasket; and ASTM A449 electroplated steel bolts and nuts, rated to 300 psi (2065 kPa) with Type K or L Copper Tubing.

2.3 EQUIPMENT/CONDENSATE DRAINS AND OVERFLOWS

- A. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), drawn; using one of the following joint types:
 1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings; ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
 2. Mechanical Joints: Copper press fittings as manufactured by Viega or Rigid Tool Co.
 - a. Press fittings: Copper press fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22. O-rings for copper press fittings shall be EPDM.

2.4 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
 1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
- B. Conform to ASME B31.9.
- C. Hangers for Pipe Sizes 1/2 to 1-1/2 Inches: Malleable iron, adjustable swivel, split ring.
- D. Hangers for Cold Pipe Sizes 2 Inches and Greater: Carbon steel, adjustable, clevis.
- E. Hangers for Hot Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
- F. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.

- G. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
 - H. Wall Support for Pipe Sizes 4 Inches and Greater: Welded steel bracket and wrought steel clamp.
 - I. Vertical Support: Steel riser clamp.
 - J. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - K. Floor Support for Hot Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 - L. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
 - M. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
 - N. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.
 - O. In grooved installations, use rigid couplings with offsetting angle-pattern bolt pads or with wedge-shaped grooves in header piping to permit support and hanging in accordance with ASME B31.9.
- 2.5 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS
- A. Unions for Pipe of 2 Inches and Less:
 - 1. Ferrous Piping: 150 psi brass or malleable iron, threaded.
 - 2. Copper Pipe: Bronze, soldered joints.
 - B. Flanges for Pipe 2 Inches and Greater:
 - 1. Ferrous Piping: 150 psig forged steel, slip-on.
 - 2. Copper Piping: Bronze.
 - 3. Gaskets: 1/16 inch thick, preformed neoprene.
 - 4. Use grooved joint flange adapters in grooved piping systems. Victaulic Style 741.
 - C. Mechanical Couplings for Grooved and Shouldered Joints: Two curved housing segments with continuous key to engage pipe groove, circular C-profile gasket, and bolts to secure and ASTM A449 compliant compress gasket.
 - 1. Dimensions and Testing: In accordance with AWWA C606.
 - 2. Mechanical Couplings: Comply with ASTM F1476.

3. Housing Material: Ductile iron, enamel coated or galvanized.
4. Housing Clamps: Two ductile iron housings, enamel coated or galvanized to engage and lock, designed to permit some angular deflection, contraction, and expansion where required.
5. Gasket Material:
 - a. EPDM-HP suitable for operating temperature range from minus 30 degrees F to 250 degrees F.
 - b. EPDM suitable for operating temperature range from minus 30 degrees F to 230 degrees F.
6. Bolts and Nuts: ASTM A449 compliant, or zinc-electroplated steel.
7. When pipe is field grooved, provide coupling manufacturer's grooving tools.
 - a. Fully automated grooving tool with touch screen controls and integral laser sensors. Tools provide traceable measurements that can be recorded locally or exported as required. Measurements include groove traceability documents, corresponding identification marks on the pipe, and confirm all critical dimensions fall into the required tolerance range as listed by the tool manufacturer for each groove. Validation records provided for the gasket sealing surface, groove width, groove diameter, pipe flare, and pipe OD. Basis of Design: Victaulic RG5200i.

D. Dielectric Connections:

1. Waterways:
 - a. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
 - b. Dry insulation barrier able to withstand 600-volt breakdown test.
 - c. Construct of galvanized steel with threaded end connections to match connecting piping.
 - d. Suitable for the required operating pressures and temperatures.
 - e. Fittings shall be a copper-silicon casting conforming to UNS C87850, and UL classified in accordance with ANSI / NSF-61 for potable water service. Fittings shall have threaded ends, grooved ends, or a combination. Basis of Design: Victaulic Style 647.
2. Flanges:
 - a. Dielectric flanges with same pressure ratings as standard flanges.

- b. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
 - c. Dry insulation barrier able to withstand 600-volt breakdown test.
 - d. Construct of galvanized steel with threaded end connections to match connecting piping.
 - e. Suitable for the required operating pressures and temperatures.
- E. Dielectric Connections: Union or waterway fitting with water impervious isolation barrier and one galvanized or plated steel end and one copper tube end, end types to match pipe joint types used.

2.6 GATE VALVES

- A. Manufacturers:
- 1. Conbraco Industries: www.apollovalves.com.
 - 2. Nibco, Inc: www.nibco.com.
 - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Up To and Including 2 Inches:
- 1. Bronze body, bronze trim, screwed bonnet, non-rising stem, lockshield stem, inside screw with backseating stem, solid wedge disc, alloy seat rings, solder ends.
- C. Over 2 Inches:
- 1. Iron body, bronze trim, bolted bonnet, rising stem, handwheel, outside screw and yoke, solid wedge disc with bronze seat rings, flanged ends.
 - 2. Provide chain-type operator for valves installed in mechanical rooms 10'-0" above finished floor.

2.7 GLOBE OR ANGLE VALVES

- A. Manufacturers:
- 1. Conbraco Industries: www.apollovalves.com.
 - 2. Nibco, Inc: www.nibco.com.
 - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.

B. Up To and Including 2 Inches:

1. Bronze body, bronze trim, screwed bonnet, rising stem and handwheel, inside screw with backseating stem, renewable composition disc and bronze seat, solder ends.

2.8 BALL VALVES

A. Manufacturers:

1. Apollo Valves: www.apollovalves.com/#sle.
2. Nibco, Inc: www.nibco.com.
3. Victaulic Company: www.victaulic.com/#sle.
4. Milwaukee Valve Company: www.milwaukeevalve.com.
5. Substitutions: See Section 01 60 00 - Product Requirements.

B. Up To and Including 2 Inches:

1. Bronze one piece body, chrome plated brass ball, teflon seats and stuffing box ring, lever handle with balancing stops, solder ends with union.

C. Provide stand off brackets for the installation of insulation.

2.9 BUTTERFLY VALVES

A. Manufacturers:

1. Hammond Valve: www.hammondvalve.com.
2. Crane Co.: www.cranevalve.com.
3. Milwaukee Valve Company: www.milwaukeevalve.com.
4. Victaulic Company: www.victaulic.com.
5. Substitutions: See Section 01 60 00 - Product Requirements.

B. Body: Cast or ductile iron with resilient replaceable EPDM pressure-responsive seat, wafer, lug, or grooved ends, extended neck.

C. Disc: Construct of aluminum bronze, electroless-nickel or chrome plated ductile iron, or stainless steel.

D. Stem: Stainless steel with stem offset from the centerline to provide full 360-degree circumferential setting.

E. Operator: Handwheel and gear drive; may use lever operator where space permits.

F. Basis of Design: Victaulic Bic300 Master Seal and AGS-Vic300

2.10 SWING CHECK VALVES

- A. Manufacturers:
 - 1. Nibco, Inc: www.nibco.com.
 - 2. Victaulic Company: www.victaulic.com.
 - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Body: Ductile iron body with stainless steel spring and shaft for vertical or horizontal installation.
- C. Disc: Stainless steel with elastomer seat / seal, or elastomer encapsulated ductile iron disc with welded-in nickel seat.
- D. Basis of Design: Victaulic Series 716 (300-psig CWP) and AGS W715 (230-psig CWP).

2.11 PRESSURE INDEPENDENT TEMPERATURE CONTROL VALVES AND BALANCING VALVES

- A. Manufacturers:
 - 1. Belimo; www.belimo.us
 - 2. Danfoss; AB-QM Valve: www.danfoss.com/#sle.
 - 3. Griswold Controls : www.griswoldcontrols.com
 - 4. RWV Hydronic Controls; www.redwhitevalvecorp.com
 - 5. Substitutions: See Section 01 60 00 - Product Requirements.
- B. If pressure independent valve are used;
 - 1. Balancing valves shown in HVAC details may be omitted.
 - 2. Contractor must provide side stream filtration.
- C. NPS 2 and Smaller: PN 16, stainless steel components.
- D. NPS 2½ through 10: Class 125 cast iron body per ASME B16.1-2010, Material class B per ASTM A 126-04 (2014), stainless steel components.
- E. Accuracy NPS ¾" and Smaller: The control valves shall accurately control the flow from 0...100% rated flow with a differential pressure range of 2.32...58 psi for low and standard flow units, 5...58 psi for high flow units within 5% of set flow value.

- F. Accuracy NPS 1 through 1¼: The control valves shall accurately control the flow from 0...100% rated flow with a differential pressure range of 2.9...58 psi for standard flow units, 5...58 psi for high flow units within 5% of set flow value.
- G. Accuracy NPS 1½ through 4: The control valves shall accurately control the flow from 0...100% rated flow with a differential pressure range of 4.35...58 psi within 5% of set flow value.
- H. Accuracy NPS 5 through 10: The control valves shall accurately control the flow from 0...100% rated flow with a differential pressure range of 5.8...58 psi for standard flow units, 8.7...58 psi for high flow units within 5% of set flow value.
- I. Flow Characteristics: Linear Control, selectable to equal percentage at the proportional valve actuator.
- J. Field adjustable flow by means of a percentage of rated valve flow.
- K. Position feedback output signal integrated into all proportional actuators.
- L. 100% authority with modulating below 1% regardless of flow settings.
- M. No cartridges requiring replacement or maintenance.
- N. Basis of Design: Belimo, SmartX PICV, or approved equal.

2.12 FLOW CONTROLS

- A. Manufacturers:
 - 1. ITT Bell & Gossett: www.bellgossett.com.
 - 2. Griswold Controls: www.griswoldcontrols.com.
 - 3. Taco, Inc: www.taco-hvac.com.
 - 4. Victaulic Company: www.victaulic.com/#sle.
 - 5. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Construction: Class 125, Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet, blowdown/backflush drain.
- C. Calibration: Control flow within 10 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, minimum pressure 2 psi.

PART 3 EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

- B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.
- C. Remove scale and dirt on inside and outside before assembly.
- D. Prepare piping connections to equipment using jointing system specified.
- E. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- F. After completion, fill, clean, and treat systems. See Section 23 25 00 for additional requirements.

3.2 ABOVE GROUND PIPING

- A. Install in accordance with manufacturer's instructions.
- B. Install heating water & glycol to ASME B31.9 requirements.
- C. Route piping in orderly manner, parallel to building structure, and maintain gradient.
- D. Install piping to conserve building space and to avoid interference with use of space.
- E. Group piping whenever practical at common elevations.
- F. Sleeve pipe passing through partitions, walls, and floors.
- G. Slope piping and arrange to drain at low points.
- H. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- I. Grooved Joints:
 - 1. Install in accordance with the manufacturer's latest published installation instructions.
 - 2. Gaskets to be suitable for the intended service, molded, and produced by the coupling manufacturer.
- J. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

K. Pipe Hangers and Supports:

1. Install in accordance with ASME B31.9, ASTM F708, or MSS SP-58.
2. Support horizontal piping as scheduled.
3. Install hangers to provide minimum 1/2-inch space between finished covering and adjacent work.
4. Place hangers within 12 inches of each horizontal elbow.
5. Use hangers with 1-1/2 inches minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
6. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
8. Provide copper plated hangers and supports for copper piping.
9. Prime coat exposed steel hangers and supports. See Section 09 9123. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

- L. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08 3100.

- M. Use eccentric reducers to maintain top of pipe level.

- N. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc-rich primer to welds.

- O. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting. See Section 09 91 23.

- P. All piping supports shall be secured to the building structure.

- Q. Install valves with stems upright or horizontal, not inverted. Ball valve operators shall allow for full range of operation.

- R. Grooved joint couplings and fittings shall be installed in accordance with the manufacturer's latest installation recommendations. Grooved joints shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's personnel in the use of grooving tools, application of groove, and installation of grooved joint

products. The manufacturer's representative shall periodically visit the jobsite and review the installation. Contractor shall remove and replace any joints deemed improperly installed.

S. Press Connections:

1. Copper press fittings shall be made in accordance with the manufacturers installation instructions.
2. The tubing shall be fully inserted into the fitting and the tube marked at the shoulder of the fitting.
3. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting.
4. The joints shall be pressed using the tool approved by the manufacturer.

3.3 FIELD QUALITY CONTROL

A. Prepare aboveground hydronic piping according to ASME B31.9.

B. Perform the following tests on aboveground hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure, but not less than 100 psi. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test.
5. After hydrostatic test pressure has been applied for at least 15 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves and adjust expansion tank pre-charge for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).

5. Verify lubrication of motors and bearings.

3.4 SCHEDULES

A. Hanger Spacing for Copper Tubing.

1. 1/2 Inch and 3/4 inch: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. 1 Inch: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. 1-1/2 Inches and 2 Inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.

B. Hanger Spacing for Steel Piping.

1. 2-1/2 Inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
2. 3 Inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
3. 4 Inches: Maximum span, 14 feet; minimum rod size, 1/2 inch.

END OF SECTION 23 21 13

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SECTION 23 21 14 - HYDRONIC SPECIALTIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Expansion tanks.
- B. Air vents.
- C. Air eliminator/dirt separator
- D. Strainers.
- E. Suction diffusers.
- F. Pump connectors.
- G. Combination pump discharge valves.
- H. Pressure-temperature test plugs.
- I. Flow meters.
- J. Relief valves.
- K. Glycol Solution
- L. Glycol Make-up system.
- M. Automatic balancing valves.

1.3 RELATED REQUIREMENTS

- A. Section 23 21 13 - Hydronic Piping.
- B. Section 23 25 00 - HVAC Water Treatment: Pipe cleaning.
- C. Section 500000 - Commissioning Requirements.

1.4 REFERENCE STANDARDS

- A. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250 2020.
- B. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels 2021.

1.5 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for submittal procedures.
- B. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description and model.
- C. Certificates: Inspection certificates for pressure vessels from authority having jurisdiction.
- D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- E. Project Record Documents: Record actual locations of flow controls.
- F. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- C. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.8 COMMISSIONING

- A. Engage a factory-authorized service representative, to perform startup service as per functional test sheets and Commissioning Requirements.
- B. Complete installation and startup checks and functional tests according to Commissioning Requirements.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start up procedure.
- D. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- E. Contractor shall replace all damaged components and components that failed the inspections at no additional charge.

- F. Inspections by the Commissioning Agent shall be on “spot check basis”. Commissioning process does not reduce responsibility of installing contractors to provide a finished and fully functioning product.
- G. This section shall in no way diminish the responsibility of the Contractors, Sub-contractors and Suppliers in performing all aspects of work and testing as outlined in the Contract Documents. Any requirements outlined in this section are in addition to requirements outlined in related specifications.

PART 2 PRODUCTS

2.1 EXPANSION TANKS

- A. Manufacturers:
 - 1. Grundfos: www.grundfos.us
 - 2. ITT Bell & Gossett: www.bellgossett.com.
 - 3. Armstrong Pumps: www.armstrongpumps.com
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Construction: Welded steel, tested and stamped in accordance with ASME BPVC-VIII-1; supplied with National Board Form U-1, adjustable flexible EPDM diaphragm or bladder seal factory precharged to 12 psi, and steel support stand.
- C. Expansion tank shall be designed to accept 30% propylene glycol.
- D. Accessories: Inspection glass, Pressure gauge and air-charging fitting, tank drain; precharge to 12 psi.

2.2 AIR VENTS

- A. Manufacturers:
 - 1. ITT Bell & Gossett: www.bellgossett.com.
 - 2. Taco, Inc: www.taco-hvac.com.
 - 3. Armstrong Pumps: www.armstrongpumps.com
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Manual Air Vent: Short vertical sections of 2-inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.
- C. Float Air Vent:
 - 1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with

isolating valve.

2.3 AIR ELMINATOR AND DIRT SEPARATOR

A. Manufacturer:

1. Spirotherm; www.spirotherm.com
2. ITT Bell & Gossett; www.bellgossett.com.
3. Armstrong Pumps; www.armstrongpumps.com

B. Units shall be fabricated steel, rated for 150 psig working pressure with entering velocities not to exceed 4 feet per second at specified GPM.

1. An internal tube bundle shall fill the entire vessel to suppress turbulence and provide high efficiency. The bundle shall consist of copper core tube with continuously wound copper medium permanently affixed to the core. A separate copper medium shall be wound completely around and permanently affixed to the internal element.

C. Each eliminator shall have a separate venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism.

1. Air Eliminators shall have the vessel extend below the pipe connections an equal distance for dirt separation.

D. Units shall include a valve side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill.

E. Air Eliminators shall be capable of removing 100% of the free and entrained air and up to 99.6% of the dissolved air in the system fluid. Dirt separation shall be at least 80% of all particles 30 micron and larger within 100 passes.

2.4 STRAINERS

A. Manufacturers:

1. Armstrong International, Inc; www.armstronginternational.com.
2. Grinnell Products, a Tyco Business; www.grinnell.com.
3. The Metraflex Company; LPD Y Strainer; www.metraflex.com/#sle.
4. Substitutions: See Section 01 60 00 - Product Requirements.

B. Size 2 inch and Under:

1. Provide threaded, grooved, or sweat brass or iron body for up to 175 psi working pressure, Y-pattern strainer with 1/32 inch stainless steel perforated screen.

C. Size 2-1/2 inch to 4 inch:

1. Provide flanged or grooved iron body for up to 175 psi working pressure, up to 250 degrees F working temperature, Y-pattern strainer with 1/16 inch or 3/64 inch stainless steel perforated screen.
2. Body Material by Fluid Service:
3. Flanged iron body for 175 psi working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

2.5 SUCTION DIFFUSERS

A. Manufacturers:

1. ITT Bell & Gossett: www.bellgossett.com.
2. Taco, Inc: www.taco-hvac.com
3. Armstrong Pumps: www.armstrongpumps.com
4. Substitutions: See Section 01 60 00 - Product Requirements.

B. Fitting: Angle pattern, cast-iron body, threaded for 2 inch and smaller, flanged for 2-1/2 inch and larger, rated for 175 psi working pressure, with inlet vanes, cylinder strainer with 3/16 inch diameter openings, disposable 5/32 inch mesh strainer to fit over cylinder strainer, 20 mesh startup screen, and permanent magnet located in flow stream and removable for cleaning.

C. Accessories: Adjustable foot support, blowdown tapping in bottom, gauge tapping in side.

2.6 PUMP CONNECTORS

A. Manufacturers:

1. Anvil International; AnviFlex: www.anvilintl.com/#sle.
2. Ferguson Enterprises Inc: www.fnw.com/#sle.
3. The Metraflex Company; Vane Flex: www.metralflex.com/#sle.
4. Substitutions: See Section 01 60 00 - Product Requirements.

B. Flexible Connectors: Flanged, braided type with wetted components of stainless steel, sized to match piping.

1. Maximum Operating Service: 150 psi at 240 degrees F.
2. Accommodate the Following:
 - a. Axial Deflection in Compression and Expansion: 2 inch.

- b. Lateral Movement: 0.5 inch.
 - c. Angular Rotation: 15 degrees.
 - d. Force developed by 1.5 times specified maximum allowable operating pressure.
- 3. End Connections: Same as specified for pipe jointing.
 - 4. End Connections: Flanged ductile iron; complying with ASME B16.1 Class 125.
 - 5. Provide pump connector with integral vanes to reduce turbulent flow.
 - 6. Provide necessary accessories including, but not limited to, swivel joints.

2.7 COMBINATION PUMP DISCHARGE VALVES

A. Manufacturers:

- 1. ITT Bell & Gossett: www.bellgossett.com.
- 2. Taco, Inc: www.taco-hvac.com.
- 3. Armstrong Pumps: www.armstrongpumps.com
- 4. Victaulic Company of America: www.victaulic.com/#sle.
- 5. Substitutions: See Section 01 60 00 - Product Requirements.

- B. Quarter-Turn Plug Type: Flanged cast-iron body with bolt-on bonnet, position indicator, stainless steel stem, backflow preventer, memory stop, metering connectors, bubble-tight shutoff, and wrench-adjustable plug flow regulator.

2.8 PRESSURE-TEMPERATURE TEST PLUGS

A. Manufacturers:

- 1. Ferguson Enterprises Inc: www.fnw.com.
- 2. Peterson Equipment Company Inc: www.petesplug.com.
- 3. Sisco Manufacturing Company Inc: www.siscomfg.com.
- 4. Substitutions: See Section 01 60 00 - Product Requirements.

- B. Construction: Brass body designed to receive temperature or pressure probe with removable protective cap, and Neoprene rated for minimum 200 degrees F.

- C. Application: Use extended length plugs to clear insulated piping.

2.9 FLOW METERS

A. Manufacturers:

1. Dwyer Instruments, Inc: www.dwyer-inst.com.
 2. EMCO Flow Systems: www.emcoflow.com.
 3. GE Infrastructure Sensing/GE Panametrics: www.gesensing.com.
 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Orifice principle by-pass circuit with direct reading gauge, soldered or flanged piping connections for 125 psi working pressure, with shut off valves, and drain and vent connections.
- C. Direct reading with insert pitot tube, threaded coupling, for 150 psi working pressure, maximum 240 degrees F, 5 percent accuracy.

2.10 RELIEF VALVES

- A. Manufacturers:
1. Armstrong International, Inc: www.armstronginternational.com.
 2. ITT Bell & Gossett: www.bellgossett.com.
 3. Wessels Co: www.westank.com
 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

2.11 GLYCOL SOLUTION

- A. Industrial inhibited propylene glycol, dyed yellow to facilitate leak detection.
- B. Final concentration 30% Propylene Glycol
- C. Equal to Dowfrost HD.

2.12 GLYCOL MAKE-UP SYSTEM (30%)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong Pumps, Inc.
 2. Bell & Gossett.
 3. Neptune Chemical Pump Co.
- B. Refer to the schedule on the contract documents for glycol pump package requirements.
- C. Packaged system including tank, pumping assembly, support frame, valves, pump controller, controls and alarms.

D. Solution Container:

1. 55 gallon heavy duty molded polypropylene with hinged lid, volume scale etched on the side of the tank, controls facia, air gap overflow and pump/controls access panel.
2. Two (2) stainless steel fill ball valves (glycol and water supply).
3. Powered agitator with timed auto-mix cycle.
4. Low fluid level warning and high fluid level alarm with remote annunciation contacts for interface with DDC system.

E. Pumping Assembly:

1. All bronze close coupled centrifugal pump, with stainless steel motor shaft, ceramic and graphite seal, high efficiency asynchronous enclosed externally vented single phase induction motor with thermal cut-off relay.
2. Pump suction strainer.
3. Bronze isolation valves.
4. Bronze check valve.
5. Pressure gauge.
6. 1/2" system connection.

F. Controls:

1. Low water cut-off float switch wired to shut down pump on low level.
2. Pump running, low fluid level warning and high fluid level alarms with remote annunciation contacts for interface with DDC system.

2.13 AUTOMATIC BALANCING VALVES

A. Manufacturers:

1. Nexus Valve : www.nexusvalve.com
2. Griswold Controls : www.griswoldcontrols.com
3. Flow Design: www.flowdesign.com
4. RWV Hydronic Controls

B. Balancing valves shall include test ports, integral union, full-ported ball valves, and other accessories as required.

- C. Flow control valves shall utilize a non clogging cartridge design. The flow cartridge shall feature no metal-to-metal contact or segmented ports and shall incorporate a flow nozzle and metering disc controlled by a pressure compensating spring fully isolated from the flow stream.
- D. The flow cartridge shall be a single assembly, constructed with 100% stainless steel moving parts and shall be accessible without removing the valve from the piping.
- E. The flow cartridge shall be factory calibrated to maintain an accuracy of +/- 5%. The accuracy shall be maintained over an operating range of 2-45 psi differential. A lifetime factory warranty on the cartridge shall be included.
- F. Valves 2" and smaller:
 - 1. Shall be forged brass, Y-pattern body with integral full-ported ball valve, blowout-proof stem with dual Viton O-ring seals, interchangeable union end with Viton O-ring seal hard chrome plated ball with Teflon seats and rated for 600 psi working pressure @ 275 degrees F. Design based on Nexus UltraMatic valve.
- G. Valves 2-1/2" and larger:
 - 1. Shall be wafer-style ductile iron design to fit between standard 125/150 ANSI flanges. Valves shall include pressure test plugs across the flow cartridge , a tag indicating the model, flow rate and operating control range. Valves shall be able to incorporate drains and vents as required and be rated for 500 psi working pressure @ 350 degrees F. Design based on Nexus UltraMatic valve.
- H. "Y" strainers with 20 mesh stainless steel elements and ball-type blowdown valves with caps/straps must be included on the inlet side of each water coil requiring a balancing device.
- I. Valves shall be provided with P/T test plugs and tags identifying the valve, the equipment served and the rated flow.
- J. Valve size shall be determined by the velocity limit of the flow cartridge. Maximum fluid velocities of 4 feet per second shall not be exceeded per ASHRAE standards. Contractor shall provide a complete project valve list including item number, quantity, vendor model number, size design flowrate, psig and location tag to the engineer and the balancing contractor for completion and submission with final balancing report.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install specialties in accordance with manufacturer's instructions.
- B. Where large air quantities can accumulate, provide enlarged air collection standpipes.
- C. Provide manual air vents at system high points and as indicated.

- D. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.
- E. Provide air separator on suction side of system circulation pump and connect to expansion tank.
- F. Provide valved drain and hose connection on strainer blowdown connection.
- G. Provide pump suction fitting on suction side of base-mounted centrifugal pumps where indicated. Remove temporary strainers after cleaning systems.
- H. Support pump fittings with floor-mounted pipe and flange supports.
- I. Provide automatic balancing valves on water outlet from air handling equipment, radiation, unit heaters, etc. as indicated on the equipment schedules and piping diagrams.
- J. Clean and flush glycol system before adding glycol solution, see Section 23 25 00.
- K. Feed glycol solution to system through make-up line with pressure regulator, venting system high points.

3.2 CLOSEOUTS

- A. See Section 017800-Closeout Submittals, for closeout submittals.

3.3 SEE SECTION 017900-DEMONSTRATION AND TRAINING, FOR ADDITIONAL REQUIREMENTS.

- A. Provide minimum 2 hours of training.

END OF SECTION 23 21 14

SECTION 23 21 23 - HYDRONIC PUMPS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. MEGNA3 Variable Speed Wet Rotor Circulator Pumps
- B. CRE-DSingle Proportional Differential Pressure Pump with Integrated Variable Speed Drive

1.3 RELATED REQUIREMENTS

- A. Section 01 91 13 - General Commissioning Requirements.
- B. Section 033000 - Cast-in-Place Concrete.
- C. Section 230548 - Vibration and Seismic Controls for HVAC.
- D. Section 230716 - HVAC Equipment Insulation.
- E. Section 230719 - HVAC Piping Insulation.
- F. Section 232113 - Hydronic Piping.
- G. Section 232114 - Hydronic Specialties.
- H. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.
- I. Section 500000 - Commissioning Requirements.

1.4 REFERENCE STANDARDS

- A. Hydraulic Institute
- B. ANSI – American National Standards Institute
- C. ASTM – American Society for Testing and Materials
- D. IEEE – Institute of Electrical and Electronics Engineers
- E. NEMA – National Electrical Manufacturers Association
- F. NEC – National Electrical Code
- G. ISO – International Standards Organization

- H. UL – Underwriters Laboratories, Inc.
- I. CSA –Canadian Standards Association
- J. ETL – ETL Listed Mark by Intertek Testing Services

1.5 PERFORMANCE REQUIREMENTS

- A. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

1.6 INSTALLATION REFERENCES

- A. The wet runner pump manufacturer shall have minimum 10 years of experience in the country of the installation.

1.7 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for submittal procedures.
- B. Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate hanging and support requirements and recommendations.
- D. Millwright's Certificate: Certify that base mounted pumps have been aligned.
- E. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacture, assembly, and field performance of pumps, with minimum three years of documented experience.
- B. Alignment: Base mounted pumps shall be aligned by qualified millwright.
- C. The pumps shall be factory performance and hydrostatic tested as a complete unit prior to shipment. The testing shall be done in accordance with ISO 9906 Annex A. No test certificate is required.

1.9 REGULATORY REQUIREMENTS

- A. Products Requiring Electrical Connection: Listed and classified by UL 778 as suitable for the purpose specified and indicated.

1.10 WARRANTY

- A. The warranty period shall be a non-prorated period of 24 months from the date of final acceptance by Owner. Warranty shall cover pump, motor and add-on modules as complete unit.

1.11 COMMISSIONING

- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 01 91 13 - General Commissioning Requirements.
- B. Complete installation, startup checks and functional tests according to Section 01 91 13 - General Commissioning Requirements and manufacturers written instructions.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start up procedure.
- D. Verify that equipment is installed and commissioned as per requirements of Section 01 91 13 and manufacturers written instructions/requirements.
- E. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- F. Contractor shall replace all damaged components and components that failed the inspections at no additional charge.
- G. Inspections by the Commissioning Agent shall be on "spot check basis". Commissioning process does not reduce responsibility of installing contractors to provide a finished and fully functioning product.
- H. This section shall in no way diminish the responsibility of the Contractors, Sub-contractors and Suppliers in performing all aspects of work and testing as outlined in the Contract Documents. Any requirements outlined in this section are in addition to requirements outlined in related specifications.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Grundfos: www.grundfos.us
- B. Bell & Gossett, a Xylem Inc. brand: www.bellgossett.com.
- C. Armstrong Pumps Inc: www.armstrongpumps.com.
- D. Substitutions: See Section 016000 - Product Requirements.

2.2 HVAC PUMPS - GENERAL

- A. Provide pumps that operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.
- B. Minimum Quality Standard: UL 778.
- C. Base Mounted Pumps: Aligned by qualified millwright.
- D. Products Requiring Electrical Connection: Listed and classified by UL or testing agency acceptable to Authority Having Jurisdiction as suitable for the purpose specified and indicated.

2.3 MEGNA3 VARIABLE SPEED WET ROTOR CIRCULATOR PUMPS

- A. b. UL 60730-1Ac. CAN/CSA No. 108
UL778
The pump shall be certified and listed by a Nationally Recognized Test Laboratory (NRTL) for U.S. and Canada to comply with:
The enclosure shall be marked "Enclosure Type 2."
The pump shall be a standard product of a single pump manufacturer. The pump, motor, and variable speed drive shall be an integral product designed and built by the same manufacturer. Pump shall be of the in-line wet rotor design. Oil lubricated pumps and shaft coupled pumps shall not be accepted.
- B. The pump shall be labeled on the nameplate as having an Energy Efficiency Index (EEI) of no greater than 0.20.

2.4 CRE-DSINGLE PROPORTIONAL DIFFERENTIAL PRESSURE PUMP WITH
INTEGRATED VARIABLE SPEED DRIVE

- A. Furnish and test a single variable speed pumping system to vary water delivery pressure based on proportional differential pressure through adaptive on-board control algorithms.
- B. B. The pump system shall be a standard product of a single pump manufacturer. The entire pump system including pump, motor, differential pressure sensor(s), variable frequency drive and pump controller, shall be designed and built by the same manufacturer.
- C. B. The pump system shall be a standard product of a single pump manufacturer. The entire pump system including pump, motor, differential pressure sensor(s), variable frequency drive and pump controller, shall be designed and built by the same manufacturer.
- D. C. As an alternate to the specified pump the contractor may substitute a pumping system consisting of the pump, motor, differential pressure sensors, variable frequency drive, in-line flow measuring device, and pump controller with algorithm for proportional differential pressure adaptation to vary flow conditions based upon system demands.

- E. D. The complete motor and drive shall be certified and listed by UL for conformance to U.S. and Canadian Standards.

2.5 PUMPS

- A. The pumps shall be ANSI/NSF 61 approved for drinking water.
- B. The pumps shall have a factory installed differential pressure sensor.
- C. The pumps shall be of the in-line vertical multi-stage design.
- D. The head-capacity curve shall have a steady rise in head from maximum to minimum flow within the preferred operating region. The shut-off head shall be a minimum of 20% higher than the head at the best efficiency point.
- E. E. Small Vertical In-Line Multi-Stage Pumps (12mm or 16mm shaft, Nominal flow from 3 to 125 gallons per minute) shall have the following features:
- F. 1. The pump impellers shall be secured directly to the pump shaft by means of a splined shaft arrangement.
- G. 2. The suction/discharge base shall have ANSI Class 250 flange or internal pipe thread (NPT) connections as determined by the pump station manufacturer.
- H. 3. Pump Construction.
- I. a. Suction/discharge base, pump head, motor stool: Cast iron (Class 30)
- J. b. Impellers, diffuser chambers, outer sleeve: 304 Stainless Steel
- K. c. Shaft 316 or 431 Stainless Steel
- L. d. Impeller wear rings: 304 Stainless Steel
- M. e. Shaft journals and chamber bearings: Silicon Carbide
- N. f. O-rings: EPDM
- O. Shaft couplings shall be made of cast iron or sintered steel.
- P. Optional materials for the suction/discharge base and pump head shall be cast 316 stainless steel (ASTM CF-8M) resulting in all wetted parts of stainless steel.
- Q. 4. The shaft seal shall be a balanced o-ring cartridge type with the following features:
- R. a. Collar, Drivers, Spring: 316 Stainless Steel
- S. b. Shaft Sleeve, Gland Plate: 316 Stainless Steel
- T. c. Stationary Ring: Silicon Carbide (Graphite Imbedded)

- U. d. Rotating Ring: Silicon Carbide (Graphite Imbedded)
- V. e. O-rings: EPDM
- W. 5. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, shaft coupling and motor.
- X. F. Large In-line Vertical Multi-Stage Pumps (22mm shaft, Nominal flows from 130 to 500 gallons per minute) shall have the following features:
- Y. 1. The pump impellers shall be secured directly to the smooth pump shaft by means of a split cone and nut design.
- Z. 2. The suction/discharge base shall have ANSI Class 150 or Class 300 flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.
- AA. 3. Pump Construction.
- BB. a. Suction/discharge base, pump head Ductile Iron (ASTM 65-45-12)
- CC. b. Shaft couplings, flange rings: Ductile Iron (ASTM 65-45-12)
- DD. b. Shaft 431 Stainless Steel
- EE. c. Motor Stool Cast Iron (ASTM Class 30)
- FF. d. Impellers, diffuser chambers, outer sleeve: 304 Stainless Steel
- GG. e. Impeller wear rings: 304 Stainless Steel
- HH. f. Intermediate Bearing Journals: Tungsten Carbide
- II. g. Intermediate Chamber Bearings: Leadless Tin Bronze
- JJ. h. Chamber Bushings: Graphite Filled PTFE
- KK. I. O-rings: EPDM
- LL. 4. The shaft seal shall be a single balanced metal bellows cartridge with the following construction:
- MM. a. Bellows: 904L Stainless Steel
- NN. b. Shaft Sleeve, Gland Plate, Drive Collar: 316 Stainless Steel
- OO. c. Stationary Ring: Carbon
- PP. d. Rotating Ring: Tungsten Carbide
- QQ. e. O-rings: EPDM

- RR. 5. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, motor couplings, motor and seal cover.

2.6 INTEGRATED VARIABLE FREQUENCY DRIVE MOTORS

- A. Each motor shall be of the Integrated Variable Frequency Drive design consisting of a motor and a Variable Frequency Drive (VFD) with a built-in pump system controller. The complete VFD/motor assembly shall be built and tested as one unit by the same manufacturer.
- B. The VFD/motor shall have an IP55 (TEFC) enclosure rating as a complete assembly. The motor shall have a standard NEMA C-Face, Class F insulation with a Class B temperature rise.
- C. The VFD shall be of the PWM (Pulse Width Modulation) design using up to date IGBT (Insulated Gate Bipolar Transistor) technology.
- D. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of the motor. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump control and to eliminate the need for motor de-rating.
- E. The VFD shall have, as a standard component, an RFI filter (Radio Frequency Interference) to minimize electrical noise disturbances between the power electronics and the power supply. The VFD/motor shall meet all requirements of the EMC directive concerning residential and light industry equipment (EN 61800-3).
- F. The VFD shall have a minimum of two skip frequency bands which can be field adjustable.
- G. The VFD shall have internal solid-state overload protection designed to trip within the range of 125-150% of rated current.
- H. The VFD/motor shall include protection against input transients, loss of AC line phase, over-voltage, under-voltage, VFD over-temperature, and motor over-temperature. The motor over-temperature protection shall consist of three series connected PTC thermistors, one for each motor phase.
- I. The VFD/motor shall provide full nameplate output capacity (horsepower and speed) within a balanced voltage range of 414 to 528 volts.

- J. Automatic De-Rate Function: The VFD/motor shall reduce speed during periods of overload allowing for reduced capacity pump operation without complete shut-down of the system. Detection of overload shall be based on continuous monitoring of current, voltage and temperature within the VFD/motor assembly.
- K. Fieldbus communication port (RS485)
Fault Signal Relay (NC or NO)
Digital remote on/off
Speed Reference Signal: 0-10 VDC, 4-20mA
- L. Motor drive end bearings shall be adequately sized so that the minimum L10 bearing life is 17,500 hours at the minimum allowable continuous flow rate for the pump at full rated speed.

2.7 PUMP SYSTEM CONTROLLER

- A. The pump system controller (Proportional Differential-Integral) shall be a standard component of the integrated variable frequency drive motor developed and supported by the pump manufacturer.
- B. The pump system controller shall have an easy to use interface mounted on the VFD/motor enclosure. Pump system start/stop and set-point adjustment shall be possible through the use of two push buttons located on the drive enclosure.
- C. The VFD/motor shall be capable of receiving a remote analog set-point (4-20mA or 0-10 VDC) as well as a remote on/off (digital) signal.
- D. Pump status and alarm state shall be indicated via two LED lights located on the VFD/motor enclosure.
- E. Advanced programming and troubleshooting shall be possible via an infra-red hand held programmer or a field connected personal computer. Pump system programming (field adjustable) shall include as a minimum the following:
 - F. System Pressure set-point, psig System start pressure, psig
 - G. System Stop pressure, psig Minimum Pump Speed, %
 - H. Pressure Transducer supply/range Maximum Pump Speed, %
 - I. System Time (Proportional Gain) Integral Action Time

- J. The infra-red programmer shall be capable of displaying the following status readings:
- | | |
|--------------------------------------|---------------------------------|
| K. Pump Status (on, off, min., max.) | System Set-point, psig |
| L. Actual system pressure, psig | Remote set-point, % |
| M. Pump speed, rpm | VFD/Motor input power, kW |
| N. VFD/Motor total cumulative kWh | VFD/Motor total operating hours |
- O. The infra-red programmer shall also be capable of displaying the following alarms, with the last five alarms stored in memory:
- | | |
|---------------------------------|-----------------------------------|
| P. Loss of sensor signal | Loss of external set-point signal |
| Q. Under-voltage & Over-voltage | Motor overload (blocked pump) |
| R. Motor over-temperature | Drive over-temperature |
| S. Drive Over-current | |

2.8 SEQUENCE OF OPERATION

- A. The system controller shall receive an analog signal [4-20mA] from the factory installed differential pressure transducer indicating the actual inlet and outlet pressures. When a flow demand is detected (system pressure drops below the start pressure) the VFD/motor shall start and increase speed until the actual system pressure matches the system set-point. As flow demand changes (increases or decreases), the speed of the pump shall be adjusted to maintain the calculated system set-point pressure and flow.
- B. If a no flow shut-down is required (periods of zero demand) a bladder type diaphragm tank shall be installed. The tank shall be downstream of the pump. When zero flow is detected by the system controller, the pump shall be switched off. When the system pressure drops to the start pressure, (flow begins after shut-down), the pump shall be switched on, increasing speed to maintain the system set-point pressure. Zero flow conditions shall be detected by the system controller/factory installed pressure transmitter without the use of additional flow switches or motor current sensing devices.

2.9 SYSTEM CONSTRUCTION

- A. The CRE-DP pump shall have a maximum working pressure ranging up to 435 psig at a temperature of 176°F.
- B. A diaphragm tank (field installed) is required for the stop function. A minimum diaphragm tank connection size of ¾" (three quarter inch) shall be provided on the discharge piping by others.

- C. A pressure transducer shall be factory installed on the pump head. Pressure transducers shall be made of 316 stainless steel. Transducer accuracy shall be +/- 1.0% full scale with hysteresis and repeatability of no greater than 0.1% full scale. The output signal shall be 4-20 mA with a supply voltage range of 9-32 VDC.
- D. An optional factory pressure switch shall be available (at an additional charge) for mounting on the suction piping for water shortage protection (Suction piping by others). The pump shut-down pressure shall be 3 psig with a reset pressure of 5 psig. Systems with a flooded suction inlet or suction lift configuration will require a field installed water shortage device. A normally open dry contact shall be available on the VFD/Motor for field installation.

2.10 TESTING

- A. The entire pump motor and VFD shall be factory performance tested as a complete unit prior to shipment.
- B. The pump shall undergo a hydrostatic test.

PART 3 EXECUTION

3.1 PREPARATION

- A. Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide access space around pumps for service. Provide no less than minimum space recommended by manufacturer.
- C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings.
- D. Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.
- E. Provide air cock and drain connection on horizontal pump casings.
- F. Check, align, and certify alignment of base-mounted pumps prior to start-up.
- G. Lubricate pumps before start-up.

3.3 CLOSEOUTS

- A. See Section 017800-Closeout Submittals, for closeout submittals.
- B. See Section 017900-Demonstration and Training, for additional requirements.

- C. Provide minimum 4 hours of training.

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SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Piping.
- B. Refrigerant.

1.3 RELATED REQUIREMENTS

- A. Section 23 07 19 - HVAC Piping Insulation.
- B. Section 23 81 28 - Variable Refrigerant Flow Zoning System.

1.4 REFERENCE STANDARDS

- A. ASHRAE Std 15 - Safety Standard for Refrigeration Systems 2019, with All Amendments and Errata.
- B. ASHRAE Std 34 - Designation and Safety Classification of Refrigerants 2019.
- C. ASME B31.5 - Refrigeration Piping and Heat Transfer Components 2020.
- D. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service 2020.
- E. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding 2019.
- F. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018.

1.5 SYSTEM DESCRIPTION

- A. Provide pipe hangers and supports in accordance with ASME B31.5 unless indicated otherwise.

1.6 SUBMITTALS

- A. Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.
- B. Shop Drawings: Indicate schematic layout of system, including equipment, critical dimensions, and sizes.

- C. Design Data: Submit design data indicating pipe sizing. Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- D. Manufacturer's Installation Instructions: Indicate support, connection requirements, and isolation for servicing.
- E. Project Record Documents: Record exact locations of equipment and refrigeration accessories on record drawings.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum [] 5 years of documented documented experience.

1.8 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 for installation of piping system.
- B. Products Requiring Electrical Connection: Listed and classified by UL, as suitable for the purpose indicated.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store piping and specialties in shipping containers with labeling in place.
- B. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.

PART 2 PRODUCTS

2.1 VRF/VRV REFRIGERANT PIPING

- A. Comply with requirements in Section "Refrigerant Piping" for system piping requirements.
- B. Refrigerant Piping:
 - 1. Copper Tube: ASTM B280, Type ACR.
 - 2. Wrought-Copper Fittings: ASME B16.22.
 - 3. Brazing Filler Metals: AWS A5.8/A5.8M.
 - 4. System shall be brazed. Any alternative type system, or press type fittings will NOT be accepted.
- C. Refrigerant Tubing Kits:
 - 1. Factory-rolled and -bundled, soft-copper tubing with tubing termination fittings at each end.
 - 2. Standard one-piece length for connecting to indoor units.

3. Pre-insulated with flexible elastomeric insulation of thickness to comply with governing energy code and sufficient to eliminate condensation.
4. Factory Charge: Dehydrated air or nitrogen.
- D. Divided-Flow Specialty Fittings: Furnished by VRF/VRV system manufacturer for proper system operation, VRF/VRV HVAC system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer. Standard tee or branch fittings will Not be accepted.
- E. Refrigerant Isolation Ball Valves:
 1. Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.
 2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
 3. Valve Connections: Flare or sweat depending on size.

2.2 PIPING

- A. Drawn (rigid) Copper Tube: Type ACR, R410 rated, ASTM B280, H58 temper, clean, dry and capped.
 1. Joints: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy.
- B. Annealed (soft) Copper Tube: Type ACR, R410 rated, ASTM B280, O60 temper, clean, dry and capped .
 1. Joints: Flare or Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy.
 2. **Use of soft copper tube shall be limited to runout piping (of nominal pipe sizes of 1/2" or less) from heat recovery units to fan coils.**
- C. Pipe Supports and Anchors:
 1. Conform to ASME B31.5.
 2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron adjustable swivel, split ring.
 3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
 4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 5. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

2.3 REFRIGERANT

- A. Refrigerant: R410a, as defined in ASHRAE Std 34.

PART 3 EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.

3.2 INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated, and as approved by manufacturers representative unless deviations to layout are approved on coordination drawings. Project pipe lengths shall be indicated and submitted to manufactures representative for input into software to verify piping lengths are in compliance.
- B. Comply with requirements in Section 232300 "Refrigerant Piping"
- C. ACR Copper with brazed joints. No exceptions or alternative methods will be accepted.
- D. Refrigerant flow balancing shall be by means of Refnet refrigerant branches and headers designed to ensure proper refrigerant flow and refrigerant balancing between branches. T-style fittings or joints are prohibited and will not be accepted. All take-offs shall be provided by the equipment manufacturer.
- E. Install refrigerant piping in strict accordance to Manufacturers written instructions.
- F. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- G. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- H. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.
- I. Install piping and tubing to permit valve servicing.
- J. Install piping and tubing at indicated slopes.
- K. Install piping and tubing free of sags.
- L. Install fittings for changes in direction.
- M. Install piping and tubing to allow application of insulation.
- N. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.
- O. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors.

- P. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors.
- Q. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- R. Install piping free of traps, sags, tee fittings, sight glasses, filter dryers, solenoid valves and other after-market accessories.
- S. Install piping to conserve building space and avoid interference with use of space.
- T. Group piping whenever practical at common elevations and locations.
- U. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- V. Installation of piping and tubing insulation
 - 1. Insulation shall comply with International Energy Conservation Code
 - 2. All refrigerant lines shall be fully insulated between the condensing unit and indoor units.
- W. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.5.
 - 2. Support horizontal piping as indicated.
 - 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 - 4. Place hangers within 12 inches of each horizontal elbow.
 - 5. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - 7. Provide copper plated hangers and supports for copper piping.
- X. Provide clearance for installation of insulation and access to valves and fittings.
- Y. Flood piping system with nitrogen when brazing.
- Z. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.

- B. Test refrigeration system in accordance with ASME B31.5.
- C. Pressure test system with dry nitrogen. Test to zero leakage. Evacuate and fully charge system after testing.

3.4 SCHEDULES

- A. Hanger Spacing for Copper Tubing.
 - 1. 1/2 inch or less, 5/8 inch, and 7/8 inch : Maximum span, 5 feet; minimum rod size, 1/4 inch.

END OF SECTION 23 23 00 23 23 00

SECTION 23 25 00 - HVAC WATER TREATMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Side Stream Water Treatment for Heating Water/Glycol System

1.3 RELATED REQUIREMENTS

- A. Section 01 91 13 - General Commissioning Requirements.
- B. Section 23 05 48 - Vibration and Seismic Controls for HVAC Systems.
- C. Section 23 21 13 - Hydronic Piping.
- D. Section 23 21 14 - Hydronic Specialties.

1.4 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Common Work Results for HVAC, Section 23 05 00, are included as a part of this Section as though written in full in this document.

1.5 SCOPE

- A. Scope of Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.

1.6 DESCRIPTION OF WORK

- A. Work Included: Perform water analysis and provide a water treatment/filtration system that uses no chemical to control corrosion, filter the water, and keep deposits from forming. In addition, provide chemicals, equipment, and labor for cleaning and flushing each system specified hereinafter as follows:
 - 1. Heating Water System
- B. Installation: Fully install and plumb a skid-mounted, side stream water treatment system including piping to and from closed loop systems as shown on mechanical drawings.
- C. Instructions: Provide operating and maintenance instructions for each water treatment system; include one set in each Owner's Manual and deliver one set to Owner's operating personnel.

- D. Testing Equipment: Furnish a dissolved oxygen test kit for each system, and test and log the dissolved oxygen in each system for three (3) months after acceptance by the Owner.
- E. Service Representative: Furnish the services of a qualified service representative to instruct Owner's operating personnel in proper operation and maintenance of water treatment systems and tests required.
- F. Replacement and Rework: Replace defective or nonconforming materials and equipment with new materials and equipment at no additional cost to the Owner for one (1) year after successful start-up of the system. All warranty work shall be FOB as installed at the project site.
 - 1. Guarantee: Provide system produced by manufacturer who is willing to execute the required guarantee.
 - 2. Agreement to Maintain: Provide system produced by manufacturer who is willing to execute (with the Owner) the required agreement for continued maintenance of the system.

1.7 QUALITY ASSURANCE

- A. Qualifications: The Contractor for work under this Section shall have:
 - 1. A service department and qualified technical service representative located within a reasonable distance of the project site.

1.8 SUBMITTALS

- A. Shop Drawings: Submit shop drawings for each water treatment system. Show wiring, piping and tubing sizes, fittings, accessories, valves, and connections.
- B. Guarantee: Submit written guarantee signed by the Manufacturer and countersigned by the Installer and Contractor, agreeing to replace or repair water treatment systems as required to achieve the required performance, during a 1-year period following the final start-up.

1.9 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: To include installation, operation, and maintenance manuals.

1.10 COORDINATION

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

1.11 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of CLG-100S System that fail in materials or workmanship within specified warranty period.
- B. Failures include, but are not limited to, the following:

1. Faulty operation of controls.
 2. Deterioration of metals, metal finishes, and other materials beyond normal use.
 - C. Warranty Period of major components are not limited to, the following periods:
 1. Filtration Tank(s) excluding the filtration media to be warranted for a period of (10) years.
 2. Backwashing filtration valve(s) body to be warranted for a period of (5) years
 3. Backwashing filtration electronic control boards, including motors, switches, and internal moving sealing parts to be warranted for a period of (1) year.
 4. System pump to be warranted for a period of (18) months.
 5. Pump motor and motor seals to be warranted got a period of (1) year.
 6. No-Salt Conditioner to be warranted got a period of (5) years.
- 1.12 REGULATORY REQUIREMENTS
- A. Conform to applicable code for addition of non-potable chemicals to building mechanical systems and to public sewage systems.
- 1.13 COMMISSIONING
- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 01 91 13 - General Commissioning Requirements.
 - B. Complete installation, startup checks and functional tests according to Section 01 91 13 - General Commissioning Requirements and manufacturers written instructions.
 - C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start up procedure.
 - D. Verify that equipment is installed and commissioned as per requirements of Section 01 91 13 and manufacturers written instructions/requirements.
- 1.14 MAINTENANCE MATERIALS
- A. See Section 01 6000 - Product Requirements, for additional provisions.
 - B. Supply sufficient chemicals for treatment and testing during warranty period.
- PART 2 PRODUCTS
- 2.1 MANUFACTURERS
- A. EasyWater Inc.: www.easywater.com

- B. ClearWater Industries Inc.; www.clearwatershelton.com
- C. Nalco, an Ecolab Company: www.nalco.com.
- D. Substitutions: See Section 01 60 00 - Product Requirements.

2.2 GENERAL

- A. Governing Laws: Ensure that neither products, waste, blow-down, nor other effluents violate local, state, EPA, or other agency regulations in effect in the project area.

2.3 SIDE STREAM WATER TREATMENT FOR HEATING WATER/GLYCOL SYSTEM

- A.
 - 1.
- B.

PART 3 EXECUTION

3.1 PIPING SYSTEMS PREPARATION

- A. General: After piping systems are erected and proven free of leaks, administer chemicals required for preparation treatment and flushing. Apply chemicals for the time period and in the concentration recommended by the chemical manufacturer.
- B. Testing: Perform test procedures and submit a written report of test conditions and results to the Engineer. If test results are unsatisfactory, repeat preparation treatment as necessary to achieve test results approved by the Owner's insurance carrier and the Engineer.

3.2 FLUSHING

- A. Drain preparation products from the systems. Flush with clean water until system tests prove systems are free of preparation products and other contaminants prior to running water through and starting up water treatment systems as specified hereinbefore.
- B. If closed loops are existing, perform a slow bleed to drain for at least one (1) week to purge the systems of treatment chemicals.

3.3 START-UP

- A. Start-up Procedures: During water system start-up, measure dissolved oxygen in the chilled and hot water systems prior to starting up water treatment systems.
- B. Reports: Log dissolved oxygen test results on provided log sheet.

3.4 PERSONNEL TRAINING

- A. Operator Training: Train Owner's personnel in use and operation of water treatment system and dissolved oxygen testing for heating and chilled water systems.

3.5 CLEANING SEQUENCE

- A. Concentration:
 - 1. As recommended by manufacturer.
- B. Procedure:
 - 1. Confirm system cleaner is compatible with connected equipment.
 - 2. Apply heat while circulating, slowly raising temperature to 160 degrees F or as recommended by boiler manufacturer, and maintain for 12 hours minimum.
 - 3. Remove heat and circulate to 100 degrees F or less; drain systems as quickly as possible and refill with clean water.
 - 4. Circulate for 6 hours at design temperatures, then drain.
 - 5. Refill with clean water and repeat until system cleaner is removed.
- C. Use neutralizer agents on recommendation of system cleaner supplier.
- D. Inspect, remove sludge, and flush low points with cleaning process is completed.

3.6 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

3.7 CLOSEOUT ACTIVITIES

- A. Training: Train Owner's personnel on operation and maintenance of chemical treatment system.
 - 1. Provide minimum of two hours of instruction for two people.
 - 2. Have operation and maintenance data prepared and available for review during training.
 - 3. Conduct training using actual equipment after treated system has been put into full operation.

3.8 MAINTENANCE

- A. See Section 01 70 00 - Execution Requirements, for additional requirements relating to maintenance service.
- B. Perform maintenance work using competent and qualified personnel under the supervision and in the direct employ of the equipment manufacturer or original installer.
- C. Provide service and maintenance of treatment systems for one year from Date of Substantial Completion.

- D. Provide monthly technical service visits to perform field inspections and make water analysis on-site. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit two copies of field service report after each visit.
- E. Provide laboratory and technical assistance services during this maintenance period.
- F. Provide on-site inspections of equipment during scheduled or emergency shutdown to properly evaluate success of water treatment program, and make recommendations in writing based upon these inspections.

3.9 CLOSEOUTS

- A. See Section 017800-Closeout Submittals, for closeout submittals.
- B. See Section 017900-Demonstration and Training, for additional requirements.
- C. Provide minimum 2 hours of training.

END OF SECTION 23 25 00

SECTION 23 31 00 - HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Metal ductwork.
- B. Nonmetal ductwork.
- C. Casings and plenums.
- D. Grease exhaust ductwork.
- E. Duct cleaning.

1.3 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.
- B. Section 11 40 00 - Foodservice Equipment: Supply of kitchen range hoods for placement by this Section.
- C. Section 23 01 30.51 - HVAC Air-Distribution System Cleaning: Cleaning ducts after completion of installation.
- D. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC.
- E. Section 23 07 13 - Duct Insulation: External insulation and duct liner.
- F. Section 23 33 00 - Air Duct Accessories.
- G. Section 23 37 00 - Air Outlets and Inlets.
- H. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC.

1.4 REFERENCE STANDARDS

- A. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals Most Recent Edition Cited by Referring Code or Reference Standard.
- B. ASTM A36/A36M - Standard Specification for Carbon Structural Steel 2019.
- C. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process 2020.

- D. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar 2015.
- E. ASTM A1011/A1011M - 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 2018a.
- F. ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate 2021.
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.
- H. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements 2015.
- I. ICC-ES AC106 - Acceptance Criteria for Pre drilled Fasteners (Screw Anchors) in Masonry Elements 2015.
- J. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements 2015.
- K. ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements 2016.
- L. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- M. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems 2021.
- N. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations 2021.
- O. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual; Sheet Metal and Air Conditioning Contractors' National Association; 2012, 2nd Edition.
- P. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2020.
- Q. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors current edition, including all revisions.
- R. UL 1978 - Grease Ducts Current Edition, Including All Revisions.
- S. UL 2221 - Tests of Fire Resistive Grease Duct Enclosure Assemblies Current Edition, Including All Revisions.
- 1.5 SUBMITTALS
 - A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
 - B. Product Data: Provide data for duct materials.

- C. Shop Drawings: Indicate duct fittings, particulars such as gauges, sizes, welds, and configuration prior to start of work for kitchen hood exhaust systems.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience, and approved by manufacturer.
- B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum 5 years of documented experience.

PART 2 PRODUCTS

2.1 DUCT ASSEMBLIES

- A. Regulatory Requirements: Construct ductwork to comply with NFPA 90A standards.
- B. Variable Volume Supply Upstream of VAV box: 2.5 inch w.g. pressure class, Class C seal, galvanized steel.
- C. Low Pressure Supply: 2 inch w.g. pressure class, Class C seal, galvanized steel.
- D. Return and Relief: 2 inch w.g. pressure class, Class C seal, galvanized steel.
- E. General Exhaust: 1 inch w.g. pressure class, Class C seal, galvanized steel.
- F. Grease Exhaust: 2 inch wg pressure class, stainless steel.
 - 1. Construct of 16 gauge un-galvanized steel.
 - 2. Construction:
 - a. Liquidtight with continuous external weld for all seams and joints.
 - b. Where ducts are not self draining back to equipment, provide low point drain pocket with copper drain pipe to sanitary sewer.
 - 3. Access Doors:
 - a. Provide for duct cleaning inside horizontal duct at drain pockets, every 20 feet and at each change of direction.
 - b. Use same material and thickness as duct with gaskets and sealants rated 1500 degrees F for grease tight construction.

2.2 MATERIALS

- A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G90/Z275 coating.

- B. Internal liner exposed to air flow shall be non-porous type or film lined.
- C. Aluminum for Ducts: ASTM B209/B209M; aluminum sheet, alloy 3003-H14. Aluminum Connectors and Bar Stock: Alloy 6061-T651 or of equivalent strength.
- D. Stainless Steel for Ducts: ASTM A666, Type 304.
- E. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
 - 1. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
 - 2. VOC Content: Not more than 250 g/L, excluding water.
 - 3. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.
- F. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.
- G. Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:
 - 1. Concrete Wedge Expansion Anchors: Complying with ICC-ES AC193.
 - 2. Masonry Wedge Expansion Anchors: Complying with ICC-ES AC01.
 - 3. Concrete Screw Type Anchors: Complying with ICC-ES AC193.
 - 4. Masonry Screw Type Anchors: Complying with ICC-ES AC106.
 - 5. Concrete Adhesive Type Anchors: Complying with ICC-ES AC308.
 - 6. Other Types: As required.

2.3 DUCTWORK FABRICATION

- A. Fabricate and support in accordance with SMACNA (DCS) and as indicated.
- B. No variation of duct configuration or size permitted except by written permission. Size round duct installed in place of rectangular ducts in accordance with ASHRAE (FUND) Handbook - Fundamentals.
- C. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- D. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes.
- E. Provide turning vanes of perforated metal with glass fiber insulation when acoustical lining is indicated.

- F. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- G. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA (DCS).
- H. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

2.4 MANUFACTURED DUCTWORK AND FITTINGS

- A. Round and Flat Oval Ducts: Machine made from round spiral lockseam duct.
 - 1. Manufacture in accordance with SMACNA (DCS).
 - 2. Fittings: Manufacture at least two gauges heavier metal than duct.
 - 3. Manufacturers:
 - a. EHG, a DMI Company: www.ehgduct.com/#sle.
 - b. Linx Industries, Inc a DMI Company: www.li-hvac.com/#sle.
 - c. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Double Wall Insulated Flat Oval Ducts: Machine made from round spiral lockseam duct.
 - 1. Manufacture in accordance with SMACNA (DCS).
 - 2. Fittings: Manufacture with solid inner wall.
 - 3. Inner Wall: Perforated galvanized steel.
 - 4. Insulation:
 - a. Thickness: 1 inch fiberglass.
- C. Double Wall Insulated Round Ducts: Round spiral lockseam duct with galvanized steel outer wall, perforated galvanized steel inner wall; fitting with solid inner wall.
 - 1. Manufacture in accordance with SMACNA (DCS).
 - 2. Insulation:
 - a. Thickness: 1 inch.
- D. Flexible Ducts: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound spring steel wire.

1. Insulation: Fiberglass insulation with polyethylene vapor barrier film.
 2. Pressure Rating: 10 inches wg positive and 1.0 inches wg negative.
 3. Maximum Velocity: 4000 fpm.
 4. Temperature Range: Minus 20 degrees F to 210 degrees F.
- E. Transverse Duct Connection System: SMACNA "E" rated rigidly class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips in accordance with SMACNA (DCS).
- F. Kitchen Hood and Grease Exhaust Ducts with Integral Insulation: Nominal 3 inches thick ceramic fiber insulation between 20 gauge, 0.0375 inch, Type 304 stainless steel liner and 24 gauge, 0.0239 inch aluminized steel sheet outer jacket.
1. Tested and UL listed for use with commercial cooking equipment in accordance with NFPA 96.
 2. Certified for zero clearance to combustible material in accordance with:
 - a. UL 2221 with a 2 hour rating.
 3. Materials and construction of the modular sections and accessories to be in accordance with the terms of the following listings:
 - a. UL 1978.
 - b. UL 2221.
 4. Manufacturers:
 - a. AMPCO by Hart & Cooley, LLC; Z-Clear: www.ampcostacks.com/#sle.
 - b. Security Chimneys International; Secure Duct (CIX3Z): www.securitychimneys.com/#sle.
 - c. Selkirk Corporation; ZeroClear (IPS-Z3): www.selkirkcommercial.com/#sle.
 - d. Substitutions: See Section 01 60 00 - Product Requirements.

2.5 CASINGS AND PLENUMS

- A. Fabricate casings in accordance with SMACNA (DCS) and construct for operating pressures indicated.
- B. Mount floor mounted casings on 4 inch high concrete curbs. At floor, rivet panels on 8 inch centers to angles. Where floors are acoustically insulated, provide liner of galvanized 18 gauge, 0.0478 inch expanded metal mesh supported at 12 inch centers, turned up 12 inches at sides with sheet metal shields.

- C. Reinforce door frames with steel angles tied to horizontal and vertical plenum supporting angles. Install hinged access doors where indicated or required for access to equipment for cleaning and inspection.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install, support, and seal ducts in accordance with SMACNA (DCS).
- B. Install in accordance with manufacturer's instructions.
- C. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- D. Flexible Ducts: Connect to metal ducts with adhesive.
- E. Kitchen Hood Exhaust: Provide residue traps at base of vertical risers with provisions for clean out.
- F. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- G. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- H. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- I. Use double nuts and lock washers on threaded rod supports.
- J. Connect terminal units to supply ducts directly with two foot minimum length of rigid round duct. Do not use flexible duct.
- K. Connect diffusers or light troffer boots to low pressure ducts directly or with 5 feet maximum length of flexible duct held in place with strap or clamp.

3.2 CLEANING

- A. See Section 01 74 19 - Construction Waste Management and Disposal, for additional requirements.
- B. Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment that could be harmed by excessive dirt with temporary filters, or bypass during cleaning.

- C. Clean duct systems with high power vacuum machines. Protect equipment that could be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.

END OF SECTION 23 31 00

SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Air turning devices/extractors.
- B. Backdraft dampers - metal.
- C. Combination fire and smoke dampers.
- D. Duct access doors.
- E. Duct test holes.
- F. Fire dampers.
- G. Flexible duct connectors.
- H. Volume control dampers.
- I. Miscellaneous products:
 - 1. Duct opening closure film.

1.3 RELATED REQUIREMENTS

- A. Section 01 91 13 - General Commissioning Requirements.
- B. Section 07 84 00 - Firestopping.
- C. Section 23 05 48 - Vibration and Seismic Controls for HVAC.
- D. Section 23 31 00 - HVAC Ducts and Casings.
- E. Section 26 05 83 - Wiring Connections: Electrical characteristics and wiring connections.

1.4 REFERENCE STANDARDS

- A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating 2018.
- B. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- C. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2020.

- D. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances Current Edition, Including All Revisions.
- E. UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces Current Edition, Including All Revisions.

1.5 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for submittal procedures.
- B. Product Data: Provide for shop fabricated assemblies including volume control dampers, duct access doors, duct test holes, and hardware used.
- C. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers, duct access doors, and duct test holes.
- D. Manufacturer's Installation Instructions: Provide instructions for fire dampers.

1.6 PROJECT RECORD DOCUMENTS

- A. Record actual locations of access doors and test holes.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Protect dampers from damage to operating linkages and blades.

1.9 COMMISSIONING

- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 01 91 13 - General Commissioning Requirements.
- B. Complete installation, startup checks and functional tests according to Section 01 91 13 - General Commissioning Requirements and manufacturers written instructions.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start up procedure.
- D. Verify that equipment is installed and commissioned as per requirements of Section 01 91 13 and manufacturers written instructions/requirements.

PART 2 PRODUCTS

2.1 AIR TURNING DEVICES/EXTRACTORS

A. Manufacturers:

1. Krueger-HVAC, Division of Air System Components: www.krueger-hvac.com/#sle.
2. Ruskin Company: www.ruskin.com/#sle.
3. Titus HVAC, a brand of Johnson Controls: www.titus-hvac.com/#sle.
4. Substitutions: See Section 01 60 00 - Product Requirements.

- B. Multi-blade device with radius blades attached to pivoting frame and bracket, steel construction, with push-pull operator strap.

2.2 BACKDRAFT DAMPERS - METAL

2.3 BACKDRAFT DAMPERS

A. Manufacturers:

1. Louvers & Dampers, Inc, a brand of Mestek, Inc: www.louvers-dampers.com/#sle.
2. Nailor Industries, Inc: www.nailor.com/#sle.
3. Ruskin Company: www.ruskin.com/#sle.
4. Substitutions: See Section 01 60 00 - Product Requirements.

- B. Gravity Backdraft Dampers, Size 18 by 18 inches or Smaller, Furnished with Air Moving Equipment: Air moving equipment manufacturer's standard construction.

- C. Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: Galvanized steel, with center pivoted blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.4 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers:

1. Greenheck Inc.: www.greenheck.com
2. Nailor Industries, Inc: www.nailor.com/#sle.
3. Ruskin Company: www.ruskin.com/#sle.
4. Substitutions: See Section 01 60 00 - Product Requirements.

- B. Fire resistance rated at 1-1/2 hours, Class I leakage rating, 350 degree F temperature rating, fabricated in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.
- C. Provide factory sleeve and collar for each damper. Sleeve shall provide out-of-wall mounting where flush mounting of sidewall grille within the rated partition is shown on the drawings.
- D. Multiple Blade Dampers: Fabricate with 16 gauge, 0.0598 inch galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 1/8 by 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.
- E. Operators: UL listed and labelled spring return electric type suitable for 120 volts, single phase, 60 Hz. Provide end switches to indicate damper position. Locate damper operator on interior of duct and link to damper operating shaft.
- F. Normally Closed Smoke Responsive Fire Dampers: Curtain type, opening upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure.
- G. Electro Thermal Link: Fusible link melting at 165 degrees F; 120 volts, single phase, 60 Hz; UL listed and labeled.

2.5 DUCT ACCESS DOORS

- A. Manufacturers:
 - 1. Nailor Industries, Inc: www.nailor.com/#sle.
 - 2. Ruskin Company: www.ruskin.com/#sle.
 - 3. SEMCO LLC: www.semcohvac.com/#sle.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ducts, install minimum 1 inch thick insulation with sheet metal cover.
 - 1. Less Than 12 inches Square: Secure with sash locks.
 - 2. Up to 18 inches Square: Provide two hinges and two sash locks.
 - 3. Up to 24 by 48 inches: Three hinges and two compression latches with outside and inside handles.
 - 4. Larger Sizes: Provide an additional hinge.
- D. Access doors with sheet metal screw fasteners are not acceptable.

2.6 DUCT TEST HOLES

- A. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.7 FIRE DAMPERS

- A. Manufacturers:
 - 1. Greenheck, Inc : www.greenheck.com
 - 2. Nailor Industries, Inc: www.nailor.com/#sle.
 - 3. Ruskin Company: www.ruskin.com/#sle.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Fire resistance rated at 1-1/2 hours, dynamic fire damper, fabricated in accordance with NFPA 90A and UL 555, and as indicated.
- C. Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream where possible. Provide sleeve for out-of-wall mounting where flush mounting of sidewall grille with in the rated partition is shown on the drawings.
- D. Fusible Links: 165 degrees F.

2.8 FLEXIBLE DUCT CONNECTORS

- A. Fabricate in accordance with SMACNA (DCS) and as indicated.
- B. Flexible Duct Connections: Fabric crimped into metal edging strip.
 - 1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz per sq yd.
 - a. Net Fabric Width: Approximately 2 inches wide.
 - 2. Metal: 3 inches wide, 24 gauge, 0.0239 inch thick galvanized steel.

2.9 VOLUME CONTROL DAMPERS

- A. Manufacturers:
 - 1. Greenheck, Inc: www.greenheck.com
 - 2. Nailor Industries, Inc: www.nailor.com/#sle.
 - 3. Ruskin Company: www.ruskin.com/#sle.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.

- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Splitter Dampers:
 - 1. Material: Same gage as duct to 24 inches size in either direction, and two gages heavier for sizes over 24 inches.
 - 2. Blade: Fabricate of single thickness sheet metal to streamline shape, secured with continuous hinge or rod.
 - 3. Operator: Minimum 1/4 inch diameter rod in self aligning, universal joint action, flanged bushing with set screw .
- D. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.
- E. Quadrants:
 - 1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
 - 2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
- F. Constant Airflow Regulators:
 - 1. General Requirements:
 - a. Provide bi-directional, air balancing regulator for pressure independent air volume control.
 - b. Complies with UL 2043 for heat and smoke release.
 - c. Complies with AMCA 500-D for the allowable leakage rates.
 - d. Airflow regulator to be field adjustable.
 - 2. Construction:
 - a. Nominal Diameter: 4 inch.
 - b. Frame: Thermoplastic resin in compliance with UL 94.
 - c. Blade: Thermoplastic resin in compliance with UL 94.
 - d. Bearings: Hydraulic blade dampener.
 - e. Outer Seal: Removable rubber gasket-type around circumference of damper.
 - f. Spring: Stainless steel leaf-type.

- g. Temperature Range: 25 degrees F to 150 degrees F .
- h. Operating Range: 0.2 inch W.C. to 2.0 inch W.C..
- 3. Accessories:
 - a. Provide airflow regulators with rectangular to round transitions.

2.10 MISCELLANEOUS PRODUCTS

- A. Duct Opening Closure Film: Mold-resistant, self-adhesive film to keep debris out of ducts during construction.
 - 1. Thickness: 2 mils.
 - 2. High tack water based adhesive.
 - 3. UV stable light blue color.
 - 4. Elongation Before Break: 325 percent, minimum.
 - 5. Where rod lengths exceed 30 inches provide regulator at both ends.

PART 3 EXECUTION

3.1 PREPARATION

- A. Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). Refer to Section 23 31 00 for duct construction and pressure class.
- B. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- C. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers and elsewhere as indicated. Provide for cleaning kitchen exhaust ducts in accordance with NFPA 96. Provide minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, and as indicated. Provide 4 x 4 inch for balancing dampers only. Review locations prior to fabrication.
- D. Provide duct test holes where indicated and required for testing and balancing purposes.
- E. Provide fire dampers and combination fire and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves and breakaway duct connections.
- F. Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92.

- G. Demonstrate re-setting of fire dampers to Owner's representative.
- H. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.
- I. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.
- J. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take-off.
- K. Use splitter dampers only where indicated.
- L. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
- M. Install balancing dampers as far as possible from each diffuser, grille or register.

END OF SECTION 23 33 00

SECTION 23 33 19 - DUCT SILENCERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Duct silencers.

1.3 RELATED REQUIREMENTS

- A. Section 23 31 00 - HVAC Ducts and Casings: Connections to silencers.
- B. Section 23 33 00 - Air Duct Accessories: Flexible duct connections.

1.4 REFERENCE STANDARDS

- A. AABC MN-1 - AABC National Standards for Total System Balance; Associated Air Balance Council; 2002.
- B. AMCA 300 - Reverberant Room Method for Sound Testing of Fans 2014.
- C. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data 2014.
- D. ANSI/ASA S1.4 PART 3 - American National Standard Electroacoustics – Sound Level Meters – Part 3: Periodic Tests 2014 (Reaffirmed 2019).
- E. ANSI S1.4 - American National Standard Specification for Sound Level Meters; 1983 (R2006) with Amd.S1.4A-1985.
- F. ANSI S1.8 - American National Standard Reference Values for Levels Used in Acoustics and Vibrations 2016 (Reaffirmed 2020).
- G. ANSI S1.13 - American National Standard Measurement of Sound Pressure Levels in Air 2020.
- H. ANSI S12.1 - American National Standard Guidelines for the Preparation of Standard Procedures to Determine the Noise Emission from Sources 1983 (Reaffirmed 2020).
- I. ANSI S12.60-2002 - American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools.
- J. ASHRAE Std 68 - Laboratory Method of Testing to Determine the Sound Power in a Duct 1997.
- K. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications Most Recent Edition Cited by Referring Code or Reference Standard.

- L. ASTM E477 - Standard Test Method for Laboratory Measurements of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers 2020.
- M. ASTM E596 - Standard Test Method for Laboratory Measurement of Noise Reduction of Sound-Isolating Enclosures 1996 (Reapproved 2016).
- N. NEBB (STDS) - Procedural Standard for Measurement of Sound and Vibration 2015, with Errata (2017).
- O. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2020.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog information indicating, materials, dimensional data, pressure losses, and acoustical performance.
- C. Shop Drawings: Indicate assembly, materials, thicknesses, dimensional data, pressure losses, acoustical performance, layout, and connection details.
- D. Design Data: Provide engineering calculations, referenced to specifications and AHRI 270, AHRI 270, AMCA 301, AMCA 301, AMCA 302, AMCA 302, AMCA 303, AMCA 303, ANSI S12.1, and ANSI S12.1 standards indicating that maximum room sound levels are not exceeded.
- E. Test Reports: Indicate dynamic insertion loss and noise generation values of silencers.
- F. Manufacturer's Installation Instructions: Indicate installation procedures necessary to maintain integrity of sound isolation.
- G. Manufacturer's Field Reports: Indicate installation is complete and in accordance with instructions.
- H. Project Record Documents: Record actual locations of cross-talk silencers, acoustic housings, ductwork lagging, and air transfer silencers.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Perform Work in accordance with AHRI 575, AHRI 575, AMCA 300, AMCA 300, ANSI S1.13, or ANSI S1.13 standards and recommendations of ASHRAE Std 68 ASHRAE Std 68.
 - 1. Maintain one copy of each document on site.

1.7 REGULATORY REQUIREMENTS

- A. Conform to applicable code for sound levels at occupied space.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Industrial Acoustics Company: www.industrialacoustics.com.
- B. Kinetics Noise Control: www.kineticsnoise.com
- C. Price: www.priceindustries.com
- D. Vibro-Acoustics; www.vibro-acoustics.com
- E. Substitutions: See Section 01 60 00 - Product Requirements.

2.2 DUCT SILENCERS

- A. Description: Duct section with sheet metal outer casing, sound absorbing fill material, and inner casing of perforated sheet metal; incorporating interior baffles of similar construction. Fabricate in accordance with SMACNA (DCS) HVAC Duct Construction Standards.
- B. Materials:
 - 1. Acoustical liners shall be non-porous type of film lined.
 - 2. Outer Casing: Minimum 22 gage thick. Galvanized steel stiffened as required, with lockformed casing constructed to SMACNA standards, 1 inch long slip connection at each end.
 - 3. Inner Casing and Splitters: Minimum 26 gage thick perforated galvanized steel.
 - 4. Fill: Glass fiber or mineral wool of minimum 4 lb/cu ft density.
 - 5. Fill Liner: Bonded glass fiber matting.
- C. Performance:
 - 1. Refer to the schedule on the plans for types, sizes and performance.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Support duct silencers independent of ducts with flexible duct connections, lagged with leaded vinyl sheet on inlet and outlet. Refer to Section 23 31 00 and Section 23 33 00.

3.2 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.

- B. Provide services of an independent testing agency to take noise measurements in accordance with provisions of NEBB (STDS). Use meters meeting requirements of ANSI/ASA S1.4 PART 3.
- C. After start-up, final corrections and balancing of systems take octave band sound measurements over full audio frequency range in areas adjacent to mechanical equipment rooms, duct and pipe shafts, and other critical locations, as directed.
- D. Provide one-third octave band measurements of artificial sound sources in areas indicated as having critical requirements.
- E. Submit complete report of test results including sound curves.

END OF SECTION 23 33 19

SECTION 23 34 23 - HVAC POWER VENTILATORS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Roof exhausters.
- B. Inline centrifugal fans and blowers.
- C. Kitchen hood upblast roof exhausters.
- D. De-stratification fans

1.3 RELATED REQUIREMENTS

- A. Section 01 91 13 - General Commissioning Requirements.
- B. Section 23 05 48 - Vibration and Seismic Controls for HVAC.
- C. Section 23 33 00 - Air Duct Accessories: Backdraft dampers.
- D. Section 25 14 00 - Integrated Automation Local Control Units.
- E. Section 26 05 83 - Wiring Connections: Electrical characteristics and wiring connections.
- F. Section 500000 - Commissioning Requirements.

1.4 REFERENCE STANDARDS

- A. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program 2015.
- B. AMCA 99 - Standards Handbook 2016.
- C. AMCA 204 - Balance Quality and Vibration Levels for Fans 2020.
- D. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating 2016.
- E. AMCA 300 - Reverberant Room Method for Sound Testing of Fans 2014.
- F. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data 2014.
- G. NEMA MG 1 - Motors and Generators 2018.

- H. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- I. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations 2021.
- J. UL 762 - Outline of Investigation for Power Roof Ventilators for Restaurant Exhaust Appliances Current Edition, Including All Revisions.

1.5 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for submittal procedures.
- B. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements.
- C. Manufacturer's Instructions: Indicate installation instructions.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Kitchen Range Hood Exhaust Fans: Comply with requirements of NFPA 96.
- C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.7 FIELD CONDITIONS

- A. Permanent ventilators may be used for ventilation during construction only after ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under observation.

1.8 WARRANTY

- A. The warranty period shall be a non-prorated period of 24 months from the date of final acceptance by Owner, unless otherwise noted., not to exceed 30 months from date of manufacture. Warranty shall cover pump, motor and add-on modules as complete unit.

1.9 COMMISSIONING

- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 01 91 13 - General Commissioning Requirements.
- B. Complete installation, startup checks and functional tests according to Section 01 91 13 - General Commissioning Requirements and manufacturers written instructions.

- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start up procedure.
- D. Verify that equipment is installed and commissioned as per requirements of Section 01 91 13 and manufacturers written instructions/requirements.
- E. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- F. Contractor shall replace all damaged components and components that failed the inspections at no additional charge.
- G. Inspections by the Commissioning Agent shall be on “spot check basis”. Commissioning process does not reduce responsibility of installing contractors to provide a finished and fully functioning product.
- H. This section shall in no way diminish the responsibility of the Contractors, Sub-contractors and Suppliers in performing all aspects of work and testing as outlined in the Contract Documents. Any requirements outlined in this section are in addition to requirements outlined in related specifications.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Loren Cook Company (Basis of design): www.lorencook.com.
- B. Greenheck: www.greenheck.com.
- C. Twin City Fans & Blowers: www.tcf.com
- D. Substitutions: See Section 01 60 00 - Product Requirements.

2.2 POWER VENTILATORS - GENERAL

- A. Static and Dynamically Balanced: Comply with AMCA 204.
- B. Performance Ratings: Comply with AMCA 210, bearing certified rating seal.
- C. Sound Ratings: Comply with AMCA 301, tested to AMCA 300, bearing certified sound ratings seal.
- D. Fabrication: Comply with AMCA 99.
- E. UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 705.
- F. Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

- G. Kitchen Hood Exhaust Fans: Comply with requirements of NFPA 96 and UL 762.

2.3 ROOF EXHAUSTERS

A. Product Requirements:

1. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.
2. Sound Ratings: AMCA 301, tested to AMCA 300, and bearing AMCA Certified Sound Rating Seal.
3. Fabrication: Conform to AMCA 99.
4. UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 705.

- B. Fan Unit: direct or belt driven as indicated, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen. The aluminum base shall have a one-piece inlet spinning and continuously welded curb cap corners for maximum leak protection. The windband shall have a rolled bead for added strength. A two-piece top cap shall have stainless steel quick release latches to provide access into the motor compartment without the use of tools.

- C. Motor: ECM

- D. Roof Curb: 18 inch high (above finish roof) self-flashing of aluminum with continuously welded seams, built-in cant strips.

- E. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor and wall mounted multiple speed switch.

2.4 INLINE CENTRIFUGAL FANS AND BLOWERS

- A. Centrifugal Fan Unit: direct driven with galvanized steel housing lined with acoustic insulation, resilient mounted motor, motorized damper in discharge.

- B. Motor: ECM

- C. Disconnect Switch: Cabinet fans shall have cord and plug in housing for thermal overload protected motor and wall mounted switch. Square inline fans shall have factory-wired, non-fusible disconnect switch, mounted to exterior of fan housing.

- D. Sheaves (for belt-drive models): Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

2.5 KITCHEN HOOD UPBLAST ROOF EXHAUSTERS

- A. Belt Drive Fan:

1. Fan Wheel:
 - a. Type: Non-overloading, backward inclined centrifugal.
 - b. Material: Aluminum, statically and dynamically balanced.
 2. Motors:
 - a. Open drip-proof (ODP).
 - b. Heavy duty ball bearing type.
 - c. Mount on vibration isolators or resilient cradle mounts, out of air stream.
 - d. Fully accessible for maintenance.
 - e. ECM or VFD driven
 3. Housing:
 - a. Rigid internal support structure.
 - b. One-piece fabricated or fully welded curb-cap base to windband for leak proof construction.
 - c. Construct drive frame assembly of heavy gauge steel, mounted on vibration isolators.
 - d. Provide breather tube for fresh air motor cooling and wiring.
- B. Shafts and Bearings:
1. Fan Shaft:
 - a. Ground and polished steel with anti-corrosive coating.
 - b. First critical speed at least 25 percent over maximum cataloged operating speed.
 2. Bearings:
 - a. Permanently sealed or pillow block type.
 - b. Minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
 - c. 100 percent factory tested.
- C. Drive Assembly:
1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
 2. Belts: Static free and oil resistant.

3. Fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
4. Motor pulley adjustable for final system balancing.
5. Readily accessible for maintenance.

D. Disconnect Switches:

1. Factory mounted and wired.
2. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Outdoor Locations: Type 3R.
3. Finish for Painted Steel Enclosures: Provide manufacturer's standard or factory applied grey unless otherwise indicated.
4. Positive electrical shutoff.
5. Wired from fan motor to junction box installed within motor compartment.

E. Drain Trough: Allows for single-point drainage of water, grease, and other residues.

F. Accessories:

1. Hinged basket kit
2. Grease Terminator
3. 18" roof curb with continuously welded corners.

2.6 DESTRATIFICATION FANS

A. MANUFACTURERS

1. Hunter Industrial: www.hunterfan.com/industrial
2. Big Ass Fans
3. Substitutions: See Section 01 60 00 - Product Requirements.

B. High Volume, Low Speed Fans

1. Complete Unit
 - a. Regulatory Requirements: The fan shall be Intertek/ETL certified pursuant to ANIS/UL 507 and CSA standard
 - b. 22.2 No. 113 in North America.

- c. Sustainability and Efficiency: The fan shall be designed to move an effective amount of air for cooling and destratification in a wide variety of applications (Industrial and Agricultural). The entire fan and components shall not weigh more than 159 lbs. to reduce stress on building structure.

C. Industrial Control Panel

1. The fan controller shall consist of a Variable Frequency Drive (VFD) enclosed in an aluminum enclosure. This enclosure is designed to contain the VFD for maximum cooling efficiency with a through the back mounting configuration along with receptacles and electrical whip for a plug-n-play install. Included in the enclosure is a Pam-4 relay for integration to existing fire panels.
2. Voltage: 100-120 VAC 1PH 50-60Hz. Continuous operation in 32° to 140° F (0° to 60°C) ambient conditions.

D. Airfoil System

1. The fan shall be equipped with four (4) airfoils made from 6005A Structural Grade aluminum. The airfoils shall be connected to the hub by means of a high strength pressed bolt system. Each airfoil shall be manufactured with a precision cut, swept style tip (instead of winglets).

E. Hub Motor

1. The fan motor shall be a high torque permanent magnet motor rated for continuous operation at maximum speed without the use of a gearbox or other mechanical torque multiplier. The motor shall be a totally enclosed non-ventilated design with the capacity for continuous operation in 32° to 140° F (0° to 60°C) ambient conditions. The hub motor enclosure shall be precision cast A380 for low weight and maximum strength.

F. Mounting System

1. The mounting system shall be designed for quick, secure installation to a wide variety of ceiling structural supports. All components of the mounting system shall be made from A36 steel and ERW tubing. The downrod shall be pre-wired with a pin and sleeve connection for simple, safe and economical installation. All mounting bolts shall be SAE Grade 5 or equivalent.

G. Safety Cables

1. The fan shall be equipped with one 1/4" 7 x 19 Safety Cable, the length of the downrod plus six feet, composed of high-tensile ANSI 316 stainless steel. The minimum breaking strength of the cable assembly supplied is 4,750 lbs. Wire rope conforms to ASTM A492. In addition, three 1/4" malleable wire rope clamps will be included.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Secure roof exhausters with cadmium plated steel lag screws to roof curb.
- C. Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.

3.2 DESTRATIFICATION FAN PREPARATION

- A. An existing building must have a mounting structure able to support two times the hanging weight of the fan. The structure the fan is attached to shall be capable of supporting a torque load of up to 70 ft·lb (95 N·m) of torque. Consult a structural engineer if necessary.
- B. Minimum Clearances
 - 1. Airfoils must be at least 10ft (3 m) above the floor.
 - 2. The sweep area (horizontally and vertically) must be at least 2ft (0.61 m) from any obstructions such as lights and cables.
 - 3. The fan shall not be applied in any location where it may be subject to cross winds or in close proximity to HVAC or radiant heat outputs.
- C. Item such as lights, cables, or any other obstacles must be relocated or removed if they do not comply with the minimum clearance requirement before installation.
- D. Dedicated branch circuit protection is required to the fans.
- E. A twist lock receptacle must be placed 5 feet outside the sweep area. Refer to the installation manual for a list of receptacles part numbers.

3.3 CLOSEOUTS

- A. See Section 017800-Closeout Submittals, for closeout submittals.
- B. See Section 017900-Demonstration and Training, for additional requirements.

END OF SECTION 23 34 23

SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Single-duct variable volume units and constant volume units.

1.3 RELATED REQUIREMENTS

- A. Section 23 05 48 - Vibration and Seismic Controls for HVAC.
- B. Section 23 09 13 - Instrumentation and Control Devices for HVAC: Thermostats and actuators.
- C. Section 23 09 23 - Direct-Digital Control System for HVAC.
- D. Section 23 09 93 - Sequence of Operations for HVAC Controls.
- E. Section 23 21 13 - Hydronic Piping: Connections to heating coils.
- F. Section 23 31 00 - HVAC Ducts and Casings.
- G. Section 23 33 00 - Air Duct Accessories.
- H. Section 23 82 00 - Convection Heating and Cooling Units: Air coils.

1.4 REFERENCE STANDARDS

- A. AHRI 880 (I-P) - Performance Rating of Air Terminals 2017.
- B. AHRI 885 - Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets 2011, with Addendum.
- C. ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. ASTM A492 - Standard Specification for Stainless Steel Rope Wire 1995 (Reapproved 2019).
- E. ASTM A603 - Standard Specification for Metallic-Coated Steel Structural Wire Rope 2019.
- F. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2021a.

- G. ASTM E488/E488M - Standard Test Methods for Strength of Anchors in Concrete Elements 2018.
- H. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- I. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems 2008.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings that indicate air flow, static pressure, and NC designation. Include electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
 - 1. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of 1 to 4 inch wg.
- D. Manufacturer's Installation Instructions: Indicate support and hanging details, installation instructions, recommendations, and service clearances required.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant-volume regulators.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.7 WARRANTY

- A. See Section 017700 - Closeout Procedures, for additional warranty requirements.
- B. Provide (1) Year from the date of final acceptance by Owner, unless otherwise noted.

1.8 COMMISSIONING

- A. Engage a factory-authorized service representative, to perform startup service as per functional test sheets and Commissioning Requirements.
- B. Complete installation and startup checks and functional tests according to Commissioning Requirements.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start up procedure.

- D. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- E. Contractor shall replace all damaged components and components that failed the inspections at no additional charge.
- F. Inspections by the Commissioning Agent shall be on “spot check basis”. Commissioning process does not reduce responsibility of installing contractors to provide a finished and fully functioning product.
- G. This section shall in no way diminish the responsibility of the Contractors, Sub-contractors and Suppliers in performing all aspects of work and testing as outlined in the Contract Documents. Any requirements outlined in this section are in addition to requirements outlined in related specifications.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. General
 - 1. Manufacturer shall participate in the AHRI Certification program. Unit performance data shall be rated in accordance with AHRI Standard 880. The manufacturer shall display the AHRI Symbol on all units.
- B. Acceptable Manufacturers
 - 1. Price Air Distribution Products: www.price-hvac.com
 - 2. Titus: www.titus-hvac.com
 - 3. Nailor Industries, Inc. (Basis of Design): nailor.com
- C. Substitutions: See Section 01 60 00 - Product Requirements.

2.2 MANUFACTURED UNITS

- A. Ceiling mounted variable air volume supply air control terminals for connection to single duct, central air systems, with electronic variable volume controls, , electric heating coils.

2.3 SINGLE DUCT VARIABLE VOLUME UNITS AND CONSTANT-VOLUME UNITS

- A. Basic Assembly:
 - 1. Casings: Minimum 22 gage galvanized steel.
 - 2. Lining: Minimum 1/2 inch thick neoprene or vinyl coated fibrous glass insulation, 1.5 lb/cu ft density, meeting NFPA 90A requirements and UL 181 erosion requirements.
 - 3. Plenum Air Inlets: Round stub connections for duct attachment.

4. Plenum Air Outlets: S slip and drive connections.

B. Basic Unit:

1. Configuration: Air volume damper assembly inside unit casing. Locate control components inside protective metal shroud.
2. Volume Damper: Construct of minimum 22 gauge galvanized steel with peripheral gasket and self lubricating bearings; maximum damper leakage: 1 percent of design air flow at 3 inches rated pressure differential.
3. Mount damper operator to position damper as indicated.

C. Hot Water Heating Coil:

1. Construction: Coils shall be factory-installed and shall consist of aluminum plated fins and seamless copper tubes. Fins shall have full fin collars to provide accurate fin spacing and maximum fin-to-tube contact. Tubes shall be mechanically expanded into the fin collars. Coils shall be leak tested under water to 450 psig pressure. Supply and return water connections shall be on the same side of the coil.

D. Velocity Reset Controller and Probe:

1. Multi-point, ring or cross-flow averaging sensor with calibration pressure taps for connection to Building Automation System (BAS) controller. Bar or single point sensing type is not acceptable.

E. Controls:

1. DDC controls.
2. Unit shall be furnished with NEMA 1 controls enclosure.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that conditions are suitable for installation.
- B. Verify that control box is on correct side of the unit.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install the inlets of air terminal units and air flow sensors a minimum of four duct diameters from elbows, transitions, and duct takeoffs.
- C. Provide ceiling access doors or locate units above easily removable ceiling components.

- D. Support units individually from structure with wire rope complying with ASTM A492 and ASTM A603 in accordance with SMACNA (SRM). See Section 23 0548.
- E. Do not support from ductwork.
- F. Connect to ductwork in accordance with Section 23 31 00.
- G. Provide minimum of 10 ft of lined ductwork downstream of units or 3-foot sound attenuator.
- H. Install heating coils in accordance with Section 23 82 00.
- I. Verify that electric power is available and of the correct characteristics.

3.3 ADJUSTING

- A. Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design flow to 30 percent full flow.

3.4 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Provide manufacturer's field representative to test, inspect, instruct, and observe field-assembled components and equipment installation, including connections and to assist in field testing. Report results in writing.
 - 1. Leak Test:
 - a. After installation, fill water coils and test for leaks.
 - b. Repair leaks and retest until no leaks exist.

3.5 CLEANING

- A. See Section 01 74 19 - Construction Waste Management and Disposal, for additional requirements.
- B. Vacuum clean coils and inside of units.

3.6 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 - Demonstration and Training, for additional requirements.

END OF SECTION 233600 23 36 00

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SECTION 23 37 00 - AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Diffusers:
 - B. Rectangular ceiling diffusers.
- C. Registers/grilles:
 - 1. Ceiling-mounted, exhaust and return register/grilles.
 - 2. Wall-mounted, supply register/grilles.
 - 3. Wall-mounted, exhaust and return register/grilles.
- D. Duct-mounted supply and return registers/louvers.

1.3 RELATED REQUIREMENTS

- A. Section 09 91 23 - Interior Painting - Painting of ducts visible behind outlets and inlets.
- B. Section 23 31 00 - HVAC Ducts and Casings.
- C. Section 23 33 00 - Air Duct Accessories.

1.4 REFERENCE STANDARDS

- A. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating 2015.
- B. ARI 890 - Standard for Air Diffusers and Air Diffuser Assemblies; Air-Conditioning and Refrigeration Institute; 2001.
- C. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Inlets 2006 (Reaffirmed 2021).
- D. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2020.

1.5 SUBMITTALS

- A. See Section 01 33 00 - Submittal Procedures, for submittal procedures.
- B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and

inlets showing type, size, location, application, and noise level.

1.6 QUALITY ASSURANCE

- A. Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

PART 2 PRODUCTS

2.1 DIFFUSERS, GRILLES AND REGISTERS

- A. MANUFACTURERS:
 - 1. Krueger: www.krueger-hvac.com/#sle.
 - 2. Price Industries: www.price-hvac.com/#sle.
 - 3. Titus: www.titus-hvac.com/#sle.

2.2 RECTANGULAR CEILING DIFFUSERS

- A. Fabrication: Aluminum with baked enamel finish.
- B. Type: Square, stamped, multi-core diffuser to discharge air in 360 degree pattern with sectorizing baffles where indicated.
- C. Frame: Surface mount type. In plaster ceilings, provide plaster frame and ceiling frame.

2.3 DUCT-MOUNTED SUPPLY AND RETURN REGISTERS/LOUVERS

- A. Type: Duct-mounted, rectangular register for round-spiral duct with adjustable pivot-ended blades, end caps, built-in volume damper, and dual cover flanges to lay flush on duct surface regardless of diameter. Performance to match manufacturer's catalog data.
- B. Material: Extruded aluminum.

2.4 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with blades set at 45 degrees, vertical face.
- B. Frame: 1-1/4 inch margin with countersunk screw mounting.
- C. Fabrication: Steel with 20 gauge, 0.0359 inch minimum frames and 22 gauge, 0.0299 inch minimum blades, steel and aluminum with 20 gauge, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.

2.5 WALL SUPPLY REGISTERS/GRILLES

- A. Type: Streamlined and individually adjustable blades, 3/4 inch minimum depth, 3/4 inch maximum spacing with spring or other device to set blades, vertical face, single deflection.
- B. Frame: 1-1/4 inch margin with countersunk screw mounting and gasket.
- C. Fabrication: Aluminum with 20 gauge, 0.0359 inch minimum frames and 22 gauge, 0.0299 inch minimum blades, steel and aluminum with 20 gauge, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.

2.6 WALL EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with spring or other device to set blades, vertical face.
- B. Frame: 1-1/4 inch margin with countersunk screw mounting.
- C. Fabrication: Aluminum extrusions, with factory baked enamel finish.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Coordinate RGD color and border type with Architect.
- C. Check location of outlets and inlets and make necessary adjustments in position to comply with architectural features, symmetry, and lighting arrangement.
- D. Install diffusers to ductwork with air tight connection.
- E. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 099123.

END OF SECTION 23 37 00

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SECTION 23 51 00 - BREECHINGS, CHIMNEYS, AND STACKS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Manufactured breechings.
- B. Manufactured chimneys and breeching for gas fired equipment (For Boilers & Gas Water Heaters).

1.3 RELATED REQUIREMENTS

1.4 REFERENCE STANDARDS

- A. ANSI Z21.66 - American National Standard for Automatic Damper Devices for Use with Gas-Fired Appliances 2015 (Reaffirmed 2020).
- B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process 2020.
- C. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar; 2010.
- D. ASTM A1011/A1011M - 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 2018a.
- E. NFPA 54 - National Fuel Gas Code 2021.
- F. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances 2019.
- H. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2020.
- I. UL 103 - Factory-Built Chimneys for Residential Type and Building Heating Appliances Current Edition, Including All Revisions.
- J. UL 378 - Standard for Draft Equipment Current Edition, Including All Revisions.
- K. UL 441 - Standard for Gas Vents Current Edition, Including All Revisions.

- L. UL 641 - Type L Low Temperature Venting Systems Current Edition, Including All Revisions.
- M. UL 959 - Medium Heat Appliance Factory Built Chimneys Current Edition, Including All Revisions.
- N. UL 1738 - Standard for Venting Systems for Gas Appliances, Categories II, III and IV.

1.5 DEFINITIONS

- A. Breeching: Vent connector.
- B. Chimney: Primarily vertical shaft enclosing at least one vent for conducting flue gases outdoors.
- C. Smoke Pipe: Round, single wall vent connector.
- D. Vent: That portion of a venting system designed to convey flue gases directly outdoors from a vent connector or from an appliance when a vent connector is not used.
- E. Vent Connector: That part of a venting system that conducts the flue gases from the flue collar of an appliance to a chimney or vent, and may include a draft control device.

1.6 SUBMITTALS

- A. See Section 01330 - Submittals, for submittal procedures.
- B. Product Data: Provide data indicating factory built chimneys, including dimensional details of components and flue caps, dimensions and weights, electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate general construction, dimensions, weights, support and layout of breechings. Submit layout drawings indicating plan view and elevations where factory built units are used.
- D. Manufacturer's Instructions: Include installation instructions, and indicate assembly, support details, and connection requirements.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum 5 years of documented experience.
- B. Installer Qualifications: Company specializing in performing the type of work specified in this section with minimum 5 years documented experience, and approved by manufacturer.

1.8 REGULATORY REQUIREMENTS

- A. Conform to applicable code for installation of natural gas burning appliances and equipment.
- B. Conform to applicable code for installation of oil burning appliances and equipment.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Metal-Fab, Inc: www.mtlfab.com. Reference Standard
- B. Selkirk Corporation: www.selkirkcorp.com.
- C. Security Chimneys International.

2.2 BREECHINGS, CHIMNEYS, AND STACKS - GENERAL REQUIREMENTS

- A. Regulatory Requirements:
 - 1. Comply with applicable codes for installation of natural gas burning appliances and equipment.
 - 2. Comply with NFPA 31 for installation of oil burning appliances and equipment.
 - 3. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

2.3 DOUBLE WALL METAL STACKS- GAS APPLIANCES

- A. Provide double wall metal stacks, tested to UL 103, UL 1738 and UL listed, for use with building heating equipment, in compliance with NFPA 54.
- B. Fabricate with 1 inch minimum air space between walls. Construct inner jacket of 15 gage ASTM A 666, AL29-4C stainless steel. Construct outer jacket of aluminum coated steel 18 gage for sizes 3 inches to 12 inches and 24 gage for sizes 14 inches to 24 inches. Metal-Fab Corr/Guard II, Type CG-Double Wall.
- C. Accessories, UL labeled:
 - 1. Ventilated Roof Thimble: Consists of roof penetration, vent flashing with spacers and storm collar.
 - 2. Exit Cone: Consists of inner cone, and outer jacket, to increase stack exit velocity 1.5 times.
 - 3. Stack Cap: Consists of conical rainshield with inverted cone for partial rain protection with low flow resistance.
 - 4. Appliance Adapter: Sized to fit specified appliance.
 - 5. Horizontal/Vertical Drain Section: Consists of concentric inner and outer pipe with drain connection fitting.
 - 6. Provide all necessary installation accessories, including but not limited to wall supports, wall hangers, plate supports, couplings, tees, elbows, caps, etc. to provide for a complete and functional system.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. For gas applications Install in accordance with NFPA 54.
- C. Install breechings with minimum of joints. Align accurately at connections, with internal surfaces smooth.
- D. Support breechings from building structure, rigidly with suitable ties, braces, hangers and anchors to hold to shape and prevent buckling. Support vertical breechings, chimneys, and stacks at 12 foot spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA (DCS) for equivalent duct support configuration and size.
- E. Install concrete inserts for support of breechings, chimneys, and stacks in coordination with formwork.
- F. Pitch breechings with positive slope up from fuel-fired equipment to chimney or stack.
- G. Assemble and install stack sections in accordance with NFPA 82, industry practices, and in compliance with UL listing. Join sections with acid-resistant joint cement. Connect base section to foundation using anchor lugs.
- H. Level and plumb chimney and stacks.
- I. Clean breechings, chimneys, and stacks during installation, removing dust and debris.
- J. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of breechings, breeching insulation, chimneys, or stacks.
- K. For condensing applications, provide drain section in chimney. Run drain pipe from drain connection to acid neutralizer tank. Install in accordance with the manufacturers instructions.
- L. For natural draft equipment, install barometric draft regulators in accordance with the equipment manufacturers instructions.

3.2 CLOSEOUTS

- A. See Section 017800-Closeout Submittals, for closeout submittals.
- B. See Section 017900-Demonstration and Training, for additional requirements.

END OF SECTION 23 51 00

SECTION 23 52 40 - CONDENSING HOT WATER BOILERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SUMMARY

- A. This section includes condensing hot water boiler(s) for indoor space-heating application.

1.3 REFERENCES

- A. Intertek (ETL)
 - 1. ETL certified to UL 795/CGA 3.1
- B. American Society of Mechanical Engineers:
 - 1. ASME Section IV - Boiler and Pressure Vessel Code - Heating Boilers
 - 2. ASME CSD-1 – Controls and Safety Devices for Automatically Fired Boilers]
- C. American Society of Heating, Refrigeration and Air Conditioning Engineers
 - 1. ASHRAE: Standard 90.1 Energy Standard for Buildings
- D. Hydronics Institute, Division of Air Conditioning, Heating & Refrigeration Institute (AHRI):
 - 1. AHRI1500: Testing Standard to Determine Efficiency of Commercial Space Heating Boilers as defined by Department of Energy in 10 CFR Part 431.
- E. National Fire Protection Association:
 - 1. NFPA 54 - National Fuel Gas Code (ANSI Z223.1)
- F. Underwriters Laboratories:
 - 1. UL 795: Commercial-Industrial Gas Heating Equipment.
- G. [Relevant local and/or project specific Codes and Standards]

1.4 SUBMITTALS

- A. In accordance with Contract Documents. Minimum product data to include:
 - 1. Capacities, accessories and options included with boiler.
 - 2. General layout, dimensions, size and location of all required connections.

3. Electrical characteristics
4. Weight and mounting loads.
5. Manufacturer's installation and start-up instructions.
6. Equipment Operation and Maintenance Manuals.

1.5 QUALITY ASSURANCE

- A. Use an adequate number of skilled workers, trained and experienced in the necessary crafts, and who are completely familiar with the specified requirements, pertinent contract documents, and methods needed for proper performance of the work described therein.
- B. Provide the services of a manufacturer's factory-authorized representative to inspect and verify proper installation of this equipment, and to provide equipment start-up and operator training.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. In accordance with Contract Documents.
- B. Accept equipment and accessories in Factory shipping packaging. Inspect for damage. Keep boiler in a horizontal position from time of delivery to final installation.
- C. While stored, all equipment must be protected from external elements such as inclement weather, job site construction activity, etc. Protect equipment from damage by leaving packaging in place until installation.

1.7 WARRANTY

- A. The boiler shall come with the warranties stated below from date of original installation.
 1. Heat Exchanger: 10-year pro-rated warranty.
 2. All other parts: 1-year limited warranty.

1.8 COMMISSIONING

- A. Engage a factory-authorized service representative, to perform startup service as per functional test sheets and Commissioning Requirements.
- B. Complete installation and startup checks and functional tests according to Commissioning Requirements.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start up procedure.
- D. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

- E. Contractor shall replace all damaged components and components that failed the inspections at no additional charge.
- F. Commissioning process does not reduce responsibility of installing contractors to provide a finished and fully functioning product.
- G. This section shall in no way diminish the responsibility of the Contractors, Sub-contractors and Suppliers in performing all aspects of work and testing as outlined in the Contract Documents. Any requirements outlined in this section are in addition to requirements outlined in related specifications.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Thermal Solutions Amp Condensing Boilers: www.thermalsolutions.com
- B. Bryan Boilers: www.bryanboilers.com
- C. Viessmann Manufacturing Co.
- D. It shall be the responsibility of the Contractor to ensure that any substituted equipment is equivalent in fit, form and function to the specified equipment. The cost of any additional work caused by the substitution of equipment shall be borne by the Contractor.

2.2 GENERAL REQUIREMENTS

- A. Boiler
 - 1. The boiler shall be assembled, fire tested and shipped as a factory-packaged unit, complete with jacket, gas manifold, burner and controls mounted & wired, with boiler connections specified in this Section.
 - 2. The boiler shall be constructed in conformance to ASME Section IV, ASME CSD-1 and UL 795. The boiler shall bear the ASME "H" stamp with a maximum allowable working pressure (MAWP) of 160 PSI. Pressure vessel shall be subjected to a hydrostatic pressure test of 240 PSIG at the factory.
 - 3. The boiler shall be an ultra-high efficiency condensing boiler with a pressure vessel, constructed of 316L stainless steel and of water tube design, which shall not require a refractory combustion chamber. Pressure vessel shall have a minimum heat transfer area of 142.1 square feet and a waterside pressure loss no more than 19 feet of head at a 20°F temperature difference between the supply and return water temperatures.
 - 4. The boiler shall be equipped with an integral pre-mix, stainless steel forced draft burner incorporating full modulation with 5:1 turndown. The burner shall be of high flame retention design and have a static swirl device to get uniform flame stability all around the combustion surface. Burner shall be equipped with a sliding guide rail with hinged door to gain full access and inspection of the burner and combustion chamber.

5. The boiler gas valve will be designed with zero pressure regulation and equipped with a variable speed blower system to precisely control the fuel/air mixture, providing fully modulating firing rates for maximum efficiency.
6. Water connections shall be located at the top of the boiler; flue gas exhaust, combustion air intake and condensate drain connections shall be located in the rear of the boiler and incoming gas connection shall be located on the left side of the boiler. A factory supplied oversized ASME relief valve shall be provided with the boiler(s).
7. The flue passages and combustion chamber shall be accessible from the front of the boiler for cleaning.
8. The boiler shall be provided with a heavy duty 16 gauge steel jacket with a rust resistant powder coat finish. Jackets made of plastic or resin material shall not be acceptable. The boiler jacket shall contain an internal electrical cabinet for power and limit circuit wiring, providing a clean finished look when the jacket is installed. Electrical connections shall be accessible from top and/or left-side of the boiler on five (5) printed circuited boards (120VAC high and 24VAC/5VDC low voltage) with fused connections for protection and clear labeling for simple and accurate wiring.
 - a. The electrical components shall be separated from incoming combustion air gas, which may contain excess humidity, dust and other contaminants brought through ducted combustion air.
9. A polypropylene condensate trap with a float-actuated shut-off switch shall be supplied with the boiler.
10. Electrical input to the boiler shall be 120v/1ph/60hz
11. Boiler shall be capable of variable primary or primary/secondary piping arrangements.
12. The boiler shall come on a base with forklift opening all sides and lifting lugs for ease of moving and rigging.

B. Boiler Control System

1. Scope of Supply Boiler Control System shall provide safety interlocks and water temperature control. The control system shall be fully integrated into the boiler control cabinet and incorporate single and multiple boiler control logic, inputs, outputs and communication interfaces. The control system shall coordinate the operation of up to eight (8) fully modulating hot water boilers and circulation pumps. The control system shall simply control boiler modulation and on/off outputs based on the boiler water supply temperature and an operator-adjusted setpoint. However, using parameter menu selections, the control system shall allow the boiler to respond to remote system water temperature and outside air temperatures with domestic hot water priority (DHWP) and warm weather shut down (WWSD) or energy management system (EMS) firing rate demand, remote setpoint or remote start/stop commands. In order to support large domestic demands it shall be parameter selectable to start two boilers simultaneously in response to a DHWP

demand.

2. **Boiler Control Using PID (proportional-integral-derivative) based control**, the remote system water temperature shall be compared with a setpoint to establish a target boiler firing rate. If the secondary loop flow speed is greater than the primary loop flow speed, firing rate is increased in response to the decrease in secondary loop temperature. When the remote system temperature is near the boiler high limit temperature, the boiler supply sensor shall limit the maximum boiler supply temperature to prevent boiler high limit events. Alternately, using parameter menu selections, the control system shall allow the boiler to respond directly to boiler supply temperature and setpoint to establish a target boiler firing rate while remote system water temperature is used for display purposes only. Each boiler's fuel flow control valve shall be mechanically linked to the air flow control device to assure an air rich fuel/air ratio. All the automated logic required to ensure that pre-purge, post-purge, light-off, and burner modulation shall be provided.
3. **Hot Water Temperature Setpoint** When the controller is in the local control mode, the control system shall establish the setpoint based on outside air temperature and a reset function curve, or be manually adjusted by the operator. When enabled, the setpoint shall be adjusted above a preset minimum setpoint upon sensing a domestic hot water demand contact input. When in remote mode, the control system shall accept a 4-20ma or Modbus 0-10Vdc remote setpoint or firing rate demand signal from an external EMS.
4. **Multiple Boiler Sequence** The controller shall incorporate its peer-to-peer communications on each connected boiler (up to eight [8] units) by using standard RJ45 ethernet cables. The control system shall allow the connected boilers to exchange signals as required to provide coordinated fully modulating lead/lag functions. It shall not be required to wire individual control signals between boilers. Multiple boilers shall be modulated in "Unison" (all at the same firing rate). To increase operational efficiency, the control system shall utilize both water temperature and firing rate based boiler sequencing algorithms to start and stop the boilers and shall minimize the total number of boilers in operation. The control system shall start and stop boilers when the water temperature is outside the adjustable temperature limit for longer than the adjustable time delay. In order to minimize temperature deviations, the control system shall start and stop the next boiler when the "lead" boiler is at an adjustable firing rate limit for longer than the adjustable time delay. The control system shall monitor both boiler lockout and limit circuits to automatically skip over those boilers that are powered down for maintenance, tripped or otherwise will not start. The boiler shall be run at low fire for warm-up for a preset low fire hold time. When enabled, warm weather shut down control logic shall prevent boiler operation. The controller shall also be capable of auto-rotation of the boilers based on user-selected run time hours.
5. **User Interface** A touch screen message display shall be provided to display real time BTU/hr, numeric data, startup and shutdown sequence status, alarm, system diagnostic, first-out messages and boiler historical information. In the event of a fault condition, the display shall provide help screens to determine the cause of the problem and corrective actions. Historical information shall include graphical trends, lockout history, boiler &

circulator cycle counts and run time hours.

6. **Circulator Control** The controller shall be capable of sequencing the boiler, domestic hot water or system circulators. Simple parameter selections shall allow all three pumps to respond properly to various hydronic piping arrangements including either a boiler or primary piped indirect water heater. The controller shall perform circulator exercise to help prevent pump rotor seizing.
7. **EMS Communication Control** and monitor the boiler via communication RS485 Modbus or direct wiring. The control shall allow for simultaneous communication for boiler peer-to-peer communication and EMS communication interfaces. Loss of EMS communication shall automatically transfer the boiler control to local operation. Boiler operation shall not be lost due to corrupt or loss of EMS communication. The boiler control system shall allow individual boiler limits, lockout, boiler and system temperatures and firing rate status to be readable and water setpoint, boiler firing rate, and start/stop command to be readable and writable. The control shall provide easy parameter selection and options for the following: Modulation Source (4-20ma or Modbus 0-10Vdc); Setpoint Source (4-20ma or Modbus 0-10Vdc); and Enable/Disable (contact wired or Modbus). The control shall allow a real time, live & convenient list of all interface signals to allow for quick interface verification. The boiler control system shall network with a communication gateway to connect with BACnet communication protocol.
8. **External Data Transfer**
 - a. The control system shall include the ability to transfer parameters from boiler to boiler. Upon completion of commissioning the first boiler, a USB flash drive shall allow settings to be “downloaded” from one boiler and “uploaded” into the next. Additionally, these files shall be able to be sent via email and “uploaded” to a remote technical support system. Additionally, it shall be possible to restore parameters to the “as shipped state” by selecting a “Factory Default” Button.
9. **Archive History**
 - a. All hard lockouts, soft lockouts (holds), sensor faults, Energy Management System (EMS) signal faults, sequencer faults and limit string faults shall be recorded with a time and date stamp. The time and date log shall stores up to 3000 alarm & events even after power cycle.” The alarm & event log must be downloadable to a USB thumb drive. The control shall include collect and store supply & return temperature, flame intensity and firing rate for at least 4 months. It shall be a simple matter to page through the boiler’s operation using the boiler mounted display or download the historical data to a USB thumb drive for off-site analysis. All data must be stored in standardly compatible CRV files.
10. **Quality Assurance**
11. The boiler control system shall be supplied as part of a factory-assembled and tested burner control cabinet.

C. Boiler Trim

1. Combination pressure-temperature gauge, 3-1/2 inch diameter.
2. Supply and return temperature sensors - shall be mounted on the supply and return connections outside of the boiler jacket. Each sensor shall be accessible from the top of the boiler. The boiler control shall measure supply and return temperatures and notify the operator if the direction of flow is reversed.
 - a. The boiler control shall adjust to impending temperature changes in such a way to minimize fuel consumption and maximize efficiency. The control shall measure temperatures and the rate of change in those temperatures and respond early, rather than waiting for temperatures to exceed limit control settings.
3. Flue gas temperature sensor shall be mounted in the flue vent connector to monitor flue gas temperatures and reduce the blower speed when flue gas temperatures exceed 189°F. If the flue temperatures exceed 195°F, a forced boiler recycle results.
4. ASME Section IV safety relief valve sized to exceed the gross output of the boiler which shall be factory set to relieve pressure at 50 psig water working pressure.
5. Water flow switch to prevent the burner operation during low water flow conditions.
6. High Temperature Limit, automatic and manual reset, to prevent burner operation if water temperature conditions rise above maximum boiler design temperature, wired to put the boiler into a hard lockout, requiring manual reset of the boiler primary control.
7. High and low gas pressure switches with manual reset and a range of 4 - 14 in W.C., wired to put the boiler into a hard lockout, requiring manual reset of the boiler primary control.
8. Low water cutoff (LWCO) device with manual reset. Boiler shall be fitted with a probe type LWCO located above the lowest safe permissible water level established by the boiler manufacturer. LWCO shall be UL listed and suitable for commercial hydronic heating service.

D. Vent & Intake Air Connections

1. The exhaust vent must be UL 1738 listed for use with Category II and IV appliances and compatible with operating temperatures up to 210°F, positive pressure, condensing flue gas service. UL certified vent material shall be Polypropylene or Stainless Steel AL29-4C.
2. The exhaust vent system shall be in accordance with National Fuel Code, NFPA 54/ANSI Z221.3, or, applicable provisions of local building codes.
3. Combustion air intake shall be capable of drawing air from inside the room or ducted from outdoors. Ducted piping shall be PVC or galvanized smoke pipe that is sealed and pressure tight. Pipe must be at least the same size as the inlet air connection on the boiler.

4. Combustion air intake shall be connected into the boiler vestibule NOT directly into the boiler blower assembly. Combustion air shall be preheated by passing around the exterior of the boiler furnace section before entering the pre-mix gas/air assembly.
5. Boiler shall be capable of common venting with an engineered vent system.
6. Venting shall have an equivalent length of up to 200 feet maximum when drawing air from inside the room or Venting shall have an equivalent length of up to 100 feet maximum and ducted combustion intake air shall have an equivalent length of up to 100 feet maximum.

PERFORMANCE

- A. Boiler thermal efficiency shall be certified with no less than 97.0%.
- B. The burner shall emit low NO_x (corrected to 3% O₂) emissions at all firing rates.
- C. Provide services of a manufacturer's authorized representative to perform combustion test including boiler firing rate, gas flow rate, heat input, burner manifold gas pressure, percent carbon monoxide, percent oxygen, percent excess air, flue gas temperature at outlet, ambient temperature, net stack temperature, percent stack loss, percent combustion efficiency, and heat output. Perform test at minimum, mid-range, and high fire.

PART 3 EXECUTION

4.1 INSTALLATION

- A. In accordance with Contract Documents and boiler manufacturer's printed instructions.
- B. Flush and clean the boiler upon completion of installation in accordance with manufacturer's start-up instructions. The boiler must be isolated when any cleaning or testing of system piping is being performed.
- C. Install skid plumb and level, to plus or minus 1/16 inch over base.
- D. Maintain manufacturer's recommended clearances around and over equipment, and as required by local Code.
- E. Arrange all electrical conduit, piping, exhaust vent, and air intake with clearances for burner removal and service of all equipment.
- F. Connect exhaust vent to boiler vent connection.
- G. If shown in Contract Drawings, connect full sized air inlet vent to flanged connector on boiler.
- H. Connect fuel piping in accordance with NFPA 54. Pipe size to be the same, or greater, than the gas train inlet connection.
- I. Use full size (minimum) pipe/tubing on all gas vent connections.

- J. Connect water piping, full size, to supply and return connections.
- K. Install all piping accessories per the details on the contract drawings.
- L. Install discharge piping from relief valves (open termination for viewing) and all drains to nearest floor drain.
- M. Provide necessary water treatment to satisfy manufacturer's specified water quality limits.

4.2 CLOSEOUTS

- A. See Section 017800-Closeout Submittals, for closeout submittals.
- B. See Section 017900-Demonstration and Training, for additional requirements.
- C. Provide minimum 4 hours of training.

END OF SECTION 23 52 40

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SECTION 23 72 15 - PACKAGED ROOFTOP UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."
- B. Drawings and general provisions of the contract, including General and Supplementary Conditions and other Division 1 specification sections, apply to this section.

1.2 GENERAL DESCRIPTION

- A. Packaged rooftop units (3 - 10 tons).
- B. Packaged rooftop units (27.5 - 50 tons)

1.3 RELATED REQUIREMENTS

- A. Section 01 91 13 - General Commissioning Requirements.

1.4 QUALITY ASSURANCE

- A. Packaged air-cooled condenser units shall be certified in accordance with ANSI/AHRI Standard 340/360 performance rating of commercial and industrial unitary air-conditioning and heat pump equipment.
- B. Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.
- C. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.
- D. ANSI/ASHRAE 37 - Testing Unitary Air Conditioning and Heat Pump Equipment.
- E. Unit shall be certified in accordance with ANSI Z21.47b/CSA 2.3b and ANSI Z83.8/CSA 2.6, Safety Standard Gas-Fired Furnaces.
- F. Unit Energy Efficiency Ratio (EER) shall be equal to or greater than prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.
- G. AHRI 210/240 - Unitary Air-Conditioning Equipment and Air- Source Heat Pump Equipment. (all under 135,000 btuh)
- H. AHRI 270 - Sound Rating of Outdoor Unitary Equipment. (all below 135,000).
- I. AHRI 370 - Sound Rating of Large Outdoor Refrigerating and Air Conditioning Equipment. (all above 135,000 Btuh)

1.5 SUBMITTALS

- A. Product Data: Literature shall be provided that indicates dimensions, operating and shipping weights, capacities, ratings, fan performance, filter information, factory supplied accessories, electrical characteristics and connection requirements. Installation, Operation and Maintenance manual with startup requirements shall be provided.
- B. Shop Drawings: Unit drawings shall be provided that indicate assembly, unit dimensions, construction details, clearances, and connection details. Computer generated fan curves for each fan shall be submitted with specific design operation point noted. Wiring diagram shall be provided with details for both power and control systems and differentiate between factory installed and field installed wiring.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Unit shall be shipped with doors bolted shut and outside air hood closed to prevent damage during transport and thereafter while in storage awaiting installation.
- B. Follow Installation, Operation and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.
- C. Unit shall be stored in a clean, dry place protected from construction traffic in accordance with the Installation, Operation and Maintenance manual.

1.7 WARRANTY

- A. Provide parts warranty (excluding refrigerant) for one year from start-up.
- B. Provide five-year extended warranty for compressors.

1.8 EXTRA MATERIALS

- A. Provide one set of filters.
- B. Furnish a complete set of fan motor drive belts.

1.9 COMMISSIONING

- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 01 91 13 - General Commissioning Requirements.
- B. Complete installation, startup checks and functional tests according to Section 01 91 13 - General Commissioning Requirements and manufacturers written instructions.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the startup procedure.

- D. Verify that equipment is installed and commissioned as per requirements of Section 01 91 13 and manufacturers written instructions/requirements.
- E. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- F. Contractor shall replace all damaged components and components that failed the inspections at no additional charge.
- G. Inspections by the Commissioning Agent shall be on “spot check basis”. Commissioning process does not reduce responsibility of installing contractors to provide a finished and fully functioning product.
- H. This section shall in no way diminish the responsibility of the Contractors, Sub-contractors and Suppliers in performing all aspects of work and testing as outlined in the Contract Documents. Any requirements outlined in this section are in addition to requirements outlined in related specifications.

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. Products shall be provided by the following manufacturers:
 - 1. AAON: www.aaon.com (Basis of Design).
 - 2. Daikin: www.northamerica-daikin.com
 - 3. Addison: <https://www.addison-hvac.com>

2.2 DOAS AND ERU UNITS

- A. General Description
 - 1. Packaged rooftop unit shall include compressors, evaporator coils, filters, supply fans, dampers, water-cooled condenser, reheat coil, exhaust fans, energy recovery wheels, and unit controls.
 - 2. Unit shall be factory assembled and tested including leak testing of the DX coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the service compartment’s literature pocket.
 - 3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
 - 4. Unit components shall be labeled, including refrigeration system components and electrical and controls components.
 - 5. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.

6. Installation, Operation, and Maintenance manual shall be supplied within the unit.
7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's hinged access door.
8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's hinged access door.

B. Construction

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
2. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F.
3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, reduces heat transfer through the panel, and prevents exterior condensation on the panel.
4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.
5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.
6. Access to filters, dampers, cooling coils, reheat coil, energy recovery wheels, compressors, water-cooled condensers, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full-length stainless-steel piano hinges shall be included on the doors.
7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
8. Units with cooling coils shall include double sloped 304 stainless steel drain pans.
9. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.

10. Unit shall include lifting lugs on the top of the unit.
11. Unit base shall be fabricated of 1-inch-thick double wall, impact resistant, rigid polyurethane foam panels.

C. Electrical

1. Unit shall have a 5kAIC SCCR.
2. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.
3. Unit shall be provided with a factory installed and factory wired 115V, 12-amp GFI outlet disconnect switch in the unit control panel.

D. Supply Fans

1. Unit shall include direct drive, unhoused, backward curved, plenum supply fans.
2. Blowers and motors shall be dynamically balance and mounted on rubber isolators.
3. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
4. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

E. Exhaust Fans

1. Exhaust dampers shall be sized for 100% relief.
2. Fans and motors shall be dynamically balanced.
3. Unit shall include barometric relief dampers.
4. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
5. Access to exhaust fans shall be through double wall, hinged access doors with quarter turn lockable handles.
6. Unit shall include belt driven, unhoused, backward curved, plenum exhaust fans.
7. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

F. Cooling Coils

1. Evaporator Coils

- a. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.
- b. Coils shall have interlaced circuitry and shall be standard capacity.
- c. Coils shall be hydrogen or helium leak tested.
- d. Coils shall be furnished with factory installed expansion valves.

G. Refrigeration System

1. Unit shall be factory charged with R-410A refrigerant.
2. Compressors shall be scroll type with thermal overload protection and carry a 5-year non-prorated warranty, from the date of original equipment shipment from the factory.
3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam injected panels to prevent the transmission of noise outside the cabinet.
4. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.
5. Each refrigeration circuit shall be equipped with expansion valve type refrigerant flow control.
6. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low-pressure sides and a factory installed liquid line filter driers.
7. Unit shall include a variable capacity scroll compressor on the lead refrigeration circuit which shall be capable of modulation from 10-100% of its capacity.
8. Unit shall include factory provided and installed compressor sound jackets on all compressors.
9. Lead refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.

H. Condensers

1. Air-Cooled Condenser
 - a. Condenser fans shall be a vertical discharge, axial flow, direct drive fans.

- b. Coils shall be designed for use with R-410A refrigerant. Coils shall be multi-pass and fabricated from aluminum microchannel tubes.
- c. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.
- d. Coils shall be hydrogen or helium leak tested.
- e. Condenser fans shall be VFD driven variable speed for condenser head pressure control. Factory provided and factory programmed VFDs shall continuously modulate the fan air flow to maintain head pressure at acceptable levels. Cooling operation shall be allowed down to 35°F with adjustable compressor lockout.

I. Gas Heating

- 1. Stainless steel heat exchanger furnace shall carry a 25-year non-prorated warranty, from the date of original equipment shipment from the factory.
- 2. Gas furnace shall consist of stainless-steel heat exchangers with multiple concavities, an induced draft blower and an electronic pressure switch to lockout the gas valve until the combustion chamber is purged and combustion airflow is established.
- 3. Furnace shall include a gas ignition system consisting of an electronic igniter to a pilot system, which will be continuous when the heater is operating, but will shut off the pilot when heating is not required.
- 4. Unit shall include a single gas connection and have gas supply piping entrances in the unit base for through-the-curb gas piping and in the outside cabinet wall for across the roof gas piping.
- 5. High Turndown Modulating Natural Gas Furnace shall be equipped with modulating gas valves, adjustable speed combustion blowers, stainless steel tubular heat exchangers, and electronic controller. Combustion blowers and gas valves shall be capable of modulation. Electronic controller includes a factory wired, field installed supply air temperature sensor. Sensor shall be field installed in the supply air ductwork. Supply air temperature setpoint shall be adjustable on the electronic controller within the controls compartment. Gas heater shall be capable of capacity turndown ratio as shown on the unit rating sheet. Heat trace shall be included on the condensate drain.

J. Filters

- 1. Unit shall include 4-inch thick, pleated panel filters with an ASHRAEMERV rating of 13, upstream of the cooling coil. Unit shall also include 2-inch thick, pleated panel pre filters with an ASHRAE MERV rating of 8, upstream of the 4-inch standard filters.
- 2. Unit shall include 1 inch aluminum mesh pre filters upstream of the outside air opening.
- 3. Unit shall include a clogged filter switch.

K. Outside Air/Economizer

1. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals.
2. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4 in. w.g. air pressure differential across the damper.
3. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Damper assembly shall be controlled by spring return.
4. DDC
5. actuator. Unit shall include outside air opening bird screen, outside air hood, and relief dampers.
6. Outdoor Airflow Monitoring
 - a. Unit shall include outside airflow measuring station and airflow signal processor that communicates directly with the factory provided control systems or can also be used with customer provided controls with a 0-10 VDC output signal. Lon Talk and BACnet may also be available for some applications. Monitoring size is dependent on the cfm.

L. Energy Recovery

1. Unit shall contain a factory mounted and tested energy recovery wheel. The energy recovery wheel shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.
2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.
3. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.
4. Energy recovery wheel cassette shall carry a 5-year non-prorated warranty, from the date of original equipment shipment from the factory. The first 12 months from the date of equipment startup, or 18 months from the date of original equipment shipment from the factory, whichever is less, shall be covered under the standard AAON limited parts warranty. The remaining period of the warranty shall be covered by Airxchange. The 5-year warranty applies to all parts and components of the cassette, with the exception of the motor, which shall carry an 18-month warranty. Warranty shall cover material and

workmanship that prove defective, within the specified warranty period, provided the Airxchange written instructions for Installation, Operation, and Maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts. Refer to the Airxchange Energy Recovery Cassette Limited Warranty Certificate.

5. Hinged service access doors shall allow access to the wheel.
6. Unit shall include energy recovery wheel defrost control which includes an adjustable temperature sensor and timer wired to periodically stop the wheel rotation, which allows the warm exhaust air to defrost the wheel.
7. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contacts for field indication of wheel rotation.

M. Controls

1. Field installed DDC controls by others.
2. Unit shall be provided with a high condensate level switch that shuts down the unit when a high-water level is detected in the drain pan.

N. Curbs

1. 18" High roof curbs (18" above finish roof) except for DOAS-1A which will have 28" high roof curb with front supply duct connection. All shall be fully gasketed between the curb top and the unit bottom with the curb providing full perimeter support, cross structure support and air seal for unit. Curb gasket shall be furnished within the control compartment of the rooftop unit to be mounted on the curb immediately before mounting of the rooftop unit.

2.3 MAKE-UP AIR UNITS (MAU-1)

A. General Description

1. Packaged rooftop unit shall include compressors, evaporator coils, filters, supply fans, dampers, air-cooled condenser coils, condenser fans, reheat coil, gas heaters, and unit controls.
2. Unit shall be factory assembled and tested including leak testing of the DX coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the service compartment's literature pocket.
3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
4. Unit components shall be labeled, including refrigeration system components and electrical and controls components.
5. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.

6. Installation, Operation, and Maintenance manual shall be supplied within the unit.
7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's hinged access door.
8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's hinged access door.

B. Construction

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
2. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F.
3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, reduces heat transfer through the panel, and prevents exterior condensation on the panel.
4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.
5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.
6. Access to filters, dampers, cooling coils, reheat coil, heaters, compressors, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full-length stainless-steel piano hinges shall be included on the doors.
7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
8. Units with cooling coils shall include double sloped 304 stainless steel drain pans.
9. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.
10. Unit shall include lifting lugs on the top of the unit.

11. The unit shall have return air by-pass damper.

C. Electrical

1. Unit shall have a 5kAIC SCCR.
2. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.
3. Unit shall be provided with a factory installed and factory wired 115V, 12-amp GFI outlet disconnect switch in the unit control panel.

D. Supply Fans

1. Unit shall include direct drive, unhooded, backward curved, plenum supply fans.
2. Blowers and motors shall be dynamically balance and mounted on rubber isolators.
3. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
4. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

E. Cooling Coils

1. Evaporator Coils
 - a. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.
 - b. Coils shall have interlaced circuitry and shall be high capacity.
 - c. Coils shall be hydrogen or helium leak tested.
 - d. Coils shall be furnished with factory installed expansion valves.

F. Refrigeration System

1. Unit shall be factory charged with R-410A refrigerant.
2. Compressors shall be scroll type with thermal overload protection and carry a 5-year non-prorated warranty, from the date of original equipment shipment from the factory.
3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam injected panels to prevent the transmission of noise outside the cabinet.

4. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.
5. Each refrigeration circuit shall be equipped with expansion valve type refrigerant flow control.
6. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low-pressure sides and a factory installed liquid line filter driers.
7. Unit shall include a variable capacity scroll compressor on all refrigeration circuits which shall be capable of modulation from 10-100% of its capacity.
8. Unit shall include factory provided and installed compressor sound jackets on all compressors.
9. Lead refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.

G. Condensers

1. Air-Cooled Condenser
 - a. Condenser fans shall be a vertical discharge, axial flow, direct drive fans.
 - b. Coils shall be designed for use with R-410A refrigerant. Coils shall be multi-pass and fabricated from aluminum microchannel tubes.
 - c. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.
 - d. Coils shall be hydrogen or helium leak tested.
 - e. Condenser fans shall be VFD driven variable speed for condenser head pressure control. Factory provided and factory programmed VFDs shall continuously modulate the fan air flow to maintain head pressure at acceptable levels. Cooling operation shall be allowed down to 35°F with adjustable compressor lockout.

H. Gas Heating

1. Stainless steel heat exchanger furnace shall carry a 25-year non-prorated warranty, from the date of original equipment shipment from the factory.
2. Gas furnace shall consist of stainless-steel heat exchangers with multiple concavities, an induced draft blower and an electronic pressure switch to lockout the gas valve until the combustion chamber is purged and combustion airflow is established.

3. Furnace shall include a gas ignition system consisting of an electronic igniter to a pilot system, which will be continuous when the heater is operating, but will shut off the pilot when heating is not required.
4. Unit shall include a single gas connection and have gas supply piping entrances in the unit base for through-the-curb gas piping and in the outside cabinet wall for across the roof gas piping.
5. High Turndown Modulating Natural Gas Furnace shall be equipped with modulating gas valves, adjustable speed combustion blowers, stainless steel tubular heat exchangers, and electronic controller. Combustion blowers and gas valves shall be capable of modulation. Electronic controller includes a factory wired, field installed supply air temperature sensor. Sensor shall be field installed in the supply air ductwork. Supply air temperature setpoint shall be adjustable on the electronic controller within the controls compartment. Gas heater shall be capable of capacity turndown ratio as shown on the unit rating sheet. Heat trace shall be included on the condensate drain.

I. Filters

1. Unit shall include 4 inch thick, pleated panel filters with an ASHRAEMERV rating of 13, upstream of the cooling coil. Unit shall also include 2 inch thick, pleated panel pre filters with an ASHRAE MERV rating of 8, upstream of the 4 inch standard filters.
2. Unit shall include a clogged filter switch.

J. Outside Air/Economizer

1. Unit shall include 100% motor operated outside air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge and end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Damper assembly shall be controlled by spring return, 2 position actuator. Unit shall include outside air opening bird screen and outside air hood.
2. Outdoor Airflow Monitoring
 - a. Unit shall include outside airflow measuring station and airflow signal processor that communicates directly with the factory provided control systems or can also be used with customer provided controls with a 0-10 VDC output signal. LonTalk and BACnet may also be available for some applications. Monitoring size is dependent on the cfm.

K. Controls

1. Field installed DDC controls by others.
2. Unit shall be provided with a high condensate level switch that shuts down the unit when a high-water level is detected in the drain pan.

L. Roof Curb

1. 18" High roof curbs (18" above finish roof) shall be fully gasketed between the curb top and the unit bottom with the curb providing full perimeter support, cross structure support and air seal for unit. Curb gasket shall be furnished within the control compartment of the rooftop unit to be mounted on the curb immediately before mounting of the rooftop unit.

M. UV Lights

DOAS/ERU/MAU

- a. The AAON feature selectable UV lights is for drain pan maintenance purposes only. Airstream disinfection via higher intensity UV—C lighting downstream of the coil for RN—series (vertical and horizontal) requires a Special Pricing Agreement (SPA).
- b. System
- c. Ultraviolet Germicidal Irradiation (UVGI) uses short—wave ultraviolet energy (254nm, UV—C) to inactivate viral, bacterial, and fungal organisms so they are unable to replicate and potentially cause disease ,1
- d. UVGI works by disrupting the DNA or RNA of microorganisms to prevent them from replicating. UVGI has been used in waste water treatment and hospitals for decades. UVGI's effectiveness on Coronaviruses (MERS-CoV and SARS-CoV) has been used to predict the effectiveness of UVGI on SARS-CoV-2 (COVID-19).• °
- e. For this SPA, the UVGI lamp array will be Installed downstream of the coil. Therefore, this SPA option requires the UV light feature to be selected (RN F16 = H,K,M,N; RN Horiz F15=C,G,K,P,R,V,Z,4). Due to space restrictions, some options may not be available in conjunction with this feature.
- f. The table below provides estimated operational values based on bulb supplier's information and bulleted operational criteria. Warmer temperatures or lower airflows will increase the UV effectiveness.
 - 1) All dosage and estimated inactivation rates at bulb end of life
 - 2) Wind chill degradation for 55°F incoming air
 - 3) Residence Time based on 500 FPM on the coil

Box Size	Nominal Tons	Number of Lamps	Lamp Power (W)	Irradiance on Evaporator Coil (W/ft')	Residence Time (seconds)	Total UV Dose (pW-s/cm')	Estimated Single Pass Inactivation Rate'
A	6-10	6	75	52.9	0.090	704	91%
B	9-15	8	75	41.1	0.141	673	90%
C	14-30	8	75	30.2	0.162	669	90%

D	26—40	8	145	36.4	0.270	1302	99%
D	50-70	10	145	33.1	0.171	750	92%

- g. Safety, Maintenance, & Disposal
- h. Lamps are a Group 3 Ultraviolet product. These lamps emit high-power UV radiation that can cause severe Injury to skin and eyes. At 254nm, these lights do not produce Ozone.
- i. Door interlock safety, UV warning decals, and appropriate transformer will be included with these SPAs.
- j. Depending on individual operating conditions, lights may require cleaning with a no-residue glass cleaner and lint free cloth per manufacturer recommendations.
- k. Manufacturer stated nominal useful life is 9,000 hours. Lamps contain mercury (Hg). Local handling and disposal guidelines must be followed.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Contractor shall verify that roof is ready to receive work and opening dimensions are as detailed on drawings.
- B. Contractor shall verify that proper power supply is available.

3.2 INSTALLATION, OPERATION, AND MAINTENANCE

- A. Contractor shall install in accordance with manufacturer's instructions.
- B. Mount units on factory-built roof mounting frame providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.
- C. Provide the services of a factory trained technician for start-up of unit. Provide assistance to the Balancing Contractor and Commissioning Agent as required in order to ensure proper start-up, balancing and commissioning of equipment.

3.3 CLOSEOUTS

- A. See Section 017800-Closeout Submittals, for closeout submittals.
- B. See Section 017900-Demonstration and Training, for additional requirements.
- C. Provide minimum 6 hours of training

END OF SECTION 23 72 15

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SECTION 23 81 26.13 - SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. The Air Conditioner system shall be a split system with Variable Speed Inverter Compressor technology. The system shall consist of a horizontal discharge, single phase outdoor unit, a matched capacity indoor section that shall be equipped with a wired wall mounted remote controller.

1.3 RELATED REQUIREMENTS

- A. Section 23 09 13 - Instrumentation and Control Devices for HVAC: Thermostats, humidistats, time clocks.
- B. Section 26 05 83 - Wiring Connections: Electrical characteristics and wiring connections and installation and wiring of thermostats and other controls components.

1.4 REFERENCE STANDARDS

- A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment 2008, Including All Addenda.
- B. AHRI 270 - Sound Performance Rating of Outdoor Unitary Equipment 2015, with Addendum.
- C. AHRI 520 - Performance Rating of Positive Displacement Condensing Units 2004.
- D. ASHRAE Std 15 - Safety Standard for Refrigeration Systems 2019, with All Amendments and Errata.
- E. ASHRAE Std 23.1 - Methods for Performance Testing Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Pressures of the Refrigerant 2019.
- F. UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical Current Edition, Including All Revisions.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.

- C. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.
- D. Design Data: Indicate refrigerant pipe sizing.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- F. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.
- G. Project Record Documents: Record actual locations of components and connections.
- H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.

1.6 QUALITY ASSURANCE

- A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL) and shall bear the ETL label.
- B. All wiring shall be in accordance with the National Electrical Code (N.E.C.) and local codes as required.
- C. The units shall be rated in accordance with Air-conditioning, Heating, and Refrigeration Institute's (AHRI) Standard 210 and bear the ARI Certification label.
- D. The units shall be manufactured in a facility registered to ISO 9001 and ISO 14001, which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
- E. A dry air holding charge shall be provided in the indoor section.
- F. The outdoor unit shall be pre-charged with R-410a refrigerant for 70 feet of refrigerant tubing.

1.7 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. The units shall have a manufacturer's parts and defects warranty for a period five (5) year from date of installation. The compressor shall have a warranty of seven (7) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer. This warranty does not include labor.
- C. Manufacturer shall have over thirty (30) years of continuous experience in the U.S. market.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Daikin
- B. LG
- C. Mitsubishi
- D. Substitutions: See Section 01 60 00 - Product Requirements.

2.2 OUTSIDE UNIT

A. General

1. The outdoor unit shall be equipped with an electronic control board that interfaces with the indoor unit to perform all necessary operation functions.
2. The outdoor unit shall be capable of cooling operation down to 0°F ambient temperature without additional low ambient controls (optional wind baffle shall be required).
3. The outdoor unit shall be able to operate with a maximum height difference of 100 feet between indoor and outdoor units.
4. System shall operate at up to a maximum refrigerant tubing length of 100 feet between indoor and outdoor units without the need for line size changes, traps or additional oil and shall be pre-charged for a maximum of 70 feet of refrigerant tubing.
5. The outdoor unit shall be completely factory assembled, piped, and wired. Each unit must be test run at the factory.

B. Cabinet

1. The casing shall be constructed from galvanized steel plate, finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection and have a Munsell 3Y 7.8/1.1 finish.
2. Mounting feet shall be provided and shall be welded to the base of the cabinet and be of sufficient size to afford reliable equipment mount and stability.
3. Easy access shall be afforded to all serviceable parts by means of removable panel sections.
4. The fan grill shall be of ABS plastic.
5. Cabinet mounting and construction shall be sufficient to withstand 155 MPH wind speed conditions for use in Hurricane condition areas. Mounting, base support, and other installation to meet Hurricane Code Conditions shall be by others.

C. Fan

1. Unit shall be furnished with a single DC fan motor.
2. The fan blade(s) shall be of aerodynamic design for quiet operation, and the fan motor bearings shall be permanently lubricated.
3. The outdoor unit shall have horizontal discharge airflow. The fan shall be mounted in front of the coil, pulling air across it from the rear and dispelling it through the front. The fan shall be provided with a raised guard to prevent external contact with moving parts

D. Coil

1. The L shaped condenser coil shall be of copper tubing with flat aluminum fins to reduce debris build up and allow maximum airflow. The coil shall be protected with an integral metal guard.
2. Refrigerant flow from the condenser shall be controlled by means of an electronic linear expansion valve (LEV) metering device. The LEV shall be controlled by a microprocessor controlled step motor.
3. All refrigerant lines between outdoor and indoor units shall be of annealed, refrigeration grade copper tubing, ARC Type, meeting ASTM B280 requirements, individually insulated in twin-tube, flexible, closed-cell, CFC-free (ozone depletion potential of zero), elastomeric material for the insulation of refrigerant pipes and tubes with thermal conductivity equal to or better than 0.27 BTU-inch/hour per Sq Ft / °F, a water vapor transmission equal to or better than 0.08 Perm-inch and superior fire ratings such that insulation will not contribute significantly to fire and up to 1" thick insulation shall have a - Flame-Spread Index of less than 25 and a Smoke-development Index of less than 50 as tested by ASTM E 84 and CAN / ULC S-102.

E. Compressor

1. The compressor shall be a DC twin-rotor rotary compressor with Variable Speed Inverter Drive Technology.
2. The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system which shall result in significant energy savings.
3. To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be automatically, intermittently applied to the compressor motor windings to maintain sufficient heat to vaporize any refrigerant. No crankcase heater is to be used.
4. The outdoor unit shall have an accumulator and high pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration.

F. Electrical

1. The electrical power of the unit shall be 208volts or 230 volts, single phase, 60 hertz. The unit shall be capable of satisfactory operation within voltage limits of 187 volts to 253 volts.
2. Power for the indoor unit shall be supplied from the outdoor unit using three (3) fourteen (14) gauge AWG conductors plus ground wire connecting the units.
3. The outdoor unit shall be controlled by the microprocessor located in the indoor unit.
4. The control signal between the indoor unit and the outdoor unit shall be pulse signal 24 volts DC.
5. The unit shall have Pulse Amplitude Modulation circuit to utilize 98% of input power supply.

2.3 INDOOR UNIT

A. General

1. The indoor unit shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board and fan motor. The unit, in conjunction with the wired wall-mounted controller, wireless wall-mounted controller or wireless handheld controller, shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry nitrogen before shipment from the factory.

B. Cabinet

1. The cabinet shall be formed from high strength molded plastic with smooth finish, flat front panel design with access for filter. Cabinet color shall be white – Munsell 1.0Y 9.2/0.2. The unit shall be wall mounted by means of a factory supplied, pre-drilled, mounting plate.

C. Fan

1. The indoor unit fan shall be high performance, double inlet, forward curve, direct drive sirocco fan with a single motor. The fans shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The indoor fan shall consist of three (3) speeds: Low, Mid, and Hi and Auto. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set-point and space temperature.

D. Vane

1. There shall be a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction for uniform air distribution. The horizontal vane shall significantly decrease downward air resistance for lower sound levels, and shall close the outlet port when operation is stopped. There shall also be a set of vertical vanes to provide horizontal swing airflow movement.

E. Filter

1. Return air shall be filtered by means of an easily removable washable filter.

F. Coil

1. The evaporator coil shall be of nonferrous construction with pre-coated aluminum strake fins on copper tubing. The multi-angled heat exchanger shall have a modified fin shape that reduces air resistance for a smoother, quieter airflow. All tube joints shall be brazed with PhosCopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil. An optional drain pan level switch, designed to connect to the control board, shall be provided if required, and installed on the condensate pan to prevent condensate from overflowing.

G. System Control

1. The control system shall consist of a minimum of two (2) microprocessors, one on each indoor and outdoor unit, interconnected by a single non-polar two-wire cable. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature, receiving and processing commands from a wireless or wired controller, providing emergency operation and controlling the outdoor unit. The control signal between the indoor and outdoor unit shall be pulse signal 24 volts DC. Indoor units shall have the ability to control supplemental heat via connector CN152 and a 12 VDC output.

H. Wired Remote Controller

1. The Wired Remote Controller shall be approximately 5" x 5" in size and white in color with a light-green LCD display. The controller shall support a selection from multiple languages (Spanish, German, Japanese, Chinese, English, Russian, Italian, or French) for display information. There shall be a built-in weekly timer with up to 8 pattern settings per day. The controller shall consist of an On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Auto/Fan/Dry mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Ventilation button, a Test Run button, and a Check Mode button. The controller shall have a built-in temperature sensor. Temperature shall be displayed in either Fahrenheit (°F) or Celsius (°C), and Temperature changes shall be by increments of 1°F (0.5°C). The PAR-21MAA shall have the capability of controlling up to a maximum of 16 systems, as a group with the same mode and set-point for all, at a maximum developed control cable distance of 1,500 feet (500 meters).
2. The control voltage from the wired controller to the indoor unit shall be 12/24 volts, DC. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. Up to two wired controllers shall be able to be used to control one unit.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions and requirements of local authorities having jurisdiction.

END OF SECTION 23 81 26.13

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SECTION 23 81 28 - VARIABLE REFRIGERANT FLOW ZONING SYSTEM

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractor and/or supplier providing goods or services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.2 SECTION INCLUDES

- A. Air-source heat pumps.
- B. Indoor ductless units.
- C. Indoor ducted units
- D. Controls.

1.3 SUBMITTALS

- A. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.
- B. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.
- C. Design Data: Indicate refrigerant pipe sizing.
- D. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.
- E. Project Record Documents: Record actual locations of components and connections.
- F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- G. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum ten years of documented experience.
- B. Units shall be tested by a nationally recognized testing laboratory and bear the ETL Label.
- C. Units shall be manufactured in a factory that is ISO 9001 and ISO 14001 registered.
- D. VRF system shall have published performance ratings certified by AHRI and listed in the AHRI Standard 1230 certified product directory.

- E. The VRF system shall be installed by a contractor with extensive installation and service training. The contractor shall show proof of completion of mandatory service and installation training by the manufacturer.

1.5 WARRANTY

- A. The units shall be covered by the manufacturer's limited warranty for a period of one (1) year from the date of installation. In addition the compressor shall have a limited warranty for a period of five (5) years from the date of installation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. LG (Basis of Design)
- B. Samsung
- C. Fujitsu
- D. Substitute equipment may be considered for approval that includes at a minimum:
 - 1. R-410a refrigerant
 - 2. Inverter compressor technology.
 - 3. Ability to meet all other provisions of the specifications herein and as specified on the drawings.

2.2 SYSTEM DESCRIPTION

- A. The VRF system shall be a variable capacity, direct expansion (dx), split system heat recovery heat pump capable of providing simultaneous heating and cooling in the individual zones. Communication between components shall be provided as an integrated feature of the VRF system.
- B. Each system shall consist of an outdoor unit, heat recovery units(s), multiple indoor units and manufacturer's Digital Controls. Each indoor unit or group of indoor units shall be capable of operating in any mode independently of other indoor units. System shall be capable of changing mode (cooling to heating, heating to cooling) with no interruption to system operation. Each indoor unit or group of indoor units shall be independently controlled.

2.3 OUTDOOR UNIT

- A. General:
 - 1. The outdoor unit shall be used specifically with specific components from the same manufacturer.

2. Outdoor Unit shall be capable of maintaining continuous compressor operation under all of the following operating ambient air conditions.
 - a. Heat Recovery System
 - 1) All IDUs Cooling: 14°F DB to 122°F DB
 - 2) All IDUs Heating: -13°F WB to 61°F WB
 - 3) Cooling-based synchronous: 14°F DB to 81°F DB
 - 4) Heating-based synchronous: 14°F WB to 61°F WB
3. The VRF system shall maintain normal heating and/or cooling operation at all IDUs while any one IDU is powered down for service. When power is restored to the IDU serviced, normal operation shall be restored with no system shutdown, interruption, reset, or power cycling of the outdoor unit.
4. The system shall use R410A refrigerant.
5. Each system shall have one, two or three air source outdoor units.
6. Multi-frame configurations shall be field piped together using manufacturer's designed and supplied Y-branch kit and field provided interconnecting pipe to form a common refrigerant circuit.
7. Refrigerant circuit configuration for Heat Recovery System
 - a. The refrigerant circuit shall be constructed using field provided copper piped together with manufacturer supplied Heat Recovery unit(s) and Y- branches or Header fittings connected to multiple (ducted, non-ducted or combination thereof) indoor units to effectively and efficiently control the simultaneous heating and cooling operation of the VRF system.
 - b. Each refrigerant pipe, y-branch, header kit, elbows and valves shall be individually insulated with no air gaps. All joints shall be glued and sealed.
8. Refrigerant circuit configuration for Heat Pump System
 - a. The refrigerant circuit shall be constructed using field provided copper piped together with manufacturer supplied Y- branches or Headers connected to multiple (ducted, non-ducted or combination thereof) indoor units to effectively and efficiently control heating or cooling operation of the VRF system.
 - b. All refrigerant pipe, y-branch, header kit, elbows and valves shall be individually insulated with no air gaps. All joints shall be glued and sealed.
9. The VRF manufacturer shall provide published documentation that specifically allows the installation of field provided full-port high quality refrigerant system isolation valves rated for use with R410A on any and all pipes of the VRF system. Isolation valves shall be

strategically placed in the refrigerant piping system to allow the VRF system service provider to isolate a portion of the piping system to avoid a pump down of the entire refrigerant piping system when replacing/repairing the refrigeration circuit piping, HR unit(s), or indoor unit(s).

10. Factory installed microprocessor controls in the outdoor unit(s), HR unit(s), and indoor unit(s) shall perform functions to efficiently operate the VRF system and communicate in a daisy chain configuration between outdoor unit and HR unit(s) and indoor unit(s) over a RS485 18AWG stranded and twisted wire data link.
11. Outdoor unit shall be able to connect to up to 64 indoor units depending upon model.
12. The total nominal capacity of all indoor units shall be no less than 50% and no more than 130% of outdoor unit's nominal capacity to ensure the VRF system will have sufficient capacity to meet the building's cooling and heating load at design day weather conditions.
13. The maximum allowable system combination ratio shall be 130%. Systems designed with a combination ratio above 130% will not be accepted.
14. Each outdoor unit refrigerant circuit shall have a high-pressure safety threaded rupture disk or threaded fusible plug fitting.
15. The outdoor unit assembly, indoor unit assembly and/or heat recovery unit assembly shall be shipped from the factory assembled and pressure tested including internal refrigerant piping, compressor, contacts, relay(s), control components, power and communications wiring necessary.
16. Each outdoor unit refrigeration circuit shall have the following components:
 - a. Inverter variable speed compressor(s)
 - b. Outdoor unit heat exchanger
 - c. Refrigerant strainer(s)
 - d. Check valve(s)
 - e. Oil separator
 - f. Accumulator
 - g. Heat exchanger circuiting control
 - h. Electronic expansion valve(s)
 - i. 4-way reversing valve
 - j. Sub-cooler circuit with controls
 - k. High and low side Schrader valve service ports with caps.

1. Service valves

B. System

1. Each outdoor unit frame shall have a stand-alone microprocessor control that varies the use of the outdoor coil circuits to optimize the use of heat transfer surface. Control shall be able to dynamically change the path and coil circuiting based on one of the following operating parameters: head pressure, suction pressure, system sub-cooling requirements, available refrigerant charge, system mode of operation, coil heat transfer efficiency shall have a variable flow path heat exchanger function to vary the refrigerant flow path based on system operating mode and operating conditions.
2. System inverter compressors shall have a mid-stage, medium pressure vapor economizer apparatus to maximize refrigerant compression efficiency.
3. System accumulator shall be provided with controls that continuously monitors, modifies, and controls the amount of refrigerant in circulation (active refrigerant charge) while the system is operating. The active refrigerant charge microprocessor shall monitor system high and low side gas pressure, coil approach temperature, liquid line temperature and pressure, and system sub-cooling requirement to control the refrigerant charge.
4. System shall comprise of the following frame configurations.
 - a. 6 through 14 ton systems shall be a single frame only.
 - b. 16 through 28 ton systems shall be dual frame only.
 - c. 30 to 42 ton systems shall be triple frame only

C. Refrigerant Pipe System Design Parameters

1. The outdoor unit shall be capable of operating at an elevation difference of up to 360 feet above or below the lowest or highest indoor unit respectively.
2. The outdoor unit shall be capable of operating with up to 3280 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.
3. The outdoor unit shall be capable of operating with up to 656 actual feet or 738 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.

D. Defrost Operations

1. The outdoor unit(s) shall be capable of Intelligent defrost operation to melt accumulated frost, snow and ice that may have accumulated on the outdoor unit heat exchanger. The defrost cycle length and sequence shall be based on outdoor ambient temperatures, outdoor unit heat exchanger temperature, and various differential pressure variables.

2. Defrost Mode Selection: The outdoor unit shall be provided with three field-selectable defrost operation modes; Normal, Fast, or Forced.
 - a. Normal Defrost operation intended for use in areas of the country with mild winter temperatures and light to moderate humidity levels. The strategy minimizes defrost cycle frequency allowing frozen precipitation to build longer in between cycles. Minimum time between defrost cycles shall be 20 minutes. Intelligent Defrost shall choose between split coil/frame and full system methods to minimize energy consumption and cycle time.
 - b. Fast Defrost operation intended for use in areas of the country that experience adverse winter weather with periods of heavy winter precipitation and extremely low temperatures. This strategy shall maximize the systems heating performance and maintain operational efficiency. When the ambient temperature is above 32°F, Intelligent Defrost shall continue to heat until the discharge temperature declines. At temperatures below 32°F, the time between defrost cycles shall be a minimum of 90 minutes. At temperatures below 4°F, a defrost cycle shall occur every two hours to optimize system heating efficiency.
 - c. Forced Defrost operation shall be available for the service provider to test defrost operations at any weather condition and to manually clear frozen water from the outdoor coil surfaces.
3. Defrost Method Selection: The outdoor unit shall be provided with two field-selectable defrost operation methods; Split Coil/Frame and Full System.
 - a. Split Coil/Frame method shall be available when Normal Defrost mode is selected. Split Coil method shall be available on all Heat Pump and Heat Recovery single-frame VRF systems. Split Frame defrost shall be available on all Heat Pump and Heat Recovery multi-frame outdoor units.
 - b. Split Coil method shall remove ice from the bottom half of the outdoor unit coil first for six minutes, then the bottom half for six minutes. Next the bottom coil shall be heated again for an additional three minutes to remove any frozen water that may have dripped onto the lower coil during the top coil defrost operation.
 - c. When Split Coil/Frame method is selected, a Full System defrost shall occur every third defrost cycle to assure 100% of the frozen precipitation has been removed to maintain optimum efficient performance.
 - d. Full System method shall be available as a field selectable option. Outdoor units located in areas of the country where large volumes of frozen precipitation are common, the commissioning agent shall select the Full System defrost method.
4. Indoor Unit Fan Operation During Defrost
 - a. During partial defrost operation indoor units operating in cooling or dry mode shall continue normal operation.

- b. During partial defrost operation, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the defrost cycle.
- c. During full system defrost operation, indoor unit fans will cycle off and remain off during the remainder of the defrost cycle.

E. Oil Management

- 1. Each outdoor unit shall have an independently operating Hi-POR (High Pressure Oil Return) system to maximize compressor efficiency and ensure a consistent film of oil on all moving compressor parts at all speeds.
- 2. The oil return system shall include a dedicated centrifugal oil separator for each compressor designed to extract oil from the oil/refrigerant gas stream leaving the compressor.
- 3. Oil collected by each compressors independent oil return system shall be returned directly to the compressor oil sump passively without the use of mechanical pumps or other apparatus
- 4. Oil return systems that depend on differential pressure to return oil to the compressor sump, for example bleeding off or bypassing any amount of high pressure gas to push oil back to the compressor sump or the suction inlet of the compressor chamber, shall not be accepted.
- 5. Compressor oil shall be maintained at the same temperature as the discharge gas leaving the compressor to prevent any blending of refrigerant and oil to maintain stable oil viscosity during compressor operation.
- 6. The oil return system shall not inject, blend, or otherwise mix collected oil with suction vapor refrigerant before entering the compressor scroll or other gas compression apparatus.
- 7. The oil return system shall provide an oil level monitor for each compressor that provides continuous feedback to the outdoor unit microprocessor.
- 8. The microprocessor shall initiate an oil return cycle when the oil level monitoring sensor indicates a low oil level in the compressor sump.
- 9. Timed and/or scheduled unmonitored oil return operations and/or any oil return system that does not initiate an oil return cycle based on compressor sump low level reading shall not be permitted

F. Cabinet:

- 1. Outdoor unit cabinet shall be made of 20 gauge galvanized steel with an enamel finish.

2. Outdoor unit cabinet shall have a heavy gauge coated wire coil guard.
3. Outdoor unit cabinet finish shall have been tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 1000 hours.
4. All internal serviceable components shall be accessible by removing the front panel of the unit. Outdoor units that require the removal of side and/or rear service panels shall not be permitted.
5. A controls maintenance and unit diagnostic access port shall be provided in front of the microprocessor to allow quick access to read service codes, set DIP switches, perform microprocessor operational checks, address system components and extract operational data without removing the unit's front panel(s).
6. The controls access port shall be no larger than 6-1/4" x 6-3/4" to the possibility of weather related moisture entering the control panel while service is in progress.
7. A baked galvanized steel access port cover with a baked enamel finish (color matching unit cabinet) shall be provided and easily removed.
8. Controls access port cover shall be secured to the unit with a factory provided braided steel wire lanyard to prevent loss/damage to the port cover.
9. The cabinet shall be designed with pre-punched pipe and electrical knockouts. Cabinet shall be designed to accept connection of refrigerant pipe, power cable, and communications wiring either:
 - a. Through the front panel
 - b. Through the right side
 - c. Through the unit's base pan (bottom)

G. Fan:

1. Each 6 ton cabinet shall be equipped with one direct drive variable speed propeller fan with Brushless Digitally Controlled (BLDC) motor mounted in a vertical top air discharge configuration.
2. Each 8 to 14 ton cabinet shall be equipped with two direct drive variable speed propeller fans with independent BLDC motors mounted in a vertical top air discharge configuration.
3. The fan blades shall be made of non-metallic light-weight Acrylonitrile Butadiene Styrene (ABS) material.
4. Fan blade design shall be a quiet, deep-V designed to minimize air turbulence as air passes over and leaves the trailing edge of the fan blade. Fan shroud shall be designed in conjunction with fan blade to minimize air turbulence along the edge of the blades to minimize noise generation.

5. Outdoor unit fan motors shall be powered using a dc inverter drive capable of operating the fans at a maximum speed of 1100 RPM.
6. Each fan motor case/frame shall be made with a lightweight non-ferrous metal alloy. Bearing shall be sealed and permanently lubricated.
7. Only one fan blade per fan motor shall be accepted. Dual fan assemblies driven by a double-end shaft motor shall not be permitted.
8. Each fan blade and motor assembly shall be balanced, tested, and mounted to the unit frame using a means of isolation that will eliminate any objectionable audible harmonic or vibration being transferred to the unit frame.
9. A raised ferrous wire metal guard with a baked enamel finish (color matching unit cabinet) shall be provided to prevent large object and animal contact with moving parts.
10. The outdoor fan inverter drive shall be provided with a DIP switch that reprograms the DC inverter drive to allow outdoor unit fan assemblies to operate under high discharge static conditions (up to 0.32 in-wg external static pressure) such as a ducted discharge application.

H. Coil:

1. Shall be a variable path design.
2. Shall be provided and built by the VRF outdoor unit provider.
3. It shall be comprised of aluminum fins mechanically bonded on copper tubing.
4. The copper tubes shall be internally ribbed to maximize heat transfer. Smooth bore tubes are not acceptable.
5. The aluminum fin heat transfer surfaces shall be treated to maximize the life of the fin material. Coil fin heat transfer surfaces shall be treated with a factory applied corrosion resistant GoldFin™ coating. Coating of fins shall be a two-step process. Base coat shall be an anticorrosive paint specifically engineered for bonding to bare aluminum. The top coat shall be a Hydrophilic paint with a gloss finish to protect the anti-corrosion coat. Hydrophilic paint shall be specifically formulated to promote liquid precipitation runoff and assist in minimizing particulate debris from sticking to the fin's heat transfer surfaces.
6. Fin material coating shall be tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 1000 hours.
7. The outdoor unit coil assembly shall be factory pressure tested to a pressure of 551 psig.
8. Coil fin series shall be up to 22 Fins per Inch (FPI).
9. All the outdoor units shall have a minimum of a 3 row heat exchanger.

I. Compressor:

1. Each 6, 8, 10 ton frames shall be equipped with one hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressor.
2. The 12 and 14 ton frames shall be equipped with two hermetically-sealed, inverter-speed controlled scroll compressors.
3. Outdoor unit frames containing constant speed 50-60 Hz compressor(s) or containing a constant speed 50-60 Hz compressor in combination with an inverter compressor(s) are not acceptable.
4. Each inverter driven, HSS scroll compressor shall be capable of operating in a frequency range from 15 Hz to 150 Hz with control in 0.5 Hz increments.
5. Each compressor shall be equipped with a minimum of a 60 Watt crankcase heater.
6. The compressor shall be provided from the factory with a full charge of Polyvinyl Ether (PVE) oil. Ester based oils are not acceptable (POE) to prevent gum from forming in the system in the case of a motor burn.
7. All compressor bearing(s) shall have Teflon™ coating.
8. All compressors shall be protected with:
 - a. High Pressure switch
 - b. Over-current/under current protection
 - c. Phase failure
 - d. Phase reversal

J. Sound Levels

1. Outdoor unit noise levels shall not exceed 60 dB A. Test protocol includes a sound level measurement taken at an elevation of 5 ft. above the mounting surface at the center point of the width of the outdoor unit frame at a distance of 1 meter in front of the front panel surface with all fans running at absolute maximum motor design speed at all unit operating modes including high heating mode in an anechoic chamber using ISO3745 test standard protocol.

K. Sensors

1. Each single cabinet shall have
 - a. Suction temperature sensor
 - b. Discharge temperature sensor
 - c. High Pressure sensor
 - d. Low Pressure sensor

- e. Outdoor temperature sensor
- f. Outdoor unit heat exchanger temperature sensor

2.4 HEAT RECOVERY UNIT

A. General

1. HR unit shall be designed and manufactured by the same manufacturer of VRF indoor unit(s) and outdoor unit(s).
2. HR units shall be available in a 2, 3, and 4-port design. Single port designs and pipe system designs that require a dedicated HR unit is not acceptable.
3. HR unit casing shall be made with galvanized steel and have a galvanized steel finish.
4. HR unit shall be powered using a 208-230V/1-phase/60Hz power supply.
5. HR Unit shall be an intermediate refrigerant control device between the air source outdoor unit and the indoor units to control the systems simultaneous cooling and heating operation.
6. HR unit shall be engineered to work with a three pipe VRF system comprised of the following:
 - a. High Pressure Vapor Pipe
 - b. Low Pressure Vapor Pipe
 - c. Liquid Pipe
7. HR unit shall be designed to be piped in a series or parallel pipe configuration relative to each other.
8. HR unit shall be a multi-port design capable of serving between one and 8 indoor units per HR unit port with a combined cooling nominal capacity of 54 Mbt per IDU port. HR units shall be able to accept/service at least two indoor units per HR unit up to a combined connected IDU cooling capacity of 192 Mbt.
9. VRF system controller shall be capable of accommodating up to 16 HR units connected to HR units piped in a single series string.
10. Each port shall be capable of operating in cooling or heating independently regardless of the operating mode of any other port on the HR unit or in the system.
11. HR unit shall be internally piped, wired, assembled, leak and run tested at the factory.
12. HR unit shall be designed for installation in a conditioned environment and provided with factory applied insulation on all cold surfaces.

13. HR unit shall have a liquid bypass circuit between the high pressure vapor and the low pressure vapor pipes.
14. Each port IDU port shall have a pair (2) two-position solenoid valves.
15. HR unit shall have a balancing valve to control the pressure between the high pressure and low pressure pipe during mode switching.
16. HR unit shall contain a sub-cooler circuit with stand-alone controls for each HR unit.
17. HR cold surface pipes shall be factory insulated to prevent condensation.
18. HR unit shall not require a condensate drain. Manufacturer's providing HR models that require a condensate drain line shall reimburse the pipe fitter or others responsible for the portion of the cost associated with the condensate drain system design, parts, and installation.
19. All field provided refrigerant piping and VRF system refrigerant piping components between outdoor unit and HR unit and from HR unit to indoor unit shall be field insulated.
20. The HR unit shall not exceed a net unit weight of 49 lbs.

B. Controls

1. HR unit(s) shall have factory installed unit mounted control boards and integral microprocessor to communicate with indoor units and outdoor units over a single stranded, shielded, twisted wire pair.
2. Manufacturer shall provide screw terminal connections at the HR unit to terminate power wiring and communications cables.

2.5 CEILING CASSETTE - 4 WAY

A. General:

1. Unit shall be factory assembled, wired, piped and run tested.
2. Unit shall be designed to be installed for indoor application.
3. Unit shall be designed to mount recessed in the ceiling and has a surface mounted grille on the bottom of the unit.
4. The unit shall be available in both 2' x 2' and 3' x 3' chassis.

B. Casing/Panel

1. Unit case shall be manufactured using galvanized steel plate.
2. The unit shall be provided with an off-white Acrylonitrile Butadiene Styrene (ABS) polymeric resin architectural grille.

3. The grille shall have a tapered trim edge, and a hinged, spring clip (screw-less) return air filter-grille door.
4. Unit shall be provided with metal ears designed to support the unit weight on four corners.
5. Ears shall have pre-punched holes designed to accept field supplied all thread rod hangers.

C. Cabinet Assembly:

1. Unit shall have four supply air outlets and one return air inlet.
2. The supply air outlet shall be through four-directional slot diffuser each equipped with independent oscillating motorized guide vane designed to change the airflow direction.
3. The grille shall have a discharge range of motion of 40° in an up/down direction with capabilities of locking the vanes.
4. The unit shall have a guide vane algorithm designed to sequentially change the predominant discharge airflow direction in counterclockwise pattern.
5. Guide vanes shall provide airflow in all directions.
6. Unit shall be equipped with factory installed temperature thermistors for:
 - a. Return air
 - b. Refrigerant entering coil
 - c. Refrigerant leaving coil
7. Unit shall have a factory assembled, piped and wired electronic expansion valve (EEV) for refrigerant control.
8. Unit shall have a built-in control panel to communicate with other indoor units and to the outdoor unit.
9. The unit shall have factory designated branch duct knockouts on the unit case.
10. The unit shall have provision of fresh air ventilation through a knock-out on the cabinet.
11. The branch duct knockouts shall have the ability to duct up to ½ the unit airflow capacity.
12. The branch duct cannot be ducted to another room.
13. Unit shall have the following functions as standard:
 - a. Self-diagnostic function
 - b. Auto addressing
 - c. Auto restart function

- d. Auto changeover function (Heat Recovery system only)
- e. Auto operation function
- f. Child lock function
- g. Forced operation
- h. Dual thermistor control
- i. Sleep mode
- j. Dual setpoint control
- k. Multiple aux heater applications
- l. Filter life and power consumption display

D. Fan Assembly:

- 1. The unit shall have a single, direct drive, turbo fan made of high strength ABS HT-700 polymeric resin.
- 2. The fan impeller shall be statically and dynamically balanced.
- 3. The fan motor is Brushless Digitally controlled (BLDC) with permanently lubricated and sealed ball bearings.
- 4. The fan motor shall include thermal, overcurrent and low RPM protection.
- 5. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.
- 6. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm.
- 7. In cooling mode, the indoor fan shall have the following settings: Low, Med, High, Power Cool, and Auto.
- 8. In heating mode, the indoor fan shall have the following settings: Low, Med, High, and Auto.
- 9. Unit shall have factory installed motorized louver to provide flow of air in up and down direction for uniform airflow.

E. Filter Assembly:

- 1. The return air inlet shall have a factory supplied removable, washable filter with antifungal treatment.
- 2. The unit shall have the option for a secondary plasma filter accessory.

3. The filter access shall be from the bottom of the unit.
4. The unit shall have provision for an optional auto-elevating grille kit designed to provide motorized ascent/descent of the return air grille/pre filter assembly.
 - a. The ascent/descent of the return air grille shall be up to a distance of 14-3/4 feet allowing access to remove and clean the filter.
 - b. The auto-elevating grille shall have a control algorithm to accept up, down and stop control commands from the controller.
 - c. The auto-elevating grille shall have a control to stop the descent automatically if a contact is made with any obstacle.

F. Coil Assembly:

1. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
2. The copper tubing shall have inner grooves for high efficiency heat exchanger.
3. Unit shall have a minimum 1 or 2 row coil, 18-19 fins per inch.
4. Unit shall have a factory supplied condensate drain pan below the coil constructed of EPS (expandable polystyrene resin).
5. Unit shall include an installed and wired condensate drain pump capable of providing minimum 27.5 inch lift from bottom surface of the unit.
6. The drain pump shall have a safety switch to shut off the unit if condensate rises too high in the drain pan.
7. Unit shall have provision of 45° flare refrigerant pipe connections.
8. The coil shall be factory pressure tested at a minimum of 551 psig.
9. All refrigerant piping from outdoor unit to indoor unit shall be field insulated.

G. Microprocessor Control:

1. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system.
2. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, 2 core, stranded and shielded communication cable.
3. The unit controls shall operate the indoor unit using one of the five operating modes:
 - a. Auto changeover (Heat Recovery System only)
 - b. Heating

- c. Cooling
 - d. Dry
 - e. Fan only
- H. Electrical:
- 1. The unit electrical power shall be 208-230/1/60 (V/Ph/Hz)
 - 2. The unit shall be capable of operating within voltage limits of +/- 10% of the rated voltage.
- I. Controls:
- 1. Unit shall use controls provided by the manufacturer to perform all functions necessary to operate the system effectively and efficiently and communicate with the outdoor unit over an RS485 daisy chain.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.
- B. Verify that proper power supply is available and in correct location.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions and requirements of local authorities having jurisdiction.
- B. Install in accordance with NFPA 90A and NFPA 90B.
- C. Install refrigeration systems in accordance with ASHRAE Std 15.
- D. Pipe drain from cooling coils to nearest receptor or to grade.
- E. Contractor shall provide additional refrigerant for system.

END OF SECTION 23 81 28 23 81 28

SECTION 23 82 00 - CONVECTION HEATING AND COOLING UNITS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 RELATED REQUIREMENTS

- A. Section 01 91 13 - General Commissioning Requirement

1.3 SECTION INCLUDES

- A. Unit heaters.
- B. Cabinet unit heaters.

1.4 RELATED REQUIREMENTS

- A. Section 22 05 13 - Common Motor Requirements for Plumbing Equipment.
- B. Section 23 05 13 - Common Motor Requirements for HVAC Equipment.
- C. Section 23 07 16 - HVAC Equipment Insulation.
- D. Section 23 07 19 - HVAC Piping Insulation.
- E. Section 23 09 13 - Instrumentation and Control Devices for HVAC.
- F. Section 23 09 93 - Sequence of Operations for HVAC Controls.
- G. Section 23 21 13 - Hydronic Piping.
- H. Section 23 21 14 - Hydronic Specialties.
- I. Section 26 05 83 - Wiring Connections: Electrical characteristics and wiring connections. Installation of room thermostats. Electrical supply to units.

1.5 REFERENCE STANDARDS

- A. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils 2001, with Addendum (2011).
- B. AHRI 440 - Performance Rating of Room Fan-Coils 2008.
- C. ASHRAE (HVAC) - ASHRAE Handbook - HVAC Applications Most Recent Edition Cited by Referring Code or Reference Standard.

- D. ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2020.
- F. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide typical catalog of information including arrangements.
- C. Shop Drawings:
 - 1. Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
 - 2. Indicate air coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions.
 - 3. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
- D. Selection Samples: For each finish product specified, color chart representing manufacturer's full range of available colors.
- E. Certificates: Certify that coils are tested and rated in accordance with AHRI 410.
- F. Manufacturer's Instructions: Indicate installation instructions and recommendations.
- G. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
- H. Warranty: (1)Year from the date of final acceptance by Owner unless otherwise noted. Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.8 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

- B. (1) Year from date of acceptance by the Owner and completion of commissioning.

PART 2 PRODUCTS

2.1 HYDRONIC UNIT HEATERS

- A. Manufacturers:
1. Zehnder Rittling: www.rittling.com.
 2. Vulcan Radiator
 3. Sterling A Mestek Co.
- B. Coils: Seamless copper tubing, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.
- C. Perform factory run test under normal operating conditions, water, and steam flow rates.
- D. Finish: Factory applied baked primer coat.
- E. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.
- F. Totally Enclosed Motors: Permanently lubricated sleeve bearings on horizontal models, grease lubricated ball bearings on vertical models. Refer to Section 23 0513.

2.2 HYDRONIC CABINET UNIT HEATERS

- A. Manufacturers:
1. Zehnder Rittling: www.rittling.com.
 2. Vulcan Radiator
 3. Sterling A Mestek Co.
- B. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.
- C. Coils:
1. Evenly spaced aluminum fins mechanically bonded to copper tubes.
 2. Heating Hot Water: Suitable for working temperatures up to a maximum not less than 200 degrees F.
- D. Vertical Cabinet: Minimum 0.0598 inch thick steel front panel with exposed corners and edges rounded, easily removed panels, glass fiber insulation, integral air outlet, and inlet grilles.

- E. Horizontal Recessed: Provide with a galvanized steel cabinet, easily removed panels, glass fiber insulation, integral air outlet, and inlet grilles with minimum 0.0478 inch thick bottom panel.
- F. Finish: Factory applied baked primer coat on visible surfaces of enclosure or cabinet.
- G. Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven.
- H. Motor: Electronically commutated motors (ECM) factory-programmed and run tested in assembled units.
- I. Filter: Easily removed, 1 inch thick glass fiber throw-away type, located to filter air before coil.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that surfaces are suitable for installation.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's recommendations.
- B. Install equipment exposed to finished areas after walls and ceilings are finished and painted.
- C. Do not damage equipment or finishes.
- D. Cabinet Unit Heaters:
 - 1. Coordinate to ensure correct recess size for recessed units.
- E. Units with Hydronic Coils:
 - 1. Provide with shut-off valve on supply piping and tamper-proof, balancing valve with memory stop on return piping.
 - 2. Provide float operated automatic air vents with stop valve for cabinet unit heaters.

3.3 FIELD QUALITY CONTROL

- A. Provide manufacturer's field representative to test, inspect, instruct, and observe.

3.4 CLEANING

- A. After construction and painting is completed, clean exposed surfaces of units.
- B. Vacuum clean coils and inside of units.
- C. Touch-up marred or scratched surfaces of factory-finished cabinets using finish materials furnished by the manufacturer.

- D. Install new filters.

3.5 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 - Demonstration and Training, for additional requirements.

3.6 PROTECTION

- A. Provide finished cabinet units with protective covers during the balance of construction.
- B. Protect installed equipment from subsequent construction operations.

END OF SECTION 23 82 00

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SECTION 23 83 00 - RADIANT HEATING AND COOLING UNITS

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SECTION INCLUDES

- A. Hydronic radiant panel heaters.
- B. Radiant heating hydronic piping.

1.3 RELATED REQUIREMENTS

- A. Section 08 31 00 - Access Doors and Panels.
- B. Section 23 07 16 - HVAC Equipment Insulation.
- C. Section 23 07 19 - HVAC Piping Insulation.
- D. Section 23 09 13 - Instrumentation and Control Devices for HVAC.
- E. Section 23 09 93 - Sequence of Operations for HVAC Controls.
- F. Section 23 21 13 - Hydronic Piping.
- G. Section 23 21 14 - Hydronic Specialties.

1.4 REFERENCE STANDARDS

- A. ASHRAE Std 138 - Method of Testing for Rating Ceiling Panels for Sensible Heating and Cooling 2021.
- B. ASTM B75/B75M - Standard Specification for Seamless Copper Tube 2020.
- C. DIN EN 14037-2 - Free hanging heating and cooling surfaces for water with a temperature below 120 Degrees C - Part 2: Pre-fabricated ceiling mounted radiant panels for space heating - Test method for thermal output 2016.
- D. DIN EN 14037-3 - Free hanging heating and cooling surfaces for water with a temperature below 120 Degrees C - Part 3: Prefabricated ceiling mounted radiant panels for space heating- Rating method and evaluation of radiant thermal output 2016.
- E. DIN 14037-3 - Ceiling Mounted Radiant Panels Supplied with Water at a Temperature Below 120 Degrees C; Part 3: Rating Method and Evaluation of Radiant Thermal Output 2016.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.

1.8 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. (1) Year from date of acceptance by the Owner and completion of commissioning.

PART 2 PRODUCTS

2.1 HYDRONIC RADIANT PANEL HEATERS

- A. Manufacturers:
 - 1. Airtite
 - 2. Airtex
 - 3. Zehnder Rittling[<>]: www.rittling.com.
- B. Modular Radiant Ceiling Panels: Heat sinks located behind panel, transfer heat between copper tubes and panel face, and radiate heat to zone.
 - 1. Water Tubes:
 - a. ASTM B75/B75M copper tubing, 1/2 inch minimum nominal diameter.
 - b. Water Connections:
 - 1) Same end only.
 - 2) Suitable for solder, compression fittings, push-on fittings, or threaded connection.
 - 3) Protect with removable seals. Prevent introduction of dirt and dust during shipping.
 - 2. Heat Sink Construction:
 - a. Mechanically fasten extruded aluminum and copper pipe to heat sink.

- b. Provide non-hardening heat transfer paste between tubing, heat sink, and panel.
3. Panel Face: Construct of minimum 18 gauge, 0.0403 inch thick aluminum.
4. Finish:
 - a. Coordinate color selection with architect.
 - b. Maintain optimal radiative properties, durability, and cleanability.
5. Water Pressure Drop and Heating Output Data: Derive from factory testing in accordance with ASHRAE Std 138 or DIN EN 14037, Parts 2 and 3.
6. Provide insulation on top of radiant ceiling panels, thickness as recommended by the manufacturer.

PART 3 EXECUTION

3.1 EXAMINATION

A. Hydronic Radiant Ceiling Panel Heaters:

1. Examine areas to receive radiant heating units for compliance with requirements for installation tolerances and other conditions affecting performance.
2. Examine roughing-in for hydronic piping connections to verify actual locations prior to installation.
3. Ensure surfaces in contact with radiant heating panels are free of burrs and sharp protrusions.
4. Ensure surfaces are level and plumb.

3.2 PREPARATION

- ##### A. Clean all surfaces prior to installation.

3.3 INSTALLATION

- ##### A. Install in accordance with manufacturer's recommendations.

B. Hydronic Radiant Ceiling Panel Heaters:

1. Install level and plumb.
2. Suspend from structure.
3. Support in grid-type suspended ceiling using grid as support element as follows:
 - a. Install a minimum of four ceiling support system rods or wires for each panel, located not more than 6 inches from panel corners.

- b. Fasten support clips to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
 - c. Install at least one independent support rod or wire from structure to tab on panel with breaking strength of the weight of panel at a safety factor of 3.
 4. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
 5. Provide tamper-proof, balancing valve with memory stop on return piping.
 6. Provide float operated automatic air vents with stop valve.
 7. See Section 23 21 13 and Section 23 21 14 for additional requirements.
 8. Refer to Radiant Ceiling Panel Piping Detail for additional information.
- C. Hydronic Radiant Panel Heaters: Consult manufacturer's installation manual for panels not installed in ceiling systems.
- D. Hydronic Radiant Heating Piping:
 1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
 2. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
 3. Install piping as indicated unless deviations to layout are approved on shop drawings or coordination drawings.
 4. Install radiant heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.
 5. Do not bend pipes in radius smaller than manufacturer's minimum bend radius dimension.
 6. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.
 7. After system balancing has been completed, mark balancing valves to permanently indicate final position.
 8. Perform the following adjustments before operating the system:
 - a. Open valves to fully open position.
 - b. Check operation of automatic valves.
 - c. Set temperature controls so all zones call for full flow.
 - d. Purge air from piping.

3.4 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Hydronic Radiant Ceiling Panel Heaters:
 - 1. Inspect for damage to finish.
 - 2. Repair damaged finish to match original finish.
 - 3. Perform the following field tests, inspections, and prepare test reports:
 - a. Leak Test:
 - 1) After installation, fill water tubes, and test for leaks.
 - 2) Repair leaks and retest until no leaks exist.
 - b. Test and adjust controls and safeties.
 - 4. Remove and replace damaged and malfunctioning controls and equipment and retest as specified above.
- C. Hydronic Radiant Heating Piping:
 - 1. Prepare radiant heating piping for testing as follows:
 - a. Open all isolation valves and close bypass valves.
 - b. Open and verify operation of zone control valves.
 - c. Flush with clean water and clean strainers.
 - 2. Perform the following tests and inspections with the assistance of a factory authorized service representative:
 - a. Leak Test:
 - 1) After installation, charge system and test for leaks.
 - 2) Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig.
 - 3) Repair leaks and retest until no leaks exist.
 - 3. Execute, complete, and pass required radiant-heating piping tests and inspections to accept installed piping.
 - 4. Prepare test and inspection reports.
 - 5. Protect hydronic piping system from damage during construction.

3.5 CLEANING

- A. Radiant Ceiling Panel Heaters: Remove paint splatters, other spots, dirt, and debris.

3.6 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 - Closeout Submittals.
- B. See Section 01 79 00 - Demonstration and Training, for additional requirements.
- C. Demonstrate Operation of Controls for the following Equipment:
 - 1. Hydronic Radiant Ceiling Panel Heaters.

3.7 PROTECTION

- A. Protect installed products from damage until Date of Substantial Completion.

END OF SECTION 23 83 00

SECTION 26 05 00 - ELECTRICAL GENERAL CONDITIONS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 DESCRIPTION

- A. Related Work Specified Elsewhere:
 - 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section..
 - 2. This section applies to certain sections of Division 1, Division 23, "Mechanical". This section applies to all sections of Division 26, "Electrical," of this project specification unless specified otherwise in the individual sections.
 - 3. Temporary Facilities and controls are specified in Section 01 50 00. Cooperate in ensuring adequate protection.
 - 4. General material, equipment and workmanship standards are specified in Section 01 60 00.
 - 5. Finished painting is specified in section 09 91 00.
 - 6. Access doors and panels to be installed in finished surfaces are specified in Section 08 31 13.
 - 7. Cutting and patching, chases, furred spaces, trenches, covers, pits, foundations and other construction required in conjunction with the work under this Division is specified in Section 01 73 29.

1.3 DRAWINGS AND COORDINATION

- A. It is not the intention of the drawings to show every item, piece of equipment and detail. Provide complete, operating systems.
- B. Install work as closely as possible to layouts shown on drawings. Modify work as necessary to meet job conditions and to clear other equipment. Consult Architect before making changes which affect the function or appearance of systems.
- C. Dimensions, elevations and locations are shown approximately. Verify actual conditions in the field.
- D. Owner, Architect, and Engineer reserve the right to order changes in layout of such items as switches, receptacles, and fixtures if such changes do not substantially affect costs and if

affected items have not been fabricated or installed.

- E. In some cases, drawings are based upon products of one or several manufactures as listed on the Contract Documents. This contractor shall be responsible for modifications made necessary by substitution of products of different manufacturers.
- F. Do not install part of a system until all critical components of the system and related systems have been approved. Coordinate parts of systems to ensure proper operation of the entire system.
- G. Install products in accordance with manufacturer's written instructions. Notify Engineer if Contract Documents conflict with manufacturer's instructions. Comply with Engineers interpretations.
- H. Provide brackets, supports, anchors and frames required for installation of work specified herein.

1.4 CODES AND STANDARDS

- A. The Codes and Standards listed below apply to all Work. Where Codes or Standards are mentioned in these Specifications, follow the latest edition or revision.
- B. The current adopted editions of the following State or local Codes apply:
 - 1. 2018 Connecticut State Building Code
 - 2. 2015 International Building Code
 - 3. 2015 International Mechanical Code
 - 4. 2015 International Plumbing Code
 - 5. 2017 National Electrical Code (NFPA 70)
 - 6. 2015 International Energy Conservation Code
 - 7. NECA 1 Standard For Good Workmanship In Electrical Construction
 - 8. ICC/ANSI A117.1-2009 Accessible and Usable Buildings and Facilities
 - 9. Connecticut School Construction Standards and Guidelines.
- C. All materials furnished and all work installed shall comply with the rules and recommendations of the NFPA, the requirements of the local utility companies, the recommendations of the fire insurance rating organization having jurisdiction and the requirements of all Governmental departments having jurisdiction.
- D. Include in the Work, without extra cost to the Owner, any labor, materials, testing, services, apparatus and Drawings in order to comply with all applicable laws, ordinances, rules and regulations, whether or not shown on Drawings and/or specified.

1.5 PERMITS AND FEES

- A. Give all necessary notices, obtain all permits; pay all Government and State sales taxes and fees where applicable, and other costs, including utility connections or extensions in connection with the Work. File all necessary Drawings, prepare all Documents and obtain all necessary approvals of all Governmental and State departments having jurisdiction, obtain all required certificates of inspections for Work and deliver a copy to the Engineer before request for acceptance and final payment for the Work.

1.6 REFERENCES

- A. FM P7825 - Approval Guide; Factory Mutual Research Corporation; current edition.
- B. NEMA MG 1 - Motors and Generators; National Electrical Manufacturers Association; 1993 (and Revision 1,2,3).
- C. NEMA ICS 6 - National Electrical Manufacturers Association; 1993 Enclosures for Industrial Control and Systems
- D. NEMA MG 10 - National Electrical Manufacturers Association; 1983; (R 1988) Energy Management Guide for Selection and Use of Polyphase Motors.
- E. NEMA MG 11 - National Electrical Manufacturers Association; 1977; (R 1992) Energy Management Guide of Selection and Use of Single-Phase Motors.
- F. NFPA 70 - National Electrical Code; National Fire Protection Association; 2005.
- G. SSPC-Paint 15 - Steel Joist Shop Paint; Society for Protective Coatings; 1991 (Part of Steel Structures Painting Manual, Vol. Two).
- H. IEEE 100 - 1992 Dictionary of Electrical and Electronics Terms.
- I. IBC 2003, Structural Loads, Seismic bracing and restraints.

1.7 DEFINITIONS

- A. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.
- B. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.
- C. The technical paragraphs referred to herein are those paragraphs in PART 2 - PRODUCTS and PART 3 - EXECUTION of the technical sections that describe products, systems, installation procedures, equipment, and test methods.
- D. FURNISH: The term "furnish" means: "to supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, and similar operations."

- E. **INSTALL:** The term "install" is used to describe operations at the project site, including the actual "unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations."
- F. **PROVIDE:** The term "provide" means: "to furnish and install, complete and ready for the intended use."

1.8 EQUIPMENT DEVIATIONS

- A. Where the Contractor proposes to deviate (substitute or provide an equivalent) from the equipment or materials as hereinafter specified, he shall do so by making a request in writing within 60 days from the Award of Contract. The Contractor shall state in his request whether it is a substitution or an equivalent to that specified, and the amount of credit involved. A copy of said request shall be included in the Base Bid with manufacturer's equipment cuts.
 - 1. The Base Product Specification shall be based on using the materials and equipment as specified and scheduled with no exceptions. Equipment Manufacturers Scheduled on Drawings are considered Base Product Specification and any other acceptable manufacturers listed in the specifications is considered an equivalent manufacturer to the Base Product Specification. Unlisted manufacturers are considered a substitution and equipment deviation and subject to the requirements for equipment substitution and deviation. When any alternate manufacturer does not qualify acceptable, as determined by the Engineer, provide the Base Bid manufacturer at no additional cost to Owner.
 - 2. Where an equivalent manufacturer is listed in the specifications, it may or may not indicate that there is an equal product available. Any products must meet all criteria of the Base Product Specification as determined by the Engineer.
- B. Substitutions and Equipment Deviations will not be considered if they have a direct bearing on the changing or revising of Contract Documents or if it involves other Contractor's scope of work or thier equipment. Coordination with all trades is required and must be acceptable to all other involved Contractors.
- C. Substitutions may be considered for one of the following:
 - 1. Substitution for Cause: Changes proposed by the Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of warranty terms.
 - 2. Substitutions for Convenience: Changes proposed by the Contractor or Owner that are not required in order to meet other Project requirements, but may offer advantage to either the Owner or Contractor.
- D. In these Specifications and on the accompanying Drawings, one or more makes of materials, apparatus or appliances may have been specified for use in this installation. This has been done for convenience in fixing the standard of workmanship, finish and design required for installation. In the event that only one (1) manufacturer of a product is specified and it is found that the manufacturer has discontinued the product, the Contractor shall use an acceptable

equivalent product that meets the requirements of an equivalent product, as noted below, and has all the features of the originally specified product. The details of workmanship, finish and design, and the guaranteed performance of any material, apparatus or appliance which the Contractor desires to deviate for those mentioned herein shall also conform to these standards.

- E. Where no specific make of material, apparatus or appliance is mentioned, any first-class product made by a reputable manufacturer may be submitted for the Engineer's review.
- F. Where two or more names are given as equivalents, the Contractor must use the specified item or one of the named equivalents. Where one name only is used and is followed by the words "or acceptable equivalent", the Contractor must use the item named or he may apply for an equipment deviation through the prescribed manner in accordance with this Specification.
- G. Equipment, material or devices submitted for review as an "accepted equivalent" shall meet the following requirements:
 - 1. The equivalent shall have the same construction features such as, but not limited to:
 - a. Material thickness, gauge, weight, density, etc.
 - b. Welded, riveted, bolted, etc., construction
 - c. Finish, undercoatings, corrosion protection
 - d. Aesthetics
 - 2. The equivalent shall perform with the same or better operating efficiency.
 - 3. The equivalent shall have equal or greater reserve capacity.
 - 4. The equivalent shall be locally represented by the manufacturer for service, parts and technical information.
 - 5. The equivalent shall bear the same labels of performance certification as is applicable to the specified item, such as AMCA or ARI labels.
- H. Where the Contractor proposes to use an item of equipment other than specified or detailed on the Drawings which requires any redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical, electrical or architectural layout, all such redesign and all new drawings and detailing required therefore shall be prepared by the Designers of Record at the expense of the Contractor and at no additional cost to the Owner.
- I. Where such accepted deviation or substitution requires a different quantity and arrangement of piping, ductwork, valves, pumps, insulation, wiring, conduit and equipment from that specified or indicated on the Drawings, the Contractor shall, with the acceptance by the Engineer, furnish and install any such additional equipment required by the system at no additional cost to the Owner, including any costs added to other trades due to the substitution.

- J. The Engineer shall determine if an "accepted equivalent" to a manufacturer listed in the Specifications is considered acceptable.
- K. The Architect shall determine if an "accepted equivalent" to a manufacturer listed in the Specifications is considered to have acceptable aesthetics.

1.9 SUBMITTALS

- A. See Section 01 33 00 - Administrative Requirements, for submittal procedures.
- B. Provide manufacturer's ORIGINAL printed product data, catalog cuts and description of any special installation procedures. Photocopied and/or illegible product data sheets shall not be acceptable. All product datasheets shall be highlighted or stamped with arrows to indicate the specific components being submitted for approval.
 - 1. Generic catalog pages and specification sheets without clear indication of all features and options submitted for review, shall be rejected without review.
 - 2. Submittal documents that are not very clearly legible will be rejected without review.
- C. Submittals shall include the manufacturer's name, trade name, place of manufacture, catalog model or number, nameplate data, size, layout dimensions, capacity, project specification and technical paragraph reference. Submittals shall also include applicable federal, military, industry, and technical society publication references, and years of satisfactory service, and other information necessary to establish contract compliance of each item to be provided. Photographs of existing installations are unacceptable and will be returned without approval.
- D. Submittals for each manufactured item shall be current manufacturer's descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves, and catalog cuts. Handwritten and typed modifications and other notations not part of the manufacturer's preprinted data will result in the rejection of the submittal. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified for certificates of compliance.
- E. Submit drawings a minimum of 14 inches by 20 inches in size using a minimum scale of 1/8 inch per foot except as specified otherwise. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.
- F. Where installation procedures or part of the installation procedures are required to be in accordance with manufacturer's instructions, submit printed copies of those instructions prior to installation. Installation of the item shall not proceed until manufacturer's instructions are received. Failure to submit manufacturer's instructions shall be cause for rejection of the equipment or material.

- G. Submit manufacturer's certifications as required for products, materials, finishes, and equipment as specified in the technical sections. Certificates from material suppliers are not acceptable. Preprinted certifications and copies of previously submitted documents will not be acceptable. The manufacturer's certifications shall name the appropriate products, equipment, or materials and the publication specified as controlling the quality of that item. Certification shall not contain statements to imply that the item does not meet requirements specified, such as "as good as"; "achieve the same end use and results as materials formulated in accordance with the referenced publications"; or "equal or exceed the service and performance of the specified material." Certifications shall simply state that the item conforms to the requirements specified. Certificates shall be printed on the manufacturer's letterhead and shall be signed by the manufacturer's official authorized to sign certificates of compliance.
- H. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations such as American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), National Electrical Manufacturers Association (NEMA), Underwriters Laboratories Inc. (UL), and Association of Edison Illuminating Companies (AEIC), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance.
- I. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.10 QUALITY ASSURANCE

A. Material and Equipment Qualifications

- 1. Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section.

B. Regulatory Requirements

- 1. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70.

C. Alternative Qualifications

- 1. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the

manufacturers' factory or laboratory tests, is furnished.

D. Service Support

1. The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

E. Manufacturer's Nameplate

1. Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

F. Modification of References

1. In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Building Official or Inspector and/or Fire Marshal.

G. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.

H. Installer Qualifications: Company specializing in performing the work of this section with minimum 5 years of experience.

I. Design Seismic bracing and restraints under direct supervision of a Professional Structural Engineer experienced in design of this Work and licensed in Connecticut.

J. Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose specified and indicated.

1.11 MATERIAL ALLOWANCE

A. The contractor shall hold a materials allowance for the benefit of the Owner until project close out. These reserve material along with labor for installation are to be held in the event that extra work is required to receive the Certificate of Occupancy from the City Building Officials.

B. The contractor shall include in the bid price for the project devices with backbox, conduit and wiring of up to 50'-0" for installation in the following quantities:

1. Exit Signs – 5 (five), to include universal mounting accessories and all face/chevron configurations.
2. Smoke Detectors – 5 (five)
3. Fire Alarm Manual Pull Stations – 5 (five)

4. Fire Alarm Strobes – 10 (ten) to include field adjustable candela ratings.
5. Fire Alarm Speaker/Strobes – 10 (ten) to include field adjustable candela ratings.
6. Fire Alarm Speakers - 10 (ten)
7. Carbon Monoxide Detectors - 5 (five)
8. Duct Smoke Detectors - 4 (four)
9. Heat Detectors - 5 (five)
10. Addressable Interface Devices - 10 (ten)
11. Emergency Bypass Relays - 5 (five)
12. Duplex Receptacles - 25 (twenty five)
13. Lighting Room Controllers - 5 (five)
14. Lighting Dimmer Switches - 5 (five)
15. Celing Speakers - 5 (five)
16. Intercomm Stations - 5 (five)
17. Clocks - 5 (five)

- C. The extra work shall be accomplished at the direction of the Construction Manager. Pricing should anticipate that the installations will be required when all finishes are in place and that no allowances will be considered for expense recovery via a Change Order.

1.12 SEISMIC RESTRAINT

- A. General: This project is in a seismic zone per State and/or Local Codes and Ordinances and all materials and equipment shall be installed, supported, and seismically restrained accordingly. Verify current seismic requirements based on project location and with Code requirements.
- B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the jurisdiction where the Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of vibration isolation bases and seismic restraints that are similar to those required for this Project in material, design, and extent.
- C. Shop Drawings: Show designs and calculations, certified by a professional engineer, for the following:
1. Design Calculations: Calculations for selection of vibration isolators, design of vibration isolation bases, design of seismic supports and selection of seismic restraints for all equipment and materials.

2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to the structure and to the supported equipment. Include auxiliary motor slides and rails, and base weights.
 3. Seismic Restraint Details: Detail fabrication and attachment of restraints, supports and snubbers.
 4. Seismic Separation Assemblies: Refer to the Architectural and/or Structural drawings for locations of seismic joints.
- D. Installation: Installation shall be carried out in strict accordance with the Seismic Engineer's submittal, current Code, accepted standards and the equipment and material manufacturers' recommendations.

1.13 COORDINATION WITH OTHER DIVISIONS

- A. Carry out all work in conjunction with other trades and give full cooperation in order that all work may proceed with a minimum of delay and interference. Particular emphasis is placed on timely installation of major apparatus and furnishing other Contractors, especially the General Contractor or Construction Manager, with information as to openings, chases, sleeves, bases, inserts, equipment locations, panels, access doors, etc. required by other trades, and to allow for serviceable access to equipment.
- B. Mechanical contractors' shall initiate coordination drawings and sections clearly showing how the work is to be installed in relation to the work of other trades, at no extra charge to the Owner. The Contractors' shall prepare coordination drawings at a scale no less than 1/4"=1'-0", showing the work of all trades, including but not limited to, the following: proposed ductwork installation in detail, including ceiling heights, approved structural steel shop drawings, duct heights, access doors, light fixtures, registers and diffusers, sprinkler piping and heads, electrical distribution conduits, wires, panels and any other electrical work which may conflict with the sheet metal ducts or piping, waste and vent piping, water piping, storm piping, and rain leaders. Provide elevation details showing connections and equipment layout and configuration based on approved submittals. Each shall use a different color code. A coordination meeting of all Contractors involved is then to be held and all possible conflicts are to be resolved. All trades shall sign acceptance of the drawings and then shall submit two (2) prints of each drawing to the Engineer for record.
- C. Contractors are required to examine all of the Project Drawings and mutually arrange work so as to avoid interference. In general, ductwork, heating piping, sprinkler piping and drainage lines take precedence over water, gas and electrical conduits. The Engineer regarding the arrangement of work, which cannot be agreed upon by the Contractors, will make final decisions. Service of equipment will take precedence.
- D. Where the work of the Contractor will be installed in close proximity to or will interfere with work of other trades, assist in working out space conditions to make a satisfactory adjustment.
- E. If work is installed before coordinating with other Divisions or so as to cause interference with work of other Sections, the Contractor causing the interference will make necessary changes to

correct the condition without extra charge to the Owner.

- F. Initial contact and coordination has been conducted with utility entities for the purpose of the preparation of Bid Documents. The Contractor shall coordinate all final specific utility requirements.

1.14 PRE-INSTALLATION MEETING

- A. Convene one week before starting work of this section.

1.15 PROJECT CONDITIONS

- A. Sequence installation to ensure utility connections are achieved in an orderly and expeditious manner.
- B. Sequence installation to conform with the project phasing indicated on the Architectural drawings.

1.16 WARRANTY

- A. See Section 017700 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a one year period after Date of Substantial Completion.

1.17 OPERATING INSTRUCTIONS

- A. Submit text of posted operating instructions for each system and principal item of equipment as specified in the technical sections. The operating instructions shall include the following:
 - 1. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.
 - 2. Start up, proper adjustment, operating, lubrication, and shutdown procedures.
 - 3. Safety precautions.
 - 4. The procedure in the event of equipment failure.
 - 5. Other items of instruction as recommended by the manufacturer of each system or item of equipment.
- B. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.18 ELECTRICAL REQUIREMENTS

- A. Electrical installations shall conform to ANSI C2, NFPA 70, and requirements specified herein.
- B. Wiring and Conduit

1. Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment, and motor control equipment, the conduit and wiring connecting such assemblies, or other power sources to equipment. Power and Control wiring and conduit shall be provided under Division 26 and shall conform to the requirements of the section specifying the associated equipment.

C. New Work

1. Provide electrical components of mechanical equipment, such as motors, motor starters, control or push-button stations, float or pressure switches, solenoid valves, integral disconnects, and other devices functioning to control mechanical equipment, as well as control wiring and conduit to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors shall not be permitted. The interconnecting power wiring and conduit, control wiring and conduit, the motor control equipment and the electrical power circuits shall be provided under Division 26, except internal wiring for components of packaged equipment shall be provided as an integral part of the equipment.
 - a. When motors and equipment furnished are larger than sizes indicated, provide any required changes to the electrical service as may be necessary and related work as a part of the work for the section specifying that motor or equipment.

D. Instruction To Owners Personnel

1. Where specified in the technical sections, furnish the services of competent instructors to give full instruction to designated Owner personnel in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Owner for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with equipment or system. When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instructions to acquaint the operating personnel with the changes or modifications. Instructions and/or training shall be video taped. Provide the owner with two copies of the video tape prior to project close out.

E. Lockout Requirements

1. Provide disconnecting means capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with 29 CFR 1910.147. Mechanical isolation of machines and other equipment shall be in accordance with requirements of Division 23, "Mechanical."

F. Local Disconnect Requirements

1. Provide local disconnecting means for appliances and other equipment to prevent unexpected startup or release of stored energy in accordance with NFPA 70 requirements.

1.19 THROUGH-PENETRATION FIRESTOP SYSTEMS

- A. Refer to Division 7 Specification for additional and more specific information.
- B. Fire-stopping systems shall be submitted as shop drawing.
- C. Penetrations through fire-rated walls, ceiling or floors and penetrations through smoke barriers, smoke resistive construction, and construction enclosing compartmentalized areas involving both empty openings, openings containing penetration items, and openings due to flue decks shall be sealed with a U.L. approved fire-stop fitting classified for an hourly rating equivalent to the fire rating of the wall, ceiling or floor.
- D. Thruwall and floor seals shall be used to provide a positive means of sealing pipes or ducts which pass through the concrete foundation of a structure below grade or below ground water level. Seals shall also be used at entry points through concrete walls or floors which must be sealed.

1.20 COMMISSIONING

- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 01 91 13 - General Commissioning Requirements.
- B. Complete installation, startup checks and functional tests according to Section 01 91 13 - General Commissioning Requirements and manufacturers written instructions.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start up procedure.
- D. Verify that equipment is installed and commissioned as per requirements of Section 01 91 13 and manufacturers written instructions/requirements.

PART 2 PRODUCTS

2.1 NOT USED

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

3.2 FIELD QUALITY CONTROL

- A. Perform field inspection and testing in accordance with Section 01 40 00.

3.3 STARTING EQUIPMENT AND SYSTEMS

- A. Provide manufacturer's field representative to prepare and start equipment.
- B. Adjust for proper operation within manufacturer's published tolerances.
- C. Demonstrate proper operation of equipment to Owner's designated representative.

3.4 CLEANING

- A. Clean the entire installation at substantial completion .
- B. Protect installed equipment from subsequent construction operations.

END OF SECTION 26 05 00 26 05 00

SECTION 26 05 05 - SELECTIVE DEMOLITION FOR ELECTRICAL

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Electrical demolition.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 01 70 00 - Execution and Closeout Requirements: Additional requirements for alterations work.
- B. Section 02 84 00 - Polychlorinate Biphenyl (PCB) Remediation: Removal of equipment and materials containing substances regulated under the Federal Toxic Substances Control Act (TSCA), including but not limited to those containing PCBs and mercury.

1.4 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Sustainable Design Documentation: Submit certification of removal and appropriate disposal of abandoned cables containing lead stabilizers.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching and extending work: As specified in individual sections.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify field measurements and circuiting arrangements are as indicated.
- B. Verify that abandoned wiring and equipment serve only abandoned facilities.
- C. Demolition drawings are based on casual field observation and existing record documents.
- D. Report discrepancies to Owner before disturbing existing installation.
- E. Report discrepancies to Engineer before disturbing existing installation.
- F. Beginning of demolition means installer accepts existing conditions.

3.2 PREPARATION

- A. Disconnect electrical systems in walls, floors, and ceilings to be removed.
- B. Coordinate utility service outages with utility company.
- C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
- D. Existing Electrical Service & Distribution: Maintain existing systems in service until new systems are complete and ready for service. Disable system only to make switchovers and connections. Minimize outage duration.
 - 1. Obtain permission from Owner at least 24 hours before partially or completely disabling system.
 - 2. Make temporary connections to maintain service in areas adjacent to work area.
 - 3. Coordinate with work indicated on plans.
- E. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Minimize outage duration.
 - 1. Notify Owner before partially or completely disabling system.
 - 2. Notify local fire service.
 - 3. Make notifications at least 24 hours in advance.
 - 4. Make temporary connections to maintain service in areas adjacent to work area.
 - 5. Utilize existing system for temporary heat detector coverage in areas under construction.
- F. Existing Telephone System: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Minimize outage duration.
 - 1. Notify Owner at least 24 hours before partially or completely disabling system.
 - 2. Notify telephone utility company at least 24 hours before partially or completely disabling system.
 - 3. Make temporary connections to maintain service in areas adjacent to work area.
- G. Existing Data, Fiber, Cable TV, Communications, Paging, Bell, Security, and Access Control Systems: Maintain existing systems in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Minimize outage duration.
 - 1. Obtain permission from Owner at least 24 hours before partially or completely disabling system.

2. Make temporary connections to maintain service in areas adjacent to work area.

3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

- A. Perform work for removal and disposal of equipment and materials containing toxic substances regulated under the Federal Toxic Substances Control Act (TSCA) in accordance with applicable federal, state, and local regulations. Applicable equipment and materials include, but are not limited to:
 1. PCB-containing electrical equipment, including transformers, capacitors, and switches.
 2. PCB- and DEHP-containing lighting ballasts.
 3. Mercury-containing lamps and tubes, including fluorescent lamps, high intensity discharge (HID), arc lamps, ultra-violet, high pressure sodium, mercury vapor, ignitron tubes, neon, and incandescent.
- B. Remove, relocate, and extend existing installations to accommodate new construction.
- C. Remove abandoned wiring to source of supply.
- D. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
- E. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets that are not removed.
- F. Disconnect and remove abandoned panelboards and distribution equipment.
- G. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
- H. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.
- I. Repair adjacent construction and finishes damaged during demolition and extension work.
- J. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.
- K. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.

3.4 CLEANING AND REPAIR

- A. See Section 01 74 19 - Construction Waste Management and Disposal for additional requirements.

- B. Clean and repair existing materials and equipment that remain or that are to be reused.

END OF SECTION 26 05 05

SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Single conductor building wire.
- B. Metal-clad cable.
- C. Wiring connectors.
- D. Electrical tape.
- E. Oxide inhibiting compound.
- F. Wire pulling lubricant.
- G. Cable ties.
- H. Firestop sleeves.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.
- B. Section 26 05 05 - Selective Demolition for Electrical: Disconnection, removal, and/or extension of existing electrical conductors and cables.
- C. Section 26 05 26 - Grounding and Bonding for Electrical Systems: Additional requirements for grounding conductors and grounding connectors.
- D. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 26 21 00 - Low-Voltage Electrical Service Entrance: Additional requirements for electrical service conductors.
- F. Section 28 46 00 - Fire Detection and Alarm: Fire alarm system conductors and cables.

1.4 REFERENCE STANDARDS

- A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire 2013 (Reapproved 2018).

- B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft 2011 (Reapproved 2017).
 - C. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes 2010, with Editorial Revision (2020).
 - D. ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation 2004 (Reapproved 2020).
 - E. ASTM B800 - Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes - Annealed and Intermediate Tempers 2005 (Reapproved 2021).
 - F. ASTM B801 - Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy Wire for Subsequent Covering of Insulation 2018.
 - G. ASTM D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape 2017.
 - H. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
 - I. NECA 104 - Recommended Practice for Installing Aluminum Building Wire and Cable 2012.
 - J. NECA 120 - Standard for Installing Armored Cable (AC) and Metal-Clad Cable (MC) 2012.
 - K. NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy 2021.
 - L. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
 - M. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
 - N. UL 44 - Thermoset-Insulated Wires and Cables Current Edition, Including All Revisions.
 - O. UL 83 - Thermoplastic-Insulated Wires and Cables Current Edition, Including All Revisions.
 - P. UL 486A-486B - Wire Connectors Current Edition, Including All Revisions.
 - Q. UL 486C - Splicing Wire Connectors Current Edition, Including All Revisions.
 - R. UL 486D - Sealed Wire Connector Systems Current Edition, Including All Revisions.
 - S. UL 510 - Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape Current Edition, Including All Revisions.
 - T. UL 1569 - Metal-Clad Cables Current Edition, Including All Revisions.
- 1.5 ADMINISTRATIVE REQUIREMENTS
- A. Coordination:

1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
3. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conductors and cables, including detailed information on materials, construction, ratings, listings, and available sizes, configurations, and stranding.
- C. Design Data: Indicate voltage drop and ampacity calculations for aluminum conductors substituted for copper conductors. Include proposed modifications to raceways, boxes, wiring gutters, enclosures, etc. to accommodate substituted conductors.
- D. Field Quality Control Test Reports.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- F. Project Record Documents: Record actual installed circuiting arrangements. Record actual routing for underground circuits.
- G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. See Section 01 60 00 - Product Requirements, for additional provisions.

1.7 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store conductors and cables in accordance with manufacturer's instructions.

1.9 FIELD CONDITIONS

- A. Do not install or otherwise handle thermoplastic-insulated conductors at temperatures lower than 14 degrees F, unless otherwise permitted by manufacturer's instructions. When installation below this temperature is unavoidable, notify Engineer and obtain direction before proceeding with work.

PART 2 PRODUCTS

2.1 CONDUCTOR AND CABLE APPLICATIONS

- A. Do not use conductors and cables for applications other than as permitted by NFPA 70, Connecticut School Construction Standards and Guidelines, and product listing.
- B. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.
- C. Nonmetallic-sheathed cable is not permitted.
- D. Underground feeder and branch-circuit cable is not permitted.
- E. Service entrance cable is not permitted.
- F. Armored cable is not permitted.
- G. Metal-clad cable (Type MC) is permitted only as follows:
 - 1. Where not otherwise restricted, may be used:
 - a. Where concealed above accessible ceilings for final connections from junction boxes to luminaires.
 - 1) Maximum Length: 6 feet.
 - b. Where concealed in hollow stud walls, above accessible ceilings, and under raised floors for branch circuits up to 20 A.
 - 1) Exception: Provide single conductor building wire in raceway for circuit homerun from first outlet to panelboard.
 - 2. In addition to other applicable restrictions, may not be used:
 - a. Unless approved by Connecticut School Construction Standards and Guidelines.
 - b. Where not approved for use by the authority having jurisdiction.

- c. Where exposed to view.
- d. Where exposed to damage.
- e. For damp, wet, or corrosive locations.

2.2 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Provide new conductors and cables manufactured not more than one year prior to installation.
- D. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.
- E. Comply with NEMA WC 70.
- F. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.
- G. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.
- H. Conductors for Grounding and Bonding: Also comply with Section 26 05 26.
- I. Conductor Material:
 - 1. Provide copper conductors except where aluminum conductors are specifically indicated or permitted for substitution. Conductor sizes indicated are based on copper unless specifically indicated as aluminum. Conductors designated with the abbreviation "AL" indicate aluminum.
 - a. Substitution of aluminum conductors for copper is permitted, when approved by Owner, Connecticut School Construction Standards and Guidelines, and authority having jurisdiction, only for the following:
 - 1) Services: Copper conductors size 4/0 AWG and larger..
 - 2) Feeders: Copper conductors size 4/0 AWG and larger..
 - b. Where aluminum conductors are substituted for copper, comply with the following:
 - 1) Size aluminum conductors to provide, when compared to copper sizes indicated, equivalent or greater ampacity and equivalent or less voltage drop.
 - 2) Increase size of raceways, boxes, wiring gutters, enclosures, etc. as required to accommodate aluminum conductors.
 - 2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.

3. Tinned Copper Conductors: Comply with ASTM B33.
 4. Aluminum Conductors (only where specifically indicated or permitted for substitution): AA-8000 series aluminum alloy conductors recognized by ASTM B800 and compact stranded in accordance with ASTM B801 unless otherwise indicated.
- J. Minimum Conductor Size:
1. Branch Circuits: 12 AWG.
 - a. Exceptions:
 - 1) 20 A, 120 V circuits longer than 75 feet: 10 AWG, for voltage drop.
 - 2) 20 A, 120 V circuits longer than 150 feet: 8 AWG, for voltage drop.
 - 3) 20 A, 277 V circuits longer than 150 feet: 10 AWG, for voltage drop.
 2. Control Circuits: 14 AWG.
- K. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- L. Conductor Color Coding:
1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
 2. Color Coding Method: Integrally colored insulation.
 - a. Conductors size 4 AWG and larger may have black insulation color coded using vinyl color coding electrical tape.
 3. Color Code:
 - a. 480Y/277 V, 3 Phase, 4 Wire System:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - 4) Neutral/Grounded: Gray.
 - b. 208Y/120 V, 3 Phase, 4 Wire System:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.

4) Neutral/Grounded: White.

c. Equipment Ground, All Systems: Green.

d. Travelers for 3-Way and 4-Way Switching: Pink.

e. For control circuits, comply with manufacturer's recommended color code.

2.3 SINGLE CONDUCTOR BUILDING WIRE

A. Manufacturers:

1. Copper Building Wire:

a. Cerro Wire LLC: www.cerrowire.com/#sle.

b. Encore Wire Corporation: www.encorewire.com/#sle.

c. General Cable Technologies Corporation; [____]: www.generalcable.com/#sle.

d. Southwire Company: www.southwire.com/#sle.

e. Substitutions: See Section 01 60 00 - Product Requirements.

2. Aluminum Building Wire (only where specifically indicated or permitted for substitution):

a. Encore Wire Corporation: www.encorewire.com/#sle.

b. Southwire Company: www.southwire.com/#sle.

c. Stabiloy, a brand of General Cable Technologies Corporation; [____]:
www.stabiloy.com/#sle.

d. Substitutions: See Section 01 60 00 - Product Requirements.

B. Description: Single conductor insulated wire.

C. Conductor Stranding:

1. Feeders and Branch Circuits:

a. Size 10 AWG and Smaller: Solid.

b. Size 8 AWG and Larger: Stranded.

2. Control Circuits: Stranded.

D. Insulation Voltage Rating: 600 V.

E. Insulation:

1. Copper Building Wire: Type THHN/THWN or THHN/THWN-2, except as indicated below.
 - a. Size 4 AWG and Larger: Type XHHW-2.
 - b. Installed Underground: Type XHHW-2.
 - c. Fixture Wiring Within Luminaires: Type TFFN/TFN for luminaires with labeled maximum temperature of 90 degrees C; Approved suitable type for luminaires with labeled maximum temperature greater than 90 degrees C.
2. Aluminum Building Wire (only where specifically indicated or permitted for substitution): Type XHHW-2.

2.4 METAL-CLAD CABLE

- A. Manufacturers:
 1. AFC Cable Systems Inc: www.afcweb.com/#sle.
 2. Encore Wire Corporation: www.encorewire.com/#sle.
 3. Southwire Company: www.southwire.com/#sle.
 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Description: NFPA 70, Type MC cable listed and labeled as complying with UL 1569, and listed for use in classified firestop systems to be used.
- C. Conductor Stranding:
 1. Size 10 AWG and Smaller: Solid.
 2. Size 8 AWG and Larger: Stranded.
- D. Insulation Voltage Rating: 600 V.
- E. Insulation: Type THHN, THHN/THWN, or THHN/THWN-2.
- F. Provide oversized neutral conductors where indicated or required.
- G. Provide dedicated neutral conductor for each phase conductor where indicated or required. Shared neutrals are not permitted.
- H. Grounding: Full-size integral equipment grounding conductor.
- I. Armor: Aluminum or steel, interlocked tape.
- J. Provide PVC jacket applied over cable armor where indicated or required for environment of installed location.

2.5 WIRING CONNECTORS

- A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.
- B. Connectors for Grounding and Bonding: Comply with Section 26 05 26.
- C. Wiring Connectors for Splices and Taps:
 - 1. Copper Conductors Size 8 AWG and Smaller: Use twist-on insulated spring connectors.
 - 2. Copper Conductors Size 6 AWG and Larger: Use mechanical connectors or compression connectors.
 - 3. Connectors for Aluminum Conductors: Use compression connectors or mechanical connectors.
- D. Wiring Connectors for Terminations:
 - 1. Provide terminal lugs for connecting conductors to equipment furnished with terminations designed for terminal lugs.
 - 2. Where over-sized conductors are larger than the equipment terminations can accommodate, provide connectors suitable for reducing to appropriate size, but not less than required for the rating of the overcurrent protective device.
 - 3. Provide motor pigtail connectors for connecting motor leads in order to facilitate disconnection.
 - 4. Copper Conductors Size 8 AWG and Larger: Use mechanical connectors or compression connectors where connectors are required.
 - 5. Aluminum Conductors: Use compression connectors for all connections.
 - 6. Stranded Conductors Size 10 AWG and Smaller: Use crimped terminals for connections to terminal screws.
 - 7. Conductors for Control Circuits: Use crimped terminals for all connections.
- E. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.
- F. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.
- G. Twist-on Insulated Spring Connectors: Rated 600 V, 221 degrees F for standard applications and 302 degrees F for high temperature applications; pre-filled with sealant and listed as complying with UL 486D for damp and wet locations.
 - 1. Manufacturers:

- a. 3M: www.3m.com/#sle.
 - b. Ideal Industries, Inc: www.idealindustries.com/#sle.
 - c. NSI Industries LLC: www.nsiindustries.com/#sle.
 - d. Substitutions: See Section 01 60 00 - Product Requirements.
- H. Mechanical Connectors: Provide bolted type or set-screw type.
- I. Compression Connectors: Provide circumferential type or hex type crimp configuration.
- J. Crimped Terminals: Nylon-insulated, with insulation grip and terminal configuration suitable for connection to be made.

2.6 WIRING ACCESSORIES

- A. Electrical Tape:
- 1. Vinyl Color Coding Electrical Tape: Integrally colored to match color code indicated; listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; suitable for continuous temperature environment up to 221 degrees F.
 - 2. Vinyl Insulating Electrical Tape: Complying with ASTM D3005 and listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; conformable for application down to 0 degrees F and suitable for continuous temperature environment up to 221 degrees F.
- B. Oxide Inhibiting Compound: Listed; suitable for use with the conductors or cables to be installed.
- 1. Manufacturers:
 - a. Burndy LLC; [____]: www.burndy.com/#sle.
 - b. Ideal Industries, Inc: www.idealindustries.com/#sle.
 - c. Ilsco: www.ilsco.com/#sle.
 - d. Substitutions: See Section 01 60 00 - Product Requirements.
- C. Wire Pulling Lubricant: Listed; suitable for use with the conductors or cables to be installed and suitable for use at the installation temperature.
- D. Cable Ties: Material and tensile strength rating suitable for application.
- E. Sealing Systems for Roof Penetrations: Premanufactured components and accessories as required to preserve integrity of roofing system and maintain roof warranty; suitable for cables and roofing system to be installed; designed to accommodate existing penetrations where applicable.

- F. Firestop Sleeves: Listed; provide as required to preserve fire resistance rating of building elements.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that interior of building has been protected from weather.
- B. Verify that work likely to damage wire and cable has been completed.
- C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.
- D. Verify that field measurements are as indicated.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

3.3 INSTALLATION

- A. Circuiting Requirements:
 - 1. Unless dimensioned, circuit routing indicated is diagrammatic.
 - 2. When circuit destination is indicated without specific routing, determine exact routing required.
 - 3. Arrange circuiting to minimize splices.
 - 4. Include circuit lengths required to install connected devices within 10 ft of location indicated.
 - 5. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.
 - 6. Maintain separation of wiring for emergency systems in accordance with NFPA 70.
 - 7. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are indicated as separate, combining them together in a single raceway is not permitted.
 - 8. Common Neutrals: Unless otherwise indicated, sharing of neutral/grounded conductors among single phase branch circuits of different phases installed in the same raceway is not permitted. Provide dedicated neutral/grounded conductor for each individual branch circuit.
- B. Install products in accordance with manufacturer's instructions.

- C. Perform work in accordance with NECA 1 (general workmanship).
- D. Install aluminum conductors in accordance with NECA 104.
- E. Install metal-clad cable (Type MC) in accordance with NECA 120.
- F. Installation in Raceway:
 - 1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
 - 2. Pull all conductors and cables together into raceway at same time.
 - 3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
 - 4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.
- G. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.
- H. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.
 - 1. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conductors and cables to lay on ceiling tiles.
 - 2. Installation in Vertical Raceways: Provide supports where vertical rise exceeds permissible limits.
- I. Terminate cables using suitable fittings.
 - 1. Metal-Clad Cable (Type MC):
 - a. Use listed fittings.
 - b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.
 - c. Do not use direct-bearing set-screw type fittings for cables with aluminum armor.
- J. Install conductors with a minimum of 12 inches of slack at each outlet.
- K. Where conductors are installed in enclosures for future termination by others, provide a minimum of 5 feet of slack.
- L. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.

- M. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.
 - N. Make wiring connections using specified wiring connectors.
 - 1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.
 - 2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
 - 3. Do not remove conductor strands to facilitate insertion into connector.
 - 4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.
 - 5. Connections for Aluminum Conductors: Fill connectors with oxide inhibiting compound where not pre-filled by manufacturer.
 - 6. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
 - 7. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
 - O. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.
 - P. Insulate ends of spare conductors using vinyl insulating electrical tape.
 - Q. Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.
 - R. Identify conductors and cables in accordance with Section 26 05 53.
 - S. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
 - T. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.
- 3.4 FIELD QUALITY CONTROL
- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
 - B. Inspect and test in accordance with NETA ATS, except Section 4.

- C. Perform inspections and tests listed in NETA ATS, Section 7.3.2. The insulation resistance test is required for all conductors. The resistance test for parallel conductors listed as optional is not required.
 - 1. Disconnect surge protective devices (SPDs) prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPDs connected.
- D. Correct deficiencies and replace damaged or defective conductors and cables.

END OF SECTION 26 05 19

SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Grounding and bonding requirements.
- B. Conductors for grounding and bonding.
- C. Connectors for grounding and bonding.
- D. Ground bars.
- E. Ground rod electrodes.
- F. Ground plate electrodes.
- G. Ground enhancement material.
- H. Ground access wells.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 41 13 - Lightning Protection for Structures.
- B. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables: Additional requirements for conductors for grounding and bonding, including conductor color coding.
 - 1. Includes oxide inhibiting compound.
- C. Section 26 05 36 - Cable Trays for Electrical Systems: Additional grounding and bonding requirements for cable tray systems.
- D. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 26 56 00 - Exterior Lighting: Additional grounding and bonding requirements for pole-mounted luminaires.

1.4 REFERENCE STANDARDS

- A. IEEE 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System 2012.

- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NEMA GR 1 - Ground Rod Electrodes and Ground Rod Electrode Couplings 2017.
- D. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- E. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. NFPA 780 - Standard for the Installation of Lightning Protection Systems 2020.
- G. UL 467 - Grounding and Bonding Equipment Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Verify exact locations of underground metal water service pipe entrances to building.
 - 2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode.
 - 3. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not install ground rod electrodes until final backfill and compaction is complete.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for grounding and bonding system components.
- C. Shop Drawings:
- D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Field quality control test reports.
- F. Project Record Documents: Record actual locations of grounding electrode system components and connections.

1.7 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Installer Qualifications for Signal Reference Grids: Company with minimum five years documented experience with high frequency grounding systems.
- E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 GROUNDING AND BONDING REQUIREMENTS

- A. Existing Work: Where existing grounding and bonding system components are indicated to be reused, they may be reused only where they are free from corrosion, integrity and continuity are verified, and where acceptable to the authority having jurisdiction.
- B. Do not use products for applications other than as permitted by NFPA 70 and product listing.
- C. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.
- D. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- E. Grounding System Resistance:
 - 1. Achieve specified grounding system resistance under normally dry conditions unless otherwise approved by Engineer. Precipitation within the previous 48 hours does not constitute normally dry conditions.
 - 2. Grounding Electrode System: Not greater than 5 ohms to ground, when tested according to IEEE 81 using "fall-of-potential" method.
- F. Grounding Electrode System:
 - 1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
 - a. Provide continuous grounding electrode conductors without splice or joint.

- b. Install grounding electrode conductors in raceway. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
- 2. Metal Underground Water Pipe(s):
 - a. Provide connection to underground metal domestic and fire protection (where present) water service pipe(s) that are in direct contact with earth for at least 10 feet at an accessible location not more than 5 feet from the point of entrance to the building.
 - b. Provide bonding jumper(s) around insulating joints/pipes as required to make pipe electrically continuous.
 - c. Provide bonding jumper around water meter of sufficient length to permit removal of meter without disconnecting jumper.
- 3. Metal In-Ground Support Structure:
 - a. Provide connection to metal in-ground support structure that is in direct contact with earth in accordance with NFPA 70.
- 4. Concrete-Encased Electrode:
 - a. Provide connection to concrete-encased electrode consisting of not less than 20 feet of either steel reinforcing bars or bare copper conductor not smaller than 4 AWG embedded within concrete foundation or footing that is in direct contact with earth in accordance with NFPA 70.
- 5. Ground Rod Electrode(s):
 - a. Provide three electrodes in an equilateral triangle configuration unless otherwise indicated or required.
 - b. Space electrodes not less than 10 feet from each other and any other ground electrode.
 - c. Where location is not indicated, locate electrode(s) at least 5 feet outside building perimeter foundation as near as possible to electrical service entrance; where possible, locate in softscape (uncovered) area.
- 6. Provide additional ground electrode(s) as required to achieve specified grounding electrode system resistance.
- 7. Ground Bar: Provide ground bar, separate from service equipment enclosure, for common connection point of grounding electrode system bonding jumpers as permitted in NFPA 70. Connect grounding electrode conductor provided for service-supplied system grounding to this ground bar.
 - a. Ground Bar Size: 1/4 by 4 by 12 inches unless otherwise indicated or required.
 - b. Where ground bar location is not indicated, locate in accessible location as near as possible to service disconnect enclosure.

- c. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.

G. Service-Supplied System Grounding:

1. For each service disconnect, provide grounding electrode conductor to connect neutral (grounded) service conductor to grounding electrode system. Unless otherwise indicated, make connection at neutral (grounded) bus in service disconnect enclosure.
2. For each service disconnect, provide main bonding jumper to connect neutral (grounded) bus to equipment ground bus where not factory-installed. Do not make any other connections between neutral (grounded) conductors and ground on load side of service disconnect.

H. Bonding and Equipment Grounding:

1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
7. Provide bonding for interior metal piping systems in accordance with NFPA 70. This includes, but is not limited to:
 - a. Metal water piping where not already effectively bonded to metal underground water pipe used as grounding electrode.
 - b. Metal gas piping.
8. Provide bonding for metal building frame.

I. Communications Systems Grounding and Bonding:

1. Provide intersystem bonding termination at service equipment or metering equipment enclosure and at disconnecting means for any additional buildings or structures in accordance with NFPA 70.
2. Provide bonding jumper in raceway from intersystem bonding termination to each communications room or backboard and provide ground bar for termination.
 - a. Bonding Jumper Size: As indicated.
 - b. Raceway Size: 1" trade size unless otherwise indicated or required.
 - c. Ground Bar Size: 1/4 by 4 by 12 inches unless otherwise indicated or required.
 - d. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.

J. Lightning Protection Systems:

1. See Section 26 41 13 for additional requirements.
2. Do not use grounding electrode dedicated for lightning protection system for component of building grounding electrode system provided under this section.
3. Provide bonding of building grounding electrode system provided under this section and lightning protection grounding electrode system in accordance with NFPA 70 and NFPA 780.

K. Pole-Mounted Luminaires: Also comply with Section 26 56 00.

2.2 GROUNDING AND BONDING COMPONENTS

A. General Requirements:

1. Provide products listed, classified, and labeled as suitable for the purpose intended.
2. Provide products listed and labeled as complying with UL 467 where applicable.

B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 26 05 26:

1. Use insulated copper conductors unless otherwise indicated.
 - a. Exceptions:
 - 1) Use bare copper conductors where installed underground in direct contact with earth.
 - 2) Use bare copper conductors where directly encased in concrete (not in raceway).

C. Connectors for Grounding and Bonding:

1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
3. Unless otherwise indicated, use mechanical connectors, compression connectors, or exothermic welded connections for accessible connections.
4. Manufacturers - Exothermic Welded Connections:
 - a. Cadweld, a brand of Erico International Corporation; [____]:
www.erico.com/#sle.
 - b. thermOweld, subsidiary of Continental Industries; division of Burndy LLC;
[____]: www.thermoweld.com/#sle.
 - c. Substitutions: See Section 01 60 00 - Product Requirements.

D. Ground Bars:

1. Description: Copper rectangular ground bars with mounting brackets and insulators.
2. Size: As indicated.
3. Holes for Connections: As indicated or as required for connections to be made.
4. Manufacturers:
 - a. As indicated on plans.
 - b. Substitutions: See Section 01 60 00 - Product Requirements.

E. Ground Rod Electrodes:

1. Comply with NEMA GR 1.
2. Material: Copper-bonded (copper-clad) steel.
3. Size: 3/4 inch diameter by 10 feet length, unless otherwise indicated.
4. Where rod lengths of greater than 10 feet are indicated or otherwise required, sectionalized ground rods may be used.

F. Ground Plate Electrodes:

1. Material: Copper.
2. Size: 24 by 24 by 1/4 inches, unless otherwise indicated.

G. Ground Enhancement Material:

1. Description: Factory-mixed conductive material designed for permanent and maintenance-free improvement of grounding effectiveness by lowering resistivity.

H. Ground Access Wells:

1. Description: Open bottom round or rectangular well with access cover for testing and inspection; suitable for the expected load at the installed location.
2. Size: As required to provide adequate access for testing and inspection, but not less than minimum size requirements specified.
3. Depth: As required to extend below frost line to prevent frost upheaval, but not less than 10 inches.
4. Cover: Factory-identified by permanent means with word "GROUND".

I. Oxide Inhibiting Compound: Comply with Section 26 05 19.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that work likely to damage grounding and bonding system components has been completed.
- B. Verify that field measurements are as indicated.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70 or provide ground plates.
- D. Ground Plate Electrodes: Unless otherwise indicated, install ground plate electrodes at a depth of not less than 30 inches.
- E. Make grounding and bonding connections using specified connectors.
 1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
 2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.

3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.

F. Identify grounding and bonding system components in accordance with Section 26 05 53.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.13.
- D. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
- E. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.
- F. Submit detailed reports indicating inspection and testing results and corrective actions taken.

END OF SECTION 26 05 26

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SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Support and attachment requirements and components for equipment, conduit, cable, boxes, and other electrical work.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 03 30 00 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 05 50 00 - Metal Fabrications: Materials and requirements for fabricated metal supports.
- C. Section 26 05 33.13 - Conduit for Electrical Systems: Additional support and attachment requirements for conduits.
- D. Section 26 05 33.16 - Boxes for Electrical Systems: Additional support and attachment requirements for boxes.
- E. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
- F. Section 26 51 00 - Interior Lighting: Additional support and attachment requirements for interior luminaires.
- G. Section 26 56 00 - Exterior Lighting: Additional support and attachment requirements for exterior luminaires.

1.4 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware 2016a.
- C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel 2019.
- D. MFMA-4 - Metal Framing Standards Publication 2004.
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.

- F. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
2. Coordinate the work with other trades to provide additional framing and materials required for installation.
3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
6. Coordinate support methods with structural engineer.

B. Sequencing:

1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 30 00.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for channel (strut) framing systems, non-penetrating rooftop supports, and post-installed concrete and masonry anchors.
- C. Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution.
- D. Installer's Qualification Statement: Include evidence of compliance with specified requirements.
- E. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.7 QUALITY ASSURANCE

- A. Comply with NFPA 70.

- B. Comply with applicable building code.
- C. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
 - 1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.
 - 2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
 - 3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of [____]. Include consideration for vibration, equipment operation, and shock loads where applicable.
 - 4. Do not use products for applications other than as permitted by NFPA 70 and product listing.
 - 5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Components for Vibration Isolation and/or Seismic Controls: Comply with Section 26 05 48.
- C. Materials for Metal Fabricated Supports: Comply with Section 05 50 00.

- D. Conduit and Cable Supports: Straps, clamps, etc. suitable for the conduit or cable to be supported.
 - 1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
 - 2. Conduit Clamps: Bolted type unless otherwise indicated.
- E. Outlet Box Supports: Hangers, brackets, etc. suitable for the boxes to be supported.
- F. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
 - 1. Comply with MFMA-4.
 - 2. Channel Material:
 - a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
 - 3. Minimum Channel Thickness: Steel sheet, 12 gauge, 0.1046 inch.
 - 4. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height.
- G. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
 - 1. Minimum Size, Unless Otherwise Indicated or Required:
 - a. Equipment Supports: 1/2 inch diameter.
 - b. Single Conduit up to 1 inch (27 mm) trade size: 3/8 inch diameter.
 - c. Single Conduit larger than 1 inch (27 mm) trade size: 3/8 inch diameter.
 - d. Trapeze Support for Multiple Conduits: 1/2 inch diameter.
 - e. Outlet Boxes: 3/8 inch diameter.
 - f. Luminaires: 3/8 inch diameter.
- H. Non-Penetrating Rooftop Supports for Low-Slope Roofs: Steel pedestals with thermoplastic or rubber bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified.
 - 1. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
 - 2. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports.

3. Mounting Height: Provide minimum clearance of 6 inches under supported component to top of roofing.
4. Manufacturers:
 - a. Cooper B-Line, a division of Eaton Corporation; [____]: www.cooperindustries.com/#sle.
 - b. Erico International Corporation; [____]: www.erico.com/#sle.
 - c. PHP Systems/Design; [____]: www.phpsd.com/#sle.
 - d. Substitutions: See Section 01 60 00 - Product Requirements.

I. Anchors and Fasteners:

1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
2. Plastic and lead anchors are not permitted.
3. Powder-actuated fasteners are not permitted.
4. Hammer-driven anchors and fasteners are not permitted.
5. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
 - a. Comply with MFMA-4.
 - b. Channel Material: Use galvanized steel.
 - c. Manufacturer: Same as manufacturer of metal channel (strut) framing system.
6. Post-Installed Concrete and Masonry Anchors: Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) for compliance with applicable building code.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).

- C. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- D. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- E. Unless specifically indicated or approved by Engineer, do not provide support from suspended ceiling support system or ceiling grid.
- F. Unless specifically indicated or approved by Engineer, do not provide support from roof deck.
- G. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- H. Provide required vibration isolation and/or seismic controls in accordance with Section 26 05 48.
- I. Equipment Support and Attachment:
 - 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
 - 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 - 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 - 4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 3 inch high concrete pad constructed in accordance with Section 03 30 00.
 - 5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- J. Conduit Support and Attachment: Also comply with Section 26 05 33.13.
- K. Box Support and Attachment: Also comply with Section 26 05 33.16.
- L. Interior Luminaire Support and Attachment: Also comply with Section 26 51 00.
- M. Exterior Luminaire Support and Attachment: Also comply with Section 26 56 00.
- N. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.
- O. Secure fasteners according to manufacturer's recommended torque settings.
- P. Remove temporary supports.
- Q. Identify independent electrical component support wires above accessible ceilings (only where specifically indicated or permitted) with color distinguishable from ceiling support wires in

accordance with NFPA 70.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect support and attachment components for damage and defects.
- C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- D. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION 26 05 29

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SECTION 26 05 33.13 - CONDUIT FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Galvanized steel rigid metal conduit (RMC).
- B. Intermediate metal conduit (IMC).
- C. PVC-coated galvanized steel rigid metal conduit (RMC).
- D. Flexible metal conduit (FMC).
- E. Liquidtight flexible metal conduit (LFMC).
- F. Electrical metallic tubing (EMT).
- G. Rigid polyvinyl chloride (PVC) conduit.
- H. Conduit fittings.
- I. Accessories.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Connecticut School Construction Standards and Guidelines.
- B. Section 03 30 00 - Cast-in-Place Concrete: Concrete encasement of conduits.
- C. Section 07 84 00 - Firestopping.
- D. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
 - 1. Includes additional requirements for fittings for grounding and bonding.
- E. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- F. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
- G. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- H. Section 26 21 00 - Low-Voltage Electrical Service Entrance: Additional requirements for electrical service conduits.

- I. Section 27 10 00 - Structured Cabling: Additional requirements for communications systems conduits.

1.4 REFERENCE STANDARDS

- A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC) 2020.
- B. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S) 2020.
- C. ANSI C80.6 - American National Standard for Electrical Intermediate Metal Conduit 2018.
- D. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- E. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT) 2013.
- F. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC) 2017.
- G. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable 2014.
- H. NEMA RN 1 - Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Metal Conduit and Intermediate Metal Conduit 2018.
- I. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit 2020.
- J. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing 2021.
- K. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- L. UL 1 - Flexible Metal Conduit Current Edition, Including All Revisions.
- M. UL 6 - Electrical Rigid Metal Conduit-Steel Current Edition, Including All Revisions.
- N. UL 360 - Liquid-Tight Flexible Metal Conduit Current Edition, Including All Revisions.
- O. UL 514B - Conduit, Tubing, and Cable Fittings Current Edition, Including All Revisions.
- P. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings Current Edition, Including All Revisions.
- Q. UL 797 - Electrical Metallic Tubing-Steel Current Edition, Including All Revisions.
- R. UL 1203 - Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations Current Edition, Including All Revisions.
- S. UL 1242 - Electrical Intermediate Metal Conduit-Steel Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate minimum sizes of conduits with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
2. Coordinate the arrangement of conduits with structural members, ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
3. Verify exact conduit termination locations required for boxes, enclosures, and equipment installed under other sections or by others.
4. Coordinate the work with other trades to provide roof penetrations that preserve the integrity of the roofing system and do not void the roof warranty.
5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:

1. Do not begin installation of conductors and cables until installation of conduit is complete between outlet, junction and splicing points.

1.6 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittals procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conduits and fittings.

C. Shop Drawings:

1. Indicate proposed arrangement for conduits to be installed within structural concrete slabs, where permitted.
2. Include proposed locations of roof penetrations and proposed methods for sealing.

D. Project Record Documents: Record actual routing for conduits installed underground, conduits embedded within concrete slabs, and conduits 2 inch (53 mm) trade size and larger.

1.7 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 CONDUIT APPLICATIONS

- A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70, product listing, and Connecticut School Construction Standards and Guidelines.
- B. Unless otherwise indicated and where not otherwise restricted, use the conduit types indicated for the specified applications. Where more than one listed application applies, comply with the most restrictive requirements. Where conduit type for a particular application is not specified, use galvanized steel rigid metal conduit.
- C. Underground:
 - 1. Under Slab on Grade: Use galvanized steel rigid metal conduit.
 - 2. Exterior, Direct-Buried: Use galvanized steel rigid metal conduit, intermediate metallic conduit (IMC), or PVC-coated galvanized steel rigid metal conduit.
 - 3. Exterior, Embedded Within 3" Concrete: Use galvanized steel rigid metal conduit, intermediate metallic conduit (IMC), PVC-coated galvanized steel rigid metal conduit, or rigid PVC conduit.
 - 4. Rigid polyvinyl (PVC) conduit is permitted only for underground portion of incoming utility service to the building, and must be encased in 3" concrete, and all elbows and risers to 6" above finished floor must be galvanized steel rigid metal conduit.
 - 5. Where steel conduit is installed in direct contact with earth, use corrosion protection tape to provide supplementary corrosion protection or use PVC-coated galvanized steel rigid metal conduit.
 - 6. Where steel conduit emerges from concrete into soil, use corrosion protection tape to provide supplementary corrosion protection for a minimum of 4 inches on either side of where conduit emerges or use PVC-coated galvanized steel rigid metal conduit.
- D. Embedded Within Concrete:
 - 1. Within Slab on Grade (within structural slabs only where approved by Structural Engineer): Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or PVC-coated galvanized steel rigid metal conduit.
 - 2. Within Slab Above Ground (within structural slabs only where approved by Structural Engineer): Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or PVC-coated galvanized steel rigid metal conduit.

3. Within Concrete Walls Above Ground: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or PVC-coated galvanized steel rigid metal conduit.
- E. Concealed Within Masonry Walls: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT).
- F. Concealed Within Hollow Stud Walls: Use electrical metallic tubing (EMT).
- G. Concealed Above Accessible Ceilings: Use electrical metallic tubing (EMT).
- H. Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit.
- I. Exposed, Interior, Not Subject to Physical Damage: Use electrical metallic tubing (EMT).
- J. Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit or intermediate metal conduit (IMC).
 1. Locations subject to physical damage include, but are not limited to:
 - a. Where exposed below 8 feet, except within electrical and communication rooms or closets.
- K. Exposed, Exterior: Use galvanized steel rigid metal conduit or intermediate metal conduit (IMC).
- L. Concealed, Exterior, Not Embedded in Concrete or in Contact With Earth: Use galvanized steel rigid metal conduit or intermediate metal conduit (IMC).
- M. Corrosive Locations Above Ground: Use PVC-coated galvanized steel rigid metal conduit or reinforced thermosetting resin conduit (RTRC).
- N. Connections to Luminaires Above Accessible Ceilings: Use flexible metal conduit.
 1. Maximum Length: 6 feet.
- O. Connections to Vibrating Equipment:
 1. Dry Locations: Use flexible metal conduit.
 2. Damp, Wet, or Corrosive Locations: Use liquidtight flexible metal conduit.
 3. Maximum Length: 6 feet unless otherwise indicated.
 4. Vibrating equipment includes, but is not limited to:
 - a. Transformers.
 - b. Motors.
- P. Fished in Existing Walls, Where Necessary: Use flexible metal conduit or [_____].

2.2 CONDUIT REQUIREMENTS

- A. Electrical Service Conduits: Also comply with Section 26 21 00.
- B. Communications Systems Conduits: Also comply with Section 27 10 00.
- C. Fittings for Grounding and Bonding: Also comply with Section 26 05 26.
- D. Provide all conduit, fittings, supports, and accessories required for a complete raceway system.
- E. Provide products listed, classified, and labeled as suitable for the purpose intended.
- F. Minimum Conduit Size, Unless Otherwise Indicated:
 - 1. Branch Circuits: 3/4 inch (21 mm) trade size.
 - 2. Branch Circuit Homeruns: 3/4 inch (21 mm) trade size.
 - 3. Control Circuits: 1/2 inch (16 mm) trade size.
 - 4. Flexible Connections to Luminaires: 1/2 inch (16 mm) trade size.
- G. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

2.3 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

- A. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.
- B. Fittings:
 - 1. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 2. Material: Use steel or malleable iron.
 - 3. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

2.4 INTERMEDIATE METAL CONDUIT (IMC)

- A. Description: NFPA 70, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.
- B. Fittings:
 - 1. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 2. Material: Use steel or malleable iron.

- a. Do not use die cast zinc fittings.
 3. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.
- 2.5 PVC-COATED GALVANIZED STEEL RIGID METAL CONDUIT (RMC)
- A. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit with external polyvinyl chloride (PVC) coating complying with NEMA RN 1 and listed and labeled as complying with UL 6.
 - B. Exterior Coating: Polyvinyl chloride (PVC), nominal thickness of 40 mil.
 - C. Interior Coating: Urethane, minimum thickness of 2 mil.
 - D. PVC-Coated Fittings:
 1. Manufacturer: Same as manufacturer of PVC-coated conduit to be installed.
 2. Non-Hazardous Locations: Use fittings listed and labeled as complying with UL 514B.
 3. Hazardous (Classified) Locations: Use fittings listed and labeled as complying with UL 1203 for the classification of the installed location.
 4. Material: Use steel or malleable iron.
 5. Exterior Coating: Polyvinyl chloride (PVC), minimum thickness of 40 mil.
 6. Interior Coating: Urethane, minimum thickness of 2 mil.
 - E. PVC-Coated Supports: Furnish with exterior coating of polyvinyl chloride (PVC), minimum thickness of 15 mil.
- 2.6 FLEXIBLE METAL CONDUIT (FMC)
- A. Description: NFPA 70, Type FMC standard wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems to be used.
 - B. Fittings:
 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 2. Material: Use steel or malleable iron.
 - a. Do not use die cast zinc fittings.
- 2.7 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)
- A. Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360.

B. Fittings:

1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Material: Use steel or malleable iron.
 - a. Do not use die cast zinc fittings.

2.8 ELECTRICAL METALLIC TUBING (EMT)

A. Manufacturers:

1. Allied Tube & Conduit, a division of Atkore International: www.alliedeg.com/#sle.
2. Nucor Tubular Products: www.nucortubular/#sle.
3. Western Tube, a division of Zekelman Industries: www.westerntube.com/#sle.
4. Wheatland Tube, a division of Zekelman Industries: www.wheatland.com/#sle.
5. Substitutions: See Section 01 60 00 - Product Requirements.

B. Description: NFPA 70, Type EMT steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.

C. Fittings:

1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Material: Use steel or malleable iron.
 - a. Do not use die cast zinc fittings.
3. Connectors and Couplings: Use compression (gland) or set-screw type.
 - a. Do not use indenter type connectors and couplings.
4. Damp or Wet Locations (where permitted): Use fittings listed for use in wet locations.
5. Embedded Within Concrete (where permitted): Use fittings listed as concrete-tight. Fittings that require taping to be concrete-tight are acceptable.

2.9 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

A. Description: NFPA 70, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 unless otherwise indicated, Schedule 80 where subject to physical damage; rated for use with conductors rated 90 degrees C; listed for concrete encasement.

B. Fittings:

1. Manufacturer: Same as manufacturer of conduit to be connected.
2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

2.10 ACCESSORIES

- A. Corrosion Protection Tape: PVC-based, minimum thickness of 20 mil.
- B. Conduit Joint Compound: Corrosion-resistant, electrically conductive; suitable for use with the conduit to be installed.
- C. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.
- D. Pull Strings: Use nylon cord with average breaking strength of not less than 200 pound-force.
- E. Sealing Compound for Sealing Fittings: Listed for use with the particular fittings to be installed.
- F. Modular Seals for Conduit Penetrations: Rated for minimum of 40 psig; Suitable for the conduits to be installed.
- G. Sealing Systems for Roof Penetrations: Premanufactured components and accessories as required to preserve integrity of roofing system and maintain roof warranty; suitable for conduits and roofing system to be installed; designed to accommodate existing penetrations where applicable.
- H. Flashing Panels for Exterior Wall Penetrations: Premanufactured components and accessories as required to preserve integrity of building envelope; suitable for conduits and facade materials to be installed.
- I. Firestop Sleeves: Listed; provide as required to preserve fire resistance rating of building elements.
 1. Products:
 - a. HoldRite, a brand of Reliance Worldwide Corporation; HydroFlame Pro Series/HydroFlame Custom Built: www.holdrite.com/#sle.
- J. Duct Bank Spacers: Nonmetallic; designed for maintaining conduit/duct spacing for concrete encasement in open trench installation; suitable for the conduit/duct arrangement to be installed.
 1. Products:
 - a. Advance Products & Systems, LLC; Duct Bank Spacers: www.apsonline.com/#sle.

- K. Bore Spacers: Nonmetallic; designed for maintaining conduit/duct spacing for installation within casing; furnished with roller wheels to facilitate installation, openings to facilitate grout flow, and holes for stabilization cable; suitable for the casing and conduit/duct arrangement to be installed.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive conduits.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install galvanized steel rigid metal conduit (RMC) in accordance with NECA 101.
- D. Install intermediate metal conduit (IMC) in accordance with NECA 101.
- E. Install PVC-coated galvanized steel rigid metal conduit (RMC) using only tools approved by the manufacturer.
- F. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.
- G. Conduit Routing:
 - 1. Unless dimensioned, conduit routing indicated is diagrammatic.
 - 2. When conduit destination is indicated without specific routing, determine exact routing required.
 - 3. Conceal all conduits unless specifically indicated to be exposed.
 - 4. Conduits in the following areas may be exposed, unless otherwise indicated:
 - a. Electrical rooms.
 - b. Mechanical equipment rooms.
 - 5. Unless otherwise approved, do not route conduits exposed:
 - a. Across floors.
 - b. Across top of parapet walls.
 - c. Across building exterior surfaces.

6. Conduits installed underground or embedded in concrete may be routed in the shortest possible manner unless otherwise indicated. Route all other conduits parallel or perpendicular to building structure and surfaces, following surface contours where practical.
7. Arrange conduit to maintain adequate headroom, clearances, and access.
8. Arrange conduit to provide no more than the equivalent of four 90 degree bends between pull points.
9. Arrange conduit to provide no more than 150 feet between pull points.
10. Route conduits above water and drain piping where possible.
11. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
12. Maintain minimum clearance of 6 inches between conduits and piping for other systems.
13. Maintain minimum clearance of 12 inches between conduits and hot surfaces. This includes, but is not limited to:
 - a. Heaters.
 - b. Hot water piping.
14. Group parallel conduits in the same area together on a common rack.

H. Conduit Support:

1. Secure and support conduits in accordance with NFPA 70 and Section 26 05 29 using suitable supports and methods approved by the authority having jurisdiction.
2. Provide required vibration isolation and/or seismic controls in accordance with Section 26 05 48.
3. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
4. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
5. Use conduit strap to support single surface-mounted conduit.
 - a. Use clamp back spacer with conduit strap for damp and wet locations to provide space between conduit and mounting surface.
6. Use metal channel (strut) with accessory conduit clamps to support multiple parallel surface-mounted conduits.
7. Use conduit clamp to support single conduit from beam clamp or threaded rod.

8. Use trapeze hangers assembled from threaded rods and metal channel (strut) with accessory conduit clamps to support multiple parallel suspended conduits.
9. Use non-penetrating rooftop supports to support conduits routed across rooftops (only where approved).
10. Use of spring steel conduit clips for support of conduits is not permitted.
11. Use of wire for support of conduits is not permitted.
12. Where conduit support intervals specified in NFPA 70 and NECA standards differ, comply with the most stringent requirements.

I. Connections and Terminations:

1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
3. Use suitable adapters where required to transition from one type of conduit to another.
4. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
5. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
6. Provide insulating bushings or insulated throats at all conduit terminations to protect conductors.
7. Secure joints and connections to provide maximum mechanical strength and electrical continuity.

J. Penetrations:

1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
2. Make penetrations perpendicular to surfaces unless otherwise indicated.
3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
4. Conceal bends for conduit risers emerging above ground.
5. Seal interior of conduits entering the building from underground at first accessible point to prevent entry of moisture and gases.

6. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
 7. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty. Include proposed locations of penetrations and methods for sealing with submittals.
 8. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- K. Embedment Within Structural Concrete Slabs (only where approved by Structural Engineer):
1. Secure conduits to prevent floating or movement during pouring of concrete.
- L. Concrete Encasement: Where conduits not otherwise embedded within concrete are indicated to be concrete-encased, provide concrete in accordance with Section 03 30 00 with minimum concrete cover of 3 inches on all sides unless otherwise indicated.
- M. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
 2. Where calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground to compensate for thermal expansion and contraction.
 3. Where conduits are subject to earth movement by settlement or frost.
- N. Condensation Prevention: Where conduits cross barriers between areas of potential substantial temperature differential, provide sealing fitting or approved sealing compound at an accessible point near the penetration to prevent condensation. This includes, but is not limited to:
1. Where conduits pass from outdoors into conditioned interior spaces.
 2. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.
- O. Provide pull string in all empty conduits and in conduits where conductors and cables are to be installed by others. Leave minimum slack of 12 inches at each end.
- P. Provide grounding and bonding in accordance with Section 26 05 26.
- Q. Identify conduits in accordance with Section 26 05 53.
- 3.3 FIELD QUALITY CONTROL
- A. See Section 01 40 00 - Quality Requirements, for additional requirements.

- B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- C. Where coating of PVC-coated galvanized steel rigid metal conduit (RMC) contains cuts or abrasions, repair in accordance with manufacturer's instructions.
- D. Correct deficiencies and replace damaged or defective conduits.

3.4 CLEANING

- A. Clean interior of conduits to remove moisture and foreign matter.

3.5 PROTECTION

- A. Immediately after installation of conduit, use suitable manufactured plugs to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

END OF SECTION 26 05 33.13

SECTION 26 05 33.16 - BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.
- B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.
- C. Boxes and enclosures for integrated power, data, and audio/video.
- D. Boxes for hazardous (classified) locations.
- E. Floor boxes.
- F. Underground boxes/enclosures.
- G. Accessories.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 03 30 00 - Cast-in-Place Concrete.
- B. Section 08 31 00 - Access Doors and Panels: Panels for maintaining access to concealed boxes.
- C. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- D. Section 26 05 33.13 - Conduit for Electrical Systems:
 - 1. Conduit bodies and other fittings.
 - 2. Additional requirements for locating boxes to limit conduit length and/or number of bends between pulling points.
- E. Section 26 05 33.23 - Surface Raceways for Electrical Systems:
- F. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
- G. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- H. Section 26 27 26 - Wiring Devices:
 - 1. Wall plates.

2. Floor box service fittings.

- I. Section 27 10 00 - Structured Cabling: Additional requirements for communications systems outlet boxes.

1.4 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NECA 130 - Standard for Installing and Maintaining Wiring Devices 2016.
- C. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable 2014.
- D. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports 2013 (Reaffirmed 2020).
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- F. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. SCTE 77 - Specification for Underground Enclosure Integrity 2017.
- H. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
- I. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
- J. UL 508A - Industrial Control Panels Current Edition, Including All Revisions.
- K. UL 514A - Metallic Outlet Boxes Current Edition, Including All Revisions.
- L. UL 1203 - Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.

4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
6. Coordinate the work with other trades to preserve insulation integrity.
7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
8. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for cabinets and enclosures, boxes for hazardous (classified) locations, floor boxes, and underground boxes/enclosures.
- C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- D. Project Record Documents: Record actual locations for outlet and device boxes, pull boxes, cabinets and enclosures, floor boxes, and underground boxes/enclosures.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. See Section 01 60 00 - Product Requirements, for additional provisions.
 2. Keys for Lockable Enclosures: Two of each different key.

1.7 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 BOXES

A. General Requirements:

1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
3. Provide products listed, classified, and labeled as suitable for the purpose intended.
4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
5. Provide grounding terminals within boxes where equipment grounding conductors terminate.

B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:

1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
2. Use cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
3. Use cast aluminum boxes where exposed galvanized steel rigid metal conduit or exposed intermediate metal conduit (IMC) is used.
4. Use suitable concrete type boxes where flush-mounted in concrete.
5. Use suitable masonry type boxes where flush-mounted in masonry walls.
6. Use raised covers suitable for the type of wall construction and device configuration where required.
7. Use shallow boxes where required by the type of wall construction.
8. Do not use "through-wall" boxes designed for access from both sides of wall.
9. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
10. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
11. Boxes for Supporting Luminaires and Ceiling Fans: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.

12. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes unless specifically indicated or permitted.
13. Minimum Box Size, Unless Otherwise Indicated:
 - a. Wiring Devices (Other Than Communications Systems Outlets): 4 inch square by 1-1/2 inch deep (100 by 38 mm) trade size.
 - b. Communications Systems Outlets: Comply with Section 27 10 00.
14. Wall Plates: Comply with Section 26 27 26.
- C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:
 1. Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
 2. NEMA 250 Environment Type, Unless Otherwise Indicated:
 - a. Indoor Clean, Dry Locations: Type 1, painted steel.
 - b. Outdoor Locations: Type 3R, painted steel.
 3. Junction and Pull Boxes Larger Than 100 cubic inches:
 - a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
 - b. Boxes 6 square feet and Larger: Provide sectionalized screw-cover or hinged-cover enclosures.
 4. Cabinets and Hinged-Cover Enclosures, Other Than Junction and Pull Boxes:
 - a. Provide lockable hinged covers, all locks keyed alike unless otherwise indicated.
 - b. Back Panels: Painted steel, removable.
 - c. Terminal Blocks: Provide voltage/current ratings and terminal quantity suitable for purpose indicated, with 25 percent spare terminal capacity.
 5. Finish for Painted Steel Enclosures: Manufacturer's standard grey unless otherwise indicated.
- D. Boxes and Enclosures for Integrated Power, Data, and Audio/Video: Size and configuration as indicated or as required with partitions to separate services; field-connected gangable boxes may be used.
- E. Boxes for Hazardous (Classified) Locations: Listed and labeled as complying with UL 1203 for the classification of the installed location.
- F. Floor Boxes:

1. Description: Floor boxes compatible with floor box service fittings provided in accordance with Section 26 05 33.16; with partitions to separate multiple services; furnished with all components, adapters, and trims required for complete installation.
2. Use cast iron floor boxes within slab on grade.
3. Use sheet-steel or cast iron floor boxes within slab above grade.
4. Metallic Floor Boxes: Fully adjustable (with integral means for leveling adjustment prior to and after concrete pour).
5. Manufacturer: Same as manufacturer of floor box service fittings.

G. Underground Boxes/Enclosures:

1. Description: In-ground, open bottom boxes furnished with flush, non-skid covers with legend indicating type of service and stainless steel tamper resistant cover bolts.
2. Size: As indicated on drawings.
3. Depth: As required to extend below frost line to prevent frost upheaval, but not less than 12 inches.
4. Provide logo on cover to indicate type of service.
5. Applications:
 - a. Sidewalks and Landscaped Areas Subject Only to Occasional Nondeliberate Vehicular Traffic: Use polymer concrete enclosures, with minimum SCTE 77 Tier 8 load rating.
 - b. Parking Lots, in Areas Subject Only To Occasional Nondeliberate Vehicular Traffic: Use polymer concrete enclosures, with minimum SCTE 77 Tier 15 load rating.
 - c. Do not use polymer concrete enclosures in areas subject to deliberate vehicular traffic.
6. Polymer Concrete Underground Boxes/Enclosures: Comply with SCTE 77.
 - a. Combination fiberglass/polymer concrete boxes/enclosures are acceptable.

2.2 ACCESSORIES

- A. Flashing Panels for Exterior Wall Penetrations: Premanufactured components and accessories as required to preserve integrity of building envelope; suitable for boxes and facade materials to be installed.
1. Manufacturers:
 - a. Quickflash Weatherproofing Products, Inc: www.quickflashproducts.com/#sle.

- b. Substitutions: See Section 01 60 00 - Product Requirements.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive boxes.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide separate boxes for emergency power and normal power systems.
- E. Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.
- F. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.
- G. Box Locations:
 - 1. Locate boxes to be accessible. Provide access panels in accordance with Section 08 31 00 as required where approved by the Architect.
 - 2. Unless dimensioned, box locations indicated are approximate.
 - 3. Locate boxes as required for devices installed under other sections or by others.
 - 4. Locate boxes so that wall plates do not span different building finishes.
 - 5. Locate boxes so that wall plates do not cross masonry joints.
 - 6. Unless otherwise indicated, where multiple outlet boxes are installed at the same location at different mounting heights, install along a common vertical center line.
 - 7. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.
 - 8. Acoustic-Rated Walls: Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches horizontal separation.

9. Fire Resistance Rated Walls: Install flush-mounted boxes such that the required fire resistance will not be reduced.
 - a. Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches separation where wall is constructed with individual noncommunicating stud cavities or protect both boxes with listed putty pads.
 - b. Do not install flush-mounted boxes with area larger than 16 square inches or such that the total aggregate area of openings exceeds 100 square inches for any 100 square feet of wall area.
 10. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points in accordance with Section 26 05 33.13.
 11. Locate junction and pull boxes in the following areas, unless otherwise indicated or approved by the Architect:
 - a. Concealed above accessible suspended ceilings.
 - b. Within joists in areas with no ceiling.
 - c. Electrical rooms.
 - d. Mechanical equipment rooms.
- H. Box Supports:
1. Secure and support boxes in accordance with NFPA 70 and Section 26 05 29 using suitable supports and methods approved by the authority having jurisdiction.
 2. Provide required seismic controls in accordance with Section 26 05 48.
 3. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.
 4. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.
 5. Use far-side support to secure flush-mounted boxes supported from single stud in hollow stud walls. Repair or replace supports for boxes that permit excessive movement.
- I. Install boxes plumb and level.
- J. Flush-Mounted Boxes:
1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more

than 1/4 inch or does not project beyond finished surface.

2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.
 3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.
- K. Floor-Mounted Cabinets: Mount on properly sized 3 inch high concrete pad constructed in accordance with Section 03 30 00.
- L. Install boxes as required to preserve insulation integrity.
- M. Metallic Floor Boxes: Install box level at the proper elevation to be flush with finished floor.
- N. Underground Boxes/Enclosures:
1. Install enclosure on gravel base, minimum 6 inches deep.
 2. Mount enclosures located in landscaped areas with top at 1 inch above finished grade.
 3. Provide cast-in-place concrete collar constructed in accordance with Section 03 30 00, minimum 10 inches wide by 12 inches deep, around enclosures that are not located in concrete areas.
 4. Install additional bracing inside enclosures in accordance with manufacturer's instructions to minimize box sidewall deflections during backfilling. Backfill with cover bolted in place.
- O. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- P. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- Q. Close unused box openings.
- R. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.
- S. Provide grounding and bonding in accordance with Section 26 05 26.
- T. Identify boxes in accordance with Section 26 05 53.
- 3.3 CLEANING
- A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

3.4 PROTECTION

- A. Immediately after installation, protect boxes from entry of moisture and foreign material until ready for installation of conductors.

END OF SECTION 26 05 33.16

SECTION 26 05 33.23 - SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Surface raceway systems.
- B. Wireways.
- C. Wall duct.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- B. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- C. Section 26 05 33.13 - Conduit for Electrical Systems.
- D. Section 26 05 33.16 - Boxes for Electrical Systems.
- E. Section 26 05 39 - Underfloor Raceways for Electrical Systems: Trench duct.
- F. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- G. Section 26 27 26 - Wiring Devices: Receptacles.

1.4 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- D. UL 5 - Surface Metal Raceways and Fittings Current Edition, Including All Revisions.
- E. UL 111 - Outline of Investigation for Multioutlet Assemblies Current Edition, Including All Revisions.
- F. UL 870 - Wireways, Auxiliary Gutters, and Associated Fittings Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate the placement of raceways with millwork, furniture, equipment, etc. installed under other sections or by others.
2. Coordinate rough-in locations of outlet boxes provided under Section 26 05 33.16 and conduit provided under Section 26 05 33.13 as required for installation of raceways provided under this section.
3. Verify minimum sizes of raceways with the actual conductors and components to be installed.
4. Wall Duct: Coordinate the work with other trades to provide walls suitable for installation of flush-mounted wall duct where indicated.
5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:

1. Do not install raceways until final surface finishes and painting are complete.
2. Do not begin installation of conductors and cables until installation of raceways is complete between outlet, junction and splicing points.

1.6 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets including dimensions, knockout sizes and locations, materials, fabrication details, finishes, service condition requirements, and accessories.

1. Surface Raceway Systems: Include information on fill capacities for conductors and cables.

C. Shop Drawings:

1. Pre-wired Surface Raceway Systems: Provide plan and elevation views including dimensioned locations of wiring devices and circuiting arrangements.
2. Wireways: Provide dimensioned plan and elevation views including adjacent equipment with all required clearances indicated.

D. Samples: Upon request, provide Three of each type and color of surface raceway system specified, 6 inches in length.

- E. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.7 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 RACEWAY REQUIREMENTS

- A. Provide all components, fittings, supports, and accessories required for a complete raceway system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Do not use raceways for applications other than as permitted by NFPA 70 and product listing.

2.2 SURFACE RACEWAY SYSTEMS

- A. Manufacturers:
 - 1. Hubbell Incorporated; [____]: www.hubbell.com/#sle.
 - 2. MonoSystems, Inc; [____]: www.monosystems.com/#sle.
 - 3. Wiremold, a brand of Legrand North America, Inc; [____]: www.legrand.us/#sle.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Surface Metal Raceways: Listed and labeled as complying with UL 5.
- C. Multioutlet Assemblies: Listed and labeled as complying with UL 111.
- D. Surface Raceway System:

1. Raceway Type: Single channel, painted steel.
2. Color: To be selected by Architect.
3. Accessory Device Boxes: Suitable for the devices to be installed; color to match raceway.
4. Integrated Device Provisions:
 - a. Receptacles:
 - 1) Comply with Section 26 27 26, except for finishes.
 - 2) Configuration: As indicated on the drawings.
 - 3) Color: Match raceway.
 - b. Communications Outlets:
 - 1) Voice and Data Jacks: As specified in Section 27 10 00.
 - 2) Configuration: As indicated on the drawings.

2.3 WIREWAYS

A. Manufacturers:

1. Cooper B-Line, a division of Cooper Industries; [____]:
www.cooperindustries.com/#sle.
2. Enduro Composites; [____]: www.endurocomposites.com/#sle.
3. Hoffman, a brand of Pentair Technical Products; [____]:
www.hoffmanonline.com/#sle.
4. Schneider Electric; Square D Products; [____]: www.schneider-electric.us/#sle.
5. Substitutions: See Section 01 60 00 - Product Requirements.

B. Description: Lay-in wireways and wiring troughs with removable covers; listed and labeled as complying with UL 870.

C. Wireway Type, Unless Otherwise Indicated:

1. Indoor Clean, Dry Locations: NEMA 250, Type 1, painted steel with screw-cover.
2. Outdoor Locations: NEMA 250, Type 3R, painted steel with screw-cover; include provision for padlocking.

D. Finish for Painted Steel Wireways: Manufacturer's standard grey unless otherwise indicated.

E. Minimum Wireway Size: 4 by 4 inches unless otherwise indicated.

- F. Where wireway size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

2.4 WALL DUCT

A. Manufacturers:

1. Dennis Filges Company, Inc; [____]: www.filgesco.com/#sle.
2. Hubbell Incorporated; [____]: www.hubbell.com/#sle.
3. Schneider Electric; Square D Products; [____]: www.schneider-electric.us/#sle.
4. Wiremold, a brand of Legrand North America, Inc; [____]: www.legrand.us/#sle.
5. Substitutions: See Section 01 60 00 - Product Requirements.
6. Source Limitations: Where the wall duct system includes connections to trench duct as specified in Section 26 05 39, furnish wall duct and associated components produced by the same manufacturer as the trench duct to be installed.

B. Material: Steel, unless otherwise indicated.

C. Mounting Provisions: Suitable for surface- or flush-mounting as indicated.

2.5 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Factory test each production unit for pre-wired surface raceway systems to verify proper wiring.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes and conduit terminations are installed in proper locations and are properly sized in accordance with NFPA 70 to accommodate raceways.
- C. Verify that mounting surfaces are ready to receive raceways and that final surface finishes are complete, including painting.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install raceways plumb and level.

- D. Arrange wireways and associated raceway connections to comply with NFPA 70, including but not limited to requirements for deflected conductors and wireways used as pullboxes. Increase size of wireway where necessary.
- E. Secure and support raceways in accordance with Section 26 05 29 at intervals complying with NFPA 70 and manufacturer's requirements.
- F. Close unused raceway openings.
- G. Provide grounding and bonding in accordance with Section 26 05 26.
- H. Identify raceways in accordance with Section 26 05 53.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect raceways for damage and defects.
- C. Surface Raceway Systems with Integrated Devices: Test each wiring device to verify operation and proper polarity.
- D. Correct wiring deficiencies and replace damaged or defective raceways.

3.4 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.5 PROTECTION

- A. Protect installed raceways from subsequent construction operations.

END OF SECTION 26 05 33.23

SECTION 26 05 36 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Metal cable tray systems:
 - 1. Metal ladder cable tray.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.
- B. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- C. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- D. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
- E. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.

1.4 REFERENCE STANDARDS

- A. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process 2020.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NEMA VE 1 - Metal Cable Tray Systems 2017.
- D. NEMA VE 2 - Cable Tray Installation Guidelines 2018.
- E. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the arrangement of cable tray with structural members, ductwork, piping, equipment and other potential conflicts installed under other sections or by others. Coordinate the work with other trades to avoid installation of obstructions within cable tray required clearances.

2. Coordinate arrangement of cable tray with the dimensions and clearance requirements of the actual products to be installed.
 3. Coordinate the work with placement of supports, anchors, etc. required for mounting.
 4. Notify of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Preinstallation Meeting: Convene one week prior to commencing work of this section; require attendance of all affected installers. Review proposed routing, sequence of installation, and protection requirements for installed cable tray.
- C. Sequencing:
1. Do not begin installation of cables until installation of associated cable tray run is complete.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for cable tray system components and accessories. Include dimensions, materials, fabrication details, finishes, and span/load ratings.
- C. Shop Drawings: Include dimensioned plan views and sections indicating proposed cable tray routing, required clearances, and locations and details of supports, fittings, building element penetrations, and equipment connections.
- D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Project Record Documents: Record actual routing of cable tray and locations of supports.

1.7 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions and NEMA VE 2, except do not store cable tray outdoors without cover as permitted in NEMA VE

2.

- B. Handle products carefully to avoid damage to finish.

PART 2 PRODUCTS

2.1 CABLE TRAY SYSTEM - GENERAL REQUIREMENTS

- A. Provide new cable tray system consisting of all required components, fittings, supports, accessories, etc. as necessary for a complete system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Do not use cable tray for applications other than as permitted by NFPA 70 and product listing/classification.
- D. Provide cable tray system and associated components suitable for use at indicated span/load ratings under the service conditions at the installed location.
- E. Unless otherwise indicated, specified span/load ratings are based on safety factor of 1.5 and working load only (no additional concentrated static load), with ratings for metal cable tray systems in accordance with NEMA VE 1.
- F. Unless otherwise indicated, specified load/fill depths and inside widths are nominal values, with values for metal cable tray systems in accordance with NEMA VE 1 including applicable allowable tolerances.

2.2 METAL CABLE TRAY SYSTEMS

- A. Comply with NEMA VE 1.
- B. Finishes:
 - 1. Mill-Galvanized Before Fabrication (Pre-Galvanized) Steel: Comply with ASTM A653/A653M, G90 coating.
- C. Metal Ladder Cable Tray:
 - 1. Material: Mill-galvanized before fabrication (pre-galvanized) steel.
 - 2. Load/Fill Depth: As indicated on drawings.
 - 3. Span/Load Rating: As indicated on drawings.
 - 4. Rung Spacing: 9 inches on center for straight lengths.
 - 5. Inside Width: As indicated on drawings.
 - 6. Inside Radius of Fittings: 12 inches.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that work likely to damage cable tray system has been completed.
- B. Verify that field measurements are as indicated.
- C. Verify that the dimensions and span/load ratings of cable tray system components are consistent with the indicated requirements.
- D. Verify that mounting surfaces are ready to receive cable tray and associated supports.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install cable tray in accordance with NECA 1 (general workmanship), and NEMA VE 2.
- C. Unless otherwise indicated, arrange cable tray to be parallel or perpendicular to building lines.
- D. Arrange cable tray to provide required clearances and maintain cable access.
- E. Install cable tray plumb and level, with sections aligned and with horizontal runs at the proper elevation.
- F. Cable Tray Movement Provisions:
 - 1. Provide suitable expansion fittings where cable tray is subject to movement, including but not limited to:
 - a. Where cable tray crosses structural joints intended for expansion.
 - b. Long straight cable tray runs in accordance with NEMA VE 2.
 - 2. Use expansion guides in lieu of hold-down clamps where prescribed in NEMA VE 2.
 - 3. Set gaps for expansion fittings in accordance with NEMA VE 2.
- G. Cable Provisions:
 - 1. Use suitable fixed barrier strips to maintain separation of cables as indicated and as required by NFPA 70.
 - 2. Use suitable drop-out fittings or bushings where cables exit cable tray as required to maintain minimum cable bending radius.
 - 3. Use suitable cable support fittings for long vertical cable tray runs with heavy cables.
- H. Provide end closures at unconnected ends of cable tray runs.

I. Cable Tray Support:

1. Use manufacturer's recommended hangers and supports, located in accordance with NEMA VE 2 and manufacturer's requirements, but not exceeding specified span unless otherwise approved by Engineer. Provide required support and attachment in accordance with Section 26 05 29, where not furnished by cable tray manufacturer.
2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.

J. Grounding and Bonding Requirements, in Addition to Requirements of Section 26 05 26:

1. Comply with grounding and bonding requirements of NEMA VE 2.
2. Metal Cable Tray Systems: Use suitable bonding jumpers or classified connectors to provide electrical continuity.
3. Provide suitable equipment grounding conductor in each cable tray, [_____]. Do not use metal cable tray system as sole equipment grounding conductor.
 - a. Equipment Grounding Conductor for Steel Cable Tray: Use bare or insulated copper conductor.
 - b. Minimum Equipment Grounding Conductor Size: 6 AWG copper.
 - c. Bond equipment grounding conductor to each cable tray section using suitable listed ground clamps. Separate bonding jumpers are not required where properly bonded equipment grounding conductor provides equivalent continuity.

K. Conduit Termination:

1. Use listed cable tray conduit clamps (evaluated for bonding connection) to terminate conduits at cable tray.
2. Provide insulating bushing at conduit termination to protect cables.
3. Provide independent support for conduit.

L. Cable Installation:

1. Comply with cable installation requirements of NEMA VE 2.
2. Use appropriate cable pulling tools, applied to prevent excessive force on cable tray system and maintain minimum cable bending radius.
3. Use cable clamps or cable ties to fasten conductors/cables to vertical and horizontal runs of cable tray.
 - a. Distance Between Fastening Points for Vertical Runs: 18 inches.

- b. Distance Between Fastening Points for Horizontal Runs: As required to maintain spacing and confine conductor/cable within the cable fill area.
 - M. Penetrations: Install firestopping to preserve fire resistance rating of building elements, using materials and methods specified in Section 07 84 00.
 - N. Identification Requirements, in Addition to Those Specified in Section 26 05 53.
 - 1. Use warning labels to identify cable tray containing service-entrance conductors with the word message "SERVICE-ENTRANCE CONDUCTORS" at maximum intervals of 10 feet.
 - 2. Use warning labels to identify electrical hazards for cable tray containing conductors operating at over 600 V nominal with the word message "DANGER; HIGH VOLTAGE; KEEP AWAY" at maximum intervals of 10 feet.
 - 3. Use warning labels to identify cable tray with the word message "WARNING! Do Not Use As A Walkway, Ladder, Or Support For Personnel. Use Only As A Mechanical Support For Cables, Tubing and Raceways." at maximum intervals of 20 feet.
 - 4. Use identification nameplates to identify cable tray containing welding cables with the word message "CABLE TRAY FOR WELDING CABLES ONLY" at maximum intervals of 20 feet.
 - O. Install cable tray covers where indicated.
- 3.3 FIELD QUALITY CONTROL
- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
 - B. Inspect cable tray system for damage and defects.
 - C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
 - D. Correct deficiencies and replace damaged or defective cable tray system components.
- 3.4 ADJUSTING
- A. Adjust tightness of mechanical connections to manufacturer's recommended torque settings.
- 3.5 CLEANING
- A. Remove dirt and debris from cable tray.
 - B. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.6 PROTECTION

- A. Protect cable tray system from subsequent construction operations.

END OF SECTION 26 05 36

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SECTION 26 05 48 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Vibration isolation requirements.
- B. Seismic control requirements.
 - 1. Includes requirements for seismic qualification of equipment not specified in this section.
- C. Vibration-isolated equipment support bases.
- D. Vibration isolators.
- E. External seismic snubber assemblies.
- F. Seismic restraint systems.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 01 45 33 - Code-Required Special Inspections and Procedures.
- B. Section 03 30 00 - Cast-in-Place Concrete.
- C. Section 26 05 29 - Hangers and Supports for Electrical Systems.

1.4 DEFINITIONS

- A. Electrical Component: Where referenced in this section in regards to seismic controls, applies to any portion of the electrical system subject to seismic evaluation in accordance with applicable codes, including distributed systems (e.g., conduit, cable tray).
- B. Seismic Restraint: Structural members or assemblies of members or manufactured elements specifically designed and applied for transmitting seismic forces between components and the seismic force-resisting system of the structure.

1.5 REFERENCE STANDARDS

- A. ASCE 19 - Structural Applications of Steel Cables for Buildings 2016.
- B. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications Most Recent Edition Cited by Referring Code or Reference Standard.

- C. ASTM E580/E580M - Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions 2020.
- D. FEMA 413 - Installing Seismic Restraints for Electrical Equipment 2004.
- E. FEMA E-74 - Reducing the Risks of Nonstructural Earthquake Damage 2012.
- F. ICC-ES AC156 - Acceptance Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components 2010, with Editorial Revision (2015).
- G. MFMA-4 - Metal Framing Standards Publication 2004.
- H. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- I. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- J. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems 2008.

1.6 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate selection and arrangement of vibration isolation and/or seismic control components with the actual equipment to be installed.
 - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
 - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
 - 4. Seismic Controls:
 - a. Coordinate the arrangement of seismic restraints with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
 - b. Coordinate the work with other trades to accommodate relative positioning of essential and nonessential components in consideration of seismic interaction.
 - 5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 30 00.

1.7 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

- B. Design Documents: Prepare and submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, details, and calculations.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.
 - 1. Vibration Isolators: Include rated load capacities and deflections; include information on color coding or other identification methods for spring element load capacities.
 - 2. Seismic Controls: Include seismic load capacities.
- D. Shop Drawings - Vibration Isolation Systems:
 - 1. Include dimensioned plan views and sections indicating proposed arrangement of vibration isolators; indicate equipment weights and static deflections.
 - 2. Vibration-Isolated Equipment Support Bases: Include base weights, including concrete fill where applicable; indicate equipment mounting provisions.
- E. Shop Drawings - Seismic Controls:
 - 1. Include dimensioned plan views and sections indicating proposed electrical component locations and distributed system routing, with locations and details of gravity supports and seismic restraints and associated attachments.
 - 2. Identify mounting conditions required for equipment seismic qualification.
 - 3. Identify anchor manufacturer, type, minimum embedment, minimum spacing, minimum member thickness, and minimum edge distance requirements.
 - 4. Indicate proposed arrangement of distributed system trapeze support groupings.
 - 5. Indicate proposed locations for distributed system flexible fittings and/or connections.
 - 6. Indicate locations of seismic separations where applicable.
- F. Seismic Design Data:
 - 1. Compile information on project-specific characteristics of actual installed electrical components necessary for determining seismic design forces required to design appropriate seismic controls, including but not limited to the following.
 - 2. Include structural calculations, stamped or sealed by seismic controls designer, demonstrating suitability of seismic controls for seismic design forces.
- G. Certification for seismically qualified equipment; identify basis for certification.
- H. Evaluation Reports: For products specified as requiring evaluation and recognition by a qualified evaluation service, provide current evaluation reports.

- I. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- J. Evidence of qualifications for seismic controls designer.
- K. Evidence of qualifications for manufacturer.
- L. Manufacturer's detailed field testing and inspection procedures.
- M. Field quality control test reports.

1.8 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Comply with applicable building code.
- C. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- D. Seismic Controls Designer Qualifications: Registered professional engineer licensed in the State in which the Project is located and with minimum five years experience designing seismic restraints for nonstructural components.
 - 1. Designer may be employed by the manufacturer of the seismic restraint products.
- E. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 VIBRATION ISOLATION REQUIREMENTS

- A. Design and provide vibration isolation systems to reduce vibration transmission to supporting structure from vibration-producing electrical equipment and/or electrical connections to vibration-isolated equipment.
- B. Comply with applicable general recommendations of ASHRAE (HVACA), where not in conflict with other specified requirements:
- C. General Requirements:
 - 1. Select vibration isolators to provide required static deflection.
 - 2. Select vibration isolators for uniform deflection based on distributed operating weight of actual installed equipment.

3. Select seismic type vibration isolators to comply with seismic design requirements, including conditions of equipment seismic certification where applicable.
4. Select vibration isolators for outdoor equipment to comply with wind design requirements.
5. Select vibration-isolated equipment support bases and associated vibration isolators to provide minimum 2-inch operating clearance beneath base unless otherwise indicated.

D. Equipment Isolation:

1. Transformers:
 - a. Specified vibration isolators are in addition to any factory-installed internal core and coil assembly vibration isolators unless otherwise indicated.
 - b. Floor-Mounted Transformers, Seismic Applications: Use seismic type resilient material isolator mounts or seismic type restrained spring isolators.
 - c. Suspended Transformers, Seismic Applications: Use seismic type resilient material isolator hangers, seismic type spring isolator hangers, or seismic type combination resilient material/spring isolator hangers.
 - d. Wall-Mounted Transformers, Seismic Applications: Use seismic type resilient material isolator mounts.

E. Conduit Isolation:

1. Use flexible conduit or cable for electrical connections to vibration-isolated equipment, including equipment installed under other sections or by others.
 - a. Minimum Length: 3 feet unless otherwise indicated.
2. Vibration Isolators:
 - a. Provide vibration isolators for conduit supports:
 - 1) Located within 50 feet of connected vibration-isolated equipment where flexible connection to equipment is not possible.
 - 2) For conduits over 2 inch trade size located below or within 50 feet of noise-sensitive areas indicated.
 - b. Minimum Static Deflection:
 - 1) First Three Supports Closest to Isolated Equipment: Same as static deflection of equipment; maximum of 2 inch deflection required.
 - c. Suspended Conduits, Seismic Applications: Use seismic type resilient material isolator hangers, seismic type spring isolator hangers, or seismic type combination resilient material/spring isolator hangers.

- d. Use modular seal or approved resilient material where vibration-isolated conduits penetrate building elements (e.g., walls, floors) arranged to prevent vibration transmission to structure.

2.2 SEISMIC CONTROL REQUIREMENTS

- A. Design and provide electrical component restraints, supports, and attachments suitable for seismic loads determined in accordance with applicable codes, as well as gravity and operating loads and other structural design considerations of the installed location. Consider wind loads for outdoor electrical components.
- B. Seismic Design Criteria: Obtain from project Structural Engineer of Record.
- C. Component Importance Factor (Ip): Electrical components essential to life safety to be assigned a component importance factor (Ip) of 1.5 as indicated or as required. This includes but is not limited to:
 1. Electrical components required to function for life safety purposes after an earthquake.
 2. Electrical components that support or otherwise contain hazardous substances.
- D. Seismic Qualification of Equipment:
 1. Provide special certification for electrical equipment furnished under other sections and assigned a component importance factor (Ip) of 1.5, certifying that equipment will remain operable following a design level earthquake.
 2. Seismic qualification to be by shake table testing in accordance with recognized testing standard procedure, such as ICC-ES AC156, acceptable to authorities having jurisdiction.
 3. Notify Engineer and obtain direction where mounting restrictions required by conditions of seismic certification conflict with specified requirements.
 4. Seismically qualified equipment to be furnished with factory-installed labels referencing certificate of compliance and associated mounting restrictions.
- E. Seismic Restraints:
 1. Provide seismic restraints for electrical components except where exempt according to applicable codes and specified seismic design criteria, as approved by authorities having jurisdiction.
 2. Seismic Restraint Exemptions:
 - a. Raceway Exemptions, All Seismic Design Categories:
 - 1) Conduits less than 2-1/2 inch trade size.
 - 2) Trapeze supported raceways weighing less than 10 pounds per foot.

- 3) Hanger supported raceways where each hanger in the raceway run is 12 inches or less in length from the raceway support to the supporting structure; rod hangers, where used, to be equipped with swivels.
- b. Lighting Exemptions, All Seismic Design Categories:
 - 1) Suspended luminaires where attachments are designed to accommodate 1.4 times the operating weight acting in both the vertical and horizontal directions and connections to structure allow for 360 degree range of motion in the horizontal plane; arrange to prevent impact between luminaires and the structure or other nonstructural components.
 - 2) Lay-in luminaires weighing less than 56 pounds secured to ceiling grid and provided with safety wires in accordance with ASTM E580/E580M.
3. Comply with applicable general recommendations of the following, where not in conflict with applicable codes, seismic design criteria, or other specified requirements:
 - a. ASHRAE (HVACA).
 - b. FEMA 413.
 - c. FEMA E-74.
 - d. SMACNA (SRM).
4. Seismic restraint capacities to be verified by a Nationally Recognized Testing Laboratory (NRTL) or certified by an independent third-party registered professional engineer acceptable to authorities having jurisdiction.
5. Seismic Type Vibration Isolators:
 - a. Comply with seismic design requirements, including conditions of equipment seismic certification where applicable.
6. External Seismic Snubber Assemblies:
 - a. Provide quantity and arrangement of external seismic snubber assemblies as required to restrain equipment in all directions (both lateral and vertical).
 - b. Do not use external seismic snubber assemblies that restrain equipment only in one or more lateral directions (but not vertical) except where uplift forces are zero or are addressed by other restraints.
7. Seismic Restraint Systems:
 - a. Except where otherwise restricted, use of either cable or rigid restraints is permitted.
 - b. Use only cable restraints to restrain vibration-isolated electrical components, including distributed systems.

- c. Use only one restraint system type for a given electrical component or distributed system (e.g., conduit, cable tray) run; mixing of cable and rigid restraints on a given component/run is not permitted.
- d. Size restraint elements, including anchorage, to resist seismic loads as necessary to restrain electrical component in all lateral directions; consider bracket geometry in anchor load calculations.
- e. Use rod stiffener clips to attach bracing to hanger rods as required to prevent rod buckling from vertical (upward) compressive load introduced by cable or rigid restraints loaded in tension, in excess of downward tensile load due to supported electrical component weight.
- f. Select hanger rods and associated anchorage as required to accommodate vertical (downward) tensile load introduced by rigid restraints loaded in compression, in addition to downward tensile load due to supported electrical component weight.
- g. Clevis hangers may only be used for attachment of transverse restraints; do not use for attachment of longitudinal restraints.
- h. Where seismic restraints are attached to clevis hangers, provide clevis bolt reinforcement accessory to prevent clevis hanger deformation.
- i. Do not introduce lateral loads on open bar joist chords or the weak axis of beams, or loads in any direction at other than panel points unless approved by project Structural Engineer of Record.
- j. Manufacturer's certified seismic restraint design may be submitted as an alternative to project-specific design and documentation, subject to approval of authorities having jurisdiction.

F. Seismic Attachments:

- 1. Attachments to be bolted, welded, or otherwise positively fastened without consideration of frictional resistance produced by the effects of gravity.
- 2. Post-Installed Concrete and Masonry Anchors: Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) or qualified evaluation service acceptable to authorities having jurisdiction for compliance with applicable building code, and qualified for seismic applications; concrete anchors to be qualified for installation in both cracked and uncracked concrete.
- 3. Do not use power-actuated fasteners.
- 4. Do not use friction clips (devices that rely on mechanically applied friction to resist loads). Beam clamps may be used for supporting sustained loads where provided with restraining straps.

5. Comply with anchor minimum embedment, minimum spacing, minimum member thickness, and minimum edge distance requirements.
6. Concrete Housekeeping Pads:
 - a. Increase size of pad as required to comply with anchor requirements.
 - b. Provide pad reinforcement and doweling to ensure integrity of pad and connection and to provide adequate load path from pad to supporting structure.

G. Seismic Interactions:

1. Include provisions to prevent seismic impact between electrical components and other structural or nonstructural components.
2. Include provisions such that failure of a component, either essential or nonessential, does not cause the failure of an essential component.

H. Seismic Relative Displacement Provisions:

1. Use suitable fittings or flexible connections to accommodate:
 - a. Relative displacements at connections between components, including distributed systems (e.g., conduit, cable tray); do not exceed load limits for equipment utility connections.
 - b. Relative displacements between component supports attached to dissimilar parts of structure that may move differently during an earthquake.
 - c. Design displacements at seismic separations.
 - d. Anticipated drifts between floors.

2.3 VIBRATION-ISOLATED EQUIPMENT SUPPORT BASES

A. Vibration-Isolated Structural Steel Bases:

1. Description: Engineered structural steel frames with integral mounting provisions for vibration isolators, sized and configured for mounting of equipment.

B. Vibration-Isolated Concrete Inertia Bases:

1. Description: Concrete-filled engineered steel forms with integral mounting provisions for vibration isolators, sized and configured for mounting of equipment.
2. Minimum Base Depth: 6 inches.
3. Minimum Base Mass (Including Concrete): 1.5 times weight of supported equipment.
4. Concrete Reinforcement: Welded or tied reinforcing bars running both ways in a single layer.

5. Concrete: Filled on site with minimum 3000 psi concrete in accordance with Section 03 30 00.

2.4 VIBRATION ISOLATORS

A. General Requirements:

1. Resilient Materials for Vibration Isolators: Oil, ozone, and oxidant resistant.
2. Spring Elements for Spring Isolators:
 - a. Color code or otherwise identify springs to indicate load capacity.
 - b. Lateral Stability: Minimum lateral stiffness to vertical stiffness ratio of 0.8.
 - c. Designed to operate in the linear portion of their load versus deflection curve over deflection range of not less than 50 percent above specified deflection.
 - d. Designed to provide additional travel to solid of not less than 50 percent of rated deflection at rated load.
 - e. Selected to provide designed deflection of not less than 75 percent of specified deflection.
 - f. Selected to function without undue stress or overloading.
3. Seismic Snubbing Elements for Seismic Isolators:
 - a. Air Gap: Between 0.125 inches and 0.25 inches unless otherwise indicated.
 - b. Points of Contact: Cushioned with resilient material, minimum 0.25 inch thick; capable of being visually inspected for damage and replaced.

B. Vibration Isolators for Seismic Applications:

1. Resilient Material Isolator Mounts, Seismic:
 - a. Description: Mounting assemblies for bolting equipment to supporting structure utilizing elastomeric (e.g., neoprene, rubber) isolator material; specifically designed and rated for seismic applications with integral snubbing in all directions.
2. Restrained Spring Isolators, Seismic:
 - a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) in series with elastomeric (e.g., neoprene, rubber) isolator material within a metal housing designed to prevent movement of supported equipment above an adjustable vertical limit stop; specifically designed and rated for seismic applications with integral snubbing in all directions.
 - b. Bottom Load Plate: Steel with provisions for bolting to supporting structure as required.

- c. Furnished with integral leveling device for positioning and securing supported equipment.
 - d. Provides constant free and operating height.
- 3. Spring Isolator Hangers, Seismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing single or multiple free-standing, laterally stable steel spring(s) in series with an elastomeric element for the lower hanger rod connection; specifically designed and rated for seismic applications with vertical limit stop to prevent upward travel of hanger rod and cushion impact.
 - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short-circuiting of isolation.
- 4. Combination Resilient Material/Spring Isolator Hangers, Seismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing single or multiple free-standing, laterally stable steel spring(s) for the lower hanger rod connection and elastomeric (e.g., neoprene, rubber) isolator material for the upper hanger rod connection; specifically designed and rated for seismic applications with vertical limit stop to prevent upward travel of hanger rod and cushion impact.
 - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short-circuiting of isolation.

2.5 EXTERNAL SEISMIC SNUBBER ASSEMBLIES

- A. Description: Steel snubbing assemblies designed for external attachment to both equipment and supporting structure that, as part of a complete system, restrain equipment motion in all directions during a seismic event while maintaining vibration isolation during normal operation.
- B. Seismic Snubbing Elements:
 - 1. Air Gap: Between 0.125 inches and 0.25 inches unless otherwise indicated.
 - 2. Points of Contact: Cushioned with resilient material, minimum 0.25 inch thick; capable of being visually inspected for damage and replaced.

2.6 SEISMIC RESTRAINT SYSTEMS

- A. Description: System components and accessories specifically designed for field assembly and attachment of seismic restraints.
- B. Cable Restraints:
 - 1. Comply with ASCE 19.

2. Cables: Pre-stretched, galvanized steel wire rope with certified break strength.
 3. Cable Connections: Use only swaged end fittings. Cable clips and wedge type end fittings are not permitted in accordance with ASCE 19.
 4. Use protective thimbles for cable loops where potential for cable damage exists.
- C. Rigid Restraints: Use MFMA-4 steel channel (strut), steel angle, or steel pipe for structural element; suitable for both compressive and tensile design loads.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that mounting surfaces are ready to receive vibration isolation and/or seismic control components and associated attachments.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 CODE-REQUIRED SPECIAL INSPECTIONS

- A. Arrange work to accommodate tests and/or inspections performed by Special Inspection Agency employed by Owner or Engineer in accordance with Section 01 45 33 and statement of special inspections as required by applicable building code.
- B. Frequency of Special Inspections: Where special inspections are designated as continuous or periodic, arrange work accordingly.
 1. Continuous Special Inspections: Special Inspection Agency to be present in the area where the work is being performed and observe the work at all times the work is in progress.
 2. Periodic Special Inspections: Special Inspection Agency to be present in the area where work is being performed and observe the work part-time or intermittently and at the completion of the work.
- C. Seismic special inspections include, but are not limited to:
 1. Seismically Qualified Equipment: Verification that label, anchorage, and mounting comply with certificate of compliance.
 2. Anchorage of electric equipment for emergency and standby power systems for Seismic Design Categories C, D, E, and F; periodic inspection.
 3. Anchorage of electrical equipment other than for emergency and standby power systems for Seismic Design Categories E and F; periodic inspection.

4. Installation and anchorage of vibration isolation systems for Seismic Design Categories C, D, E, and F where Contract Documents require a nominal clearance of 1/4 inch or less between equipment support frame and seismic restraint; periodic inspection.

- D. Prior to starting work, Contractor to submit written statement of responsibility to authorities having jurisdiction and to Owner acknowledging awareness of special requirements contained in the statement of special inspections.
- E. Special Inspection Agency services do not relieve Contractor from performing inspections and testing specified elsewhere.

3.3 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install products in accordance with applicable requirements of NECA 1 (general workmanship).
- C. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- D. Secure fasteners according to manufacturer's recommended torque settings.
- E. Install flexible conduit and cable connections to provide sufficient slack for vibration isolation and/or seismic relative displacements as indicated or as required.
- F. Vibration Isolation Systems:
 1. Vibration-Isolated Equipment Support Bases:
 - a. Provide specified minimum clearance beneath base.
 2. Spring Isolators:
 - a. Position equipment at operating height; provide temporary blocking as required.
 - b. Lift equipment free of isolators prior to lateral repositioning to avoid damage to isolators.
 - c. Level equipment by adjusting isolators gradually in sequence to raise equipment uniformly such that excessive weight or stress is not placed on any single isolator.
 3. Isolator Hangers:
 - a. Use precompressed isolator hangers where required to facilitate installation and prevent damage to equipment utility connection provisions.
 - b. Locate isolator hangers at top of hanger rods in accordance with manufacturer's instructions.
 4. Clean debris from beneath vibration-isolated equipment that could cause short-circuiting of isolation.

5. Use elastomeric grommets for attachments where required to prevent short-circuiting of isolation.
6. Adjust isolators to be free of isolation short circuits during normal operation.
7. Do not overtighten fasteners such that resilient material isolator pads are compressed beyond manufacturer's maximum recommended deflection.

G. Seismic Controls:

1. Provide specified snubbing element air gap; remove any factory-installed spacers, debris or other obstructions.
2. Use only specified components, anchorage, and hardware evaluated by seismic design. Comply with conditions of seismic certification where applicable.
3. Where mounting hole diameter exceeds bolt diameter by more than 0.125 inch, use epoxy grout, elastomeric grommet, or welded washer to reduce clearance to 0.125 inch or less.
4. Equipment with Sheet Metal Housings:
 - a. Use Belleville washers to distribute stress over a larger surface area of the sheet metal connection interface as approved by manufacturer.
 - b. Attach additional steel as approved by manufacturer where required to transfer loads to structure.
 - c. Where mounting surface is irregular, do not shim housing; reinforce housing with additional steel as approved by manufacturer.
5. Concrete Housekeeping Pads:
 - a. Size in accordance with seismic design to meet anchor requirements.
 - b. Install pad reinforcement and doweling in accordance with seismic design to ensure integrity of pad and associated connection to slab.
6. Seismic Restraint Systems:
 - a. Do not attach seismic restraints and gravity supports to dissimilar parts of structure that may move differently during an earthquake.
 - b. Install restraints within permissible angles in accordance with seismic design.
 - c. Install cable restraints straight between component/run and structural attachment; do not bend around other nonstructural components or structural elements.
 - d. Install cable restraints for vibration-isolated components slightly slack to prevent short-circuiting of isolation.

- e. Install hanger rod stiffeners where indicated using only specified clamps; do not weld stiffeners to hanger rod.

3.4 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect vibration isolation and/or seismic control components for damage and defects.
- C. Vibration Isolation Systems:
 - 1. Verify isolator static deflections.
 - 2. Verify required clearance beneath vibration-isolated equipment support bases.
 - 3. Verify vibration isolation performance during normal operation; investigate sources of isolation short circuits.
- D. Seismic Controls:
 - 1. Verify snubbing element air gaps.
- E. Correct deficiencies and replace damaged or defective vibration isolation and/or seismic control components.
- F. Submit detailed reports indicating inspection and testing results and corrective actions taken.

END OF SECTION 26 05 48

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SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Electrical identification requirements.
- B. Identification nameplates and labels.
- C. Wire and cable markers.
- D. Voltage markers.
- E. Underground warning tape.
- F. Floor marking tape.
- G. Warning signs and labels.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 09 91 13 - Exterior Painting.
- B. Section 09 91 23 - Interior Painting.
- C. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables: Color coding for power conductors and cables 600 V and less; vinyl color coding electrical tape.
- D. Section 26 05 36 - Cable Trays for Electrical Systems: Additional identification requirements for cable tray systems.
- E. Section 26 05 73 - Power System Studies: Arc flash hazard warning labels.
- F. Section 26 27 26 - Wiring Devices - Lutron: Device and wallplate finishes; factory pre-marked wallplates.
- G. Section 27 10 00 - Structured Cabling: Identification for communications cabling and devices.

1.4 REFERENCE STANDARDS

- A. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- B. UL 969 - Marking and Labeling Systems Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Verify final designations for equipment, systems, and components to be identified prior to fabrication of identification products.

B. Sequencing:

1. Do not conceal items to be identified, in locations such as above suspended ceilings, until identification products have been installed.
2. Do not install identification products until final surface finishes and painting are complete.

1.6 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittals procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.

C. Shop Drawings: Provide schedule of items to be identified indicating proposed designations, materials, legends, and formats.

D. Samples:

1. Identification Nameplates: One of each type and color specified.
2. Warning Signs and Labels: One of each type and legend specified.

E. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation and installation of product.

1.7 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

1.8 FIELD CONDITIONS

A. Do not install adhesive products when ambient temperature is lower than recommended by manufacturer.

PART 2 PRODUCTS

2.1 IDENTIFICATION REQUIREMENTS

A. Existing Work: Unless specifically excluded, identify existing elements to remain that are not already identified in accordance with specified requirements.

B. Identification for Equipment:

1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.
 - a. Switchboards:
 - 1) Identify ampere rating.
 - 2) Identify voltage and phase.
 - 3) Identify power source and circuit number. Include location when not within sight of equipment.
 - 4) Use identification nameplate to identify main overcurrent protective device.
 - 5) Use identification nameplate to identify load(s) served for each branch device. Do not identify spares and spaces.
 - b. Panelboards:
 - 1) Identify ampere rating.
 - 2) Identify voltage and phase.
 - 3) Identify power source and circuit number. Include location when not within sight of equipment.
 - 4) Identify main overcurrent protective device. Use identification label for panelboards with a door. For power distribution panelboards without a door, use identification nameplate.
 - 5) Use typewritten circuit directory to identify load(s) served for panelboards with a door. Identify spares and spaces.
 - 6) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device. Identify spares and spaces.
 - c. Transformers:
 - 1) Identify kVA rating.
 - 2) Identify voltage and phase for primary and secondary.
 - 3) Identify power source and circuit number. Include location when not within sight of equipment.
 - 4) Identify load(s) served. Include location.
 - d. Enclosed switches, circuit breakers, and motor controllers:
 - 1) Identify voltage and phase.

- 2) Identify power source and circuit number. Include location when not within sight of equipment.
- 3) Identify load(s) served. Include location when not within sight of equipment.
- e. Time Switches:
 - 1) Identify load(s) served and associated circuits controlled. Include location.
- f. Enclosed Contactors:
 - 1) Identify ampere rating.
 - 2) Identify voltage and phase.
 - 3) Identify configuration, e.g., E.O.E.H. (electrically operated, electrically held) or E.O.M.H. (electrically operated, mechanically held).
 - 4) Identify coil voltage.
 - 5) Identify load(s) and associated circuits controlled. Include location.
- g. Centralized Emergency Lighting Inverters:
 - 1) Identify input and output voltage and phase.
 - 2) Identify power source and circuit number for normal power source. Include location when not within sight of equipment.
 - 3) Identify load(s) served. Include location.
- h. Transfer Switches:
 - 1) Identify voltage and phase.
 - 2) Identify power source and circuit number for both normal power source and standby power source. Include location when not within sight of equipment.
 - 3) Identify load(s) served. Include location when not within sight of equipment.
 - 4) Identify short circuit current rating based on the specific overcurrent protective device type and settings protecting the transfer switch.
- i. Electricity Meters:
 - 1) Identify load(s) metered.
2. Service Equipment:
 - a. Use identification nameplate to identify each service disconnecting means.

- b. For buildings or structures supplied by more than one service, or any combination of branch circuits, feeders, and services, use identification nameplate or means of identification acceptable to authority having jurisdiction at each service disconnecting means to identify all other services, feeders, and branch circuits supplying that building or structure. Verify format and descriptions with authority having jurisdiction.
3. Use voltage marker to identify highest voltage present for each piece of electrical equipment.
4. Use identification nameplate to identify disconnect location for equipment with remote disconnecting means.
5. Use identification label or identification nameplate on inside of door at each fused switch to identify required NEMA fuse class and size.
6. Use identification label or identification nameplate on inside of door at each motor controller to identify nameplate horsepower, full load amperes, code letter, service factor, voltage, and phase of motor(s) controlled.
7. Use identification label or identification nameplate to identify overcurrent protective devices for branch circuits serving fire alarm circuits. Identify with text "FIRE ALARM CIRCUIT".
8. Use field-painted floor markings, floor marking tape, or warning labels to identify required equipment working clearances where indicated or where required by the authority having jurisdiction.
 - a. Field-Painted Floor Markings: Alternating black and white stripes, 3 inches wide, painted in accordance with Section 09 91 23 and 09 91 13.
9. Available Fault Current Documentation: Use identification label to identify the available fault current and date calculations were performed at locations requiring documentation by NFPA 70 including but not limited to the following.
 - a. Service equipment.
 - b. Industrial control panels.
 - c. Elevator control panels.
10. Arc Flash Hazard Warning Labels: Comply with Section 26 05 73.
11. Use warning labels, identification nameplates, or identification labels to identify electrical hazards for equipment where multiple power sources are present with the word message "DANGER; Hazardous voltage; Multiple power sources may be present; Disconnect all electric power including remote disconnects before servicing" or approved equivalent.

C. Identification for Conductors and Cables:

1. Color Coding for Power Conductors 600 V and Less: Comply with Section 26 05 19.
2. Identification for Communications Conductors and Cables: Comply with Section 27 10 00.
3. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment.
4. Use wire and cable markers to identify circuit number or other designation indicated for power, control, and instrumentation conductors and cables at the following locations:
 - a. At each source and load connection.
 - b. Within boxes when more than one circuit is present.
 - c. Within equipment enclosures when conductors and cables enter or leave the enclosure.
 - d. In cable tray, at maximum intervals of 20 feet.
5. Use wire and cable markers to identify connected grounding electrode system components for grounding electrode conductors.

D. Identification for Raceways:

1. Use voltage markers to identify highest voltage present for accessible conduits at maximum intervals of 20 feet.
2. Use voltage markers or color-coded bands to identify systems other than normal power system for accessible conduits at maximum intervals of 20 feet.
 - a. Color-Coded Bands: Use field-painting or vinyl color coding electrical tape to mark bands 3 inches wide.
 - 1) Color Code:
 - (a) Emergency Power System: Red.
 - (b) Fire Alarm System: Red.
 - 2) Field-Painting: Comply with Section 09 91 23 and 09 91 13.
 - 3) Vinyl Color Coding Electrical Tape: Comply with Section 26 05 19.
3. Use identification labels or plastic marker tags to identify circuits enclosed for accessible conduits at wall penetrations, at floor penetrations, at roof penetrations, and at equipment terminations when source is not within sight.
4. Use identification labels, handwritten text using indelible marker, or plastic marker tags to identify spare conduits at each end. Identify purpose and termination location.

5. Use underground warning tape to identify underground raceways.
 6. Use voltage markers to identify highest voltage present for wireways at maximum intervals of 20 feet.
 - E. Identification for Cable Tray: Comply with Section 26 05 36.
 - F. Identification for Boxes:
 1. Use voltage markers to identify highest voltage present.
 2. Use voltage markers or color coded boxes to identify systems other than normal power system.
 - a. Color-Coded Boxes: Field-painted in accordance with Section 09 91 23 and 09 91 13 per the same color code used for raceways.
 - b. For exposed boxes in public areas, do not color code.
 3. Use identification labels to identify circuits enclosed.
 - G. Identification for Devices:
 1. Identification for Communications Devices: Comply with Section 27 10 00.
 2. Wiring Device and Wallplate Finishes: Comply with Section 26 27 26.
 3. Factory Pre-Marked Wallplates: Comply with Section 26 27 26.
 4. Use identification label to identify fire alarm system devices.
 - a. For devices concealed above suspended ceilings, provide additional identification on ceiling tile below device location.
 5. Use engraved wallplate to identify serving branch circuit for all receptacles.
 6. Use identification label or engraved wallplate to identify load controlled for wall-mounted control devices controlling loads that are not visible from the control location and for multiple wall-mounted control devices installed at one location.
 7. Use identification label to identify receptacles protected by upstream GFI protection, where permitted.
 - H. Identification for Luminaires:
 1. Use permanent red dot on luminaire frame to identify luminaires connected to emergency power system.
- 2.2 IDENTIFICATION NAMEPLATES AND LABELS
- A. Identification Nameplates:

1. Materials:
 - a. Indoor Clean, Dry Locations: Use plastic nameplates.
 - b. Outdoor Locations: Use plastic, stainless steel, or aluminum nameplates suitable for exterior use.
 2. Plastic Nameplates: Two-layer or three-layer laminated acrylic or electrically non-conductive phenolic with beveled edges; minimum thickness of 1/16 inch; engraved text.
 - a. Exception: Provide minimum thickness of 1/8 inch when any dimension is greater than 4 inches.
 3. Stainless Steel Nameplates: Minimum thickness of 1/32 inch; engraved text.
 4. Aluminum Nameplates: Anodized; minimum thickness of 1/32 inch; engraved text.
 5. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch high; Four, located at corners for larger sizes.
- B. Identification Labels:
1. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
 2. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.
- C. Format for Equipment Identification:
1. Minimum Size: 1 inch by 2.5 inches.
 2. Legend:
 - a. Equipment designation or other approved description.
 - b. Other information as indicated.
 3. Text: All capitalized unless otherwise indicated.
 4. Minimum Text Height:
 - a. System Designation: 1 inch.
 - b. Equipment Designation: 1/2 inch.
 - c. Other Information: 1/4 inch.
 - d. Exception: Provide minimum text height of 1 inch for equipment located more than 10 feet above floor or working platform.

5. Color:
 - a. Normal Power System: White text on black background.
 - b. Emergency Power System: White text on red background.
 - c. Fire Alarm System: White text on red background.
- D. Format for General Information and Operating Instructions:
 1. Minimum Size: 1 inch by 2.5 inches.
 2. Legend: Include information or instructions indicated or as required for proper and safe operation and maintenance.
 3. Text: All capitalized unless otherwise indicated.
 4. Minimum Text Height: 1/4 inch.
 5. Color: Black text on white background unless otherwise indicated.
 - a. Exceptions:
 - 1) Provide white text on red background for general information or operational instructions for emergency systems.
 - 2) Provide white text on red background for general information or operational instructions for fire alarm systems.
- E. Format for Caution and Warning Messages:
 1. Minimum Size: 2 inches by 4 inches.
 2. Legend: Include information or instructions indicated or as required for proper and safe operation and maintenance.
 3. Text: All capitalized unless otherwise indicated.
 4. Minimum Text Height: 1/2 inch.
 5. Color: Black text on yellow background unless otherwise indicated.
- F. Format for Receptacle Identification:
 1. Minimum Size: 3/8 inch by 1.5 inches.
 2. Legend: Power source and circuit number or other designation indicated.
 - a. Include voltage and phase for other than 120 V, single phase circuits.
 3. Text: All capitalized unless otherwise indicated.

4. Minimum Text Height: 3/16 inch.
5. Color: Black text on clear background.

G. Format for Control Device Identification:

1. Minimum Size: 3/8 inch by 1.5 inches.
2. Legend: Load controlled or other designation indicated.
3. Text: All capitalized unless otherwise indicated.
4. Minimum Text Height: 3/16 inch.
5. Color: Black text on clear background.

H. Format for Fire Alarm Device Identification:

1. Minimum Size: 3/8 inch by 1.5 inches.
2. Legend: Designation indicated and device zone or address.
3. Text: All capitalized unless otherwise indicated.
4. Minimum Text Height: 3/16 inch.
5. Color: Red text on white background.

2.3 WIRE AND CABLE MARKERS

- A. Markers for Conductors and Cables: Use wrap-around self-adhesive vinyl cloth, wrap-around self-adhesive vinyl self-laminating, heat-shrink sleeve, plastic sleeve, plastic clip-on, or vinyl split sleeve type markers suitable for the conductor or cable to be identified.
- B. Markers for Conductor and Cable Bundles: Use plastic marker tags secured by nylon cable ties.
- C. Legend: Power source and circuit number or other designation indicated.
- D. Text: Use factory pre-printed or machine-printed text, all capitalized unless otherwise indicated.
 1. Do not use handwritten text.
- E. Minimum Text Height: 1/8 inch.
- F. Color: Black text on white background unless otherwise indicated.

2.4 VOLTAGE MARKERS

- A. Markers for Conduits: Use factory pre-printed self-adhesive vinyl, self-adhesive vinyl cloth, or vinyl snap-around type markers.

- B. Markers for Boxes and Equipment Enclosures: Use factory pre-printed self-adhesive vinyl or self-adhesive vinyl cloth type markers.
- C. Minimum Size:
 - 1. Markers for Equipment: 1 1/8 by 4 1/2 inches.
 - 2. Markers for Conduits: As recommended by manufacturer for conduit size to be identified.
 - 3. Markers for Pull Boxes: 1 1/8 by 4 1/2 inches.
 - 4. Markers for Junction Boxes: 1/2 by 2 1/4 inches.
- D. Legend:
 - 1. Markers for Voltage Identification: Highest voltage present.
 - 2. Markers for System Identification:
- E. Color: Black text on orange background unless otherwise indicated.

2.5 UNDERGROUND WARNING TAPE

- A. Materials: Use non-detectable type polyethylene tape suitable for direct burial, unless otherwise indicated.
 - 1. Exception: Use foil-backed detectable type tape where required by serving utility or where directed by Owner.
- B. Non-detectable Type Tape: 6 inches wide, with minimum thickness of 4 mil.
- C. Foil-backed Detectable Type Tape: 3 inches wide, with minimum thickness of 5 mil, unless otherwise required for proper detection.
- D. Legend: Type of service, continuously repeated over full length of tape.
- E. Color:

2.6 FLOOR MARKING TAPE

- A. Floor Marking Tape for Equipment Working Clearance Identification: Self-adhesive vinyl or polyester tape with overlamine, 3 inches wide, with alternating black and white stripes.

2.7 WARNING SIGNS AND LABELS

- A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.
- B. Warning Signs:
 - 1. Materials:

- a. Indoor Dry, Clean Locations: Use factory pre-printed rigid plastic or self-adhesive vinyl signs.
 - b. Outdoor Locations: Use factory pre-printed rigid aluminum signs.
2. Rigid Signs: Provide four mounting holes at corners for mechanical fasteners.
3. Minimum Size: 7 by 10 inches unless otherwise indicated.
- C. Warning Labels:
 1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
 - a. Do not use labels designed to be completed using handwritten text.
 2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
 3. Minimum Size: 2 by 4 inches unless otherwise indicated.

PART 3 EXECUTION

3.1 PREPARATION

- A. Clean surfaces to receive adhesive products according to manufacturer's instructions.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
 1. Surface-Mounted Equipment: Enclosure front.
 2. Flush-Mounted Equipment: Inside of equipment door.
 3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
 4. Elevated Equipment: Legible from the floor or working platform.
 5. Branch Devices: Adjacent to device.
 6. Interior Components: Legible from the point of access.
 7. Conduits: Legible from the floor.
 8. Boxes: Outside face of cover.

9. Conductors and Cables: Legible from the point of access.

10. Devices: Outside face of cover.

C. Install identification products centered, level, and parallel with lines of item being identified.

D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws and to interior surfaces using self-adhesive backing or epoxy cement.

E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.

F. Install underground warning tape above buried lines with one tape per trench at 3 inches below finished grade.

G. Secure rigid signs using stainless steel screws.

H. Mark all handwritten text, where permitted, to be neat and legible.

3.3 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

END OF SECTION 26 05 53

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SECTION 26 05 73 - POWER SYSTEM STUDIES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Short-circuit study.
- B. Protective device coordination study.
- C. Arc flash and shock risk assessment.
 - 1. Includes arc flash hazard warning labels.
- D. Criteria for the selection and adjustment of equipment and associated protective devices not specified in this section, as determined by studies to be performed.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 05 53 - Identification for Electrical Systems: Additional requirements for arc flash hazard warning labels.
- B. Section 26 21 00 - Low-Voltage Electrical Service Entrance.
- C. Section 26 24 13 - Switchboards.
- D. Section 26 24 16 - Panelboards.
- E. Section 26 28 13 - Fuses.
- F. Section 26 28 16.13 - Enclosed Circuit Breakers.
- G. Section 26 28 16.16 - Enclosed Switches.
- H. Section 26 29 13 - Enclosed Controllers.
- I. Section 26 33 23 - Central Battery Equipment.

1.4 REFERENCE STANDARDS

- A. ANSI Z535.4 - American National Standard for Product Safety Signs and Labels 2011 (Reaffirmed 2017).
- B. IEEE 141 - IEEE Recommended Practice for Electrical Power Distribution for Industrial Plants 1993 (Reaffirmed 1999).

- C. IEEE 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems 2001, with Errata (2003).
- D. IEEE 399 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis 1997.
- E. IEEE 551 - IEEE Recommended Practice for Calculating Short-Circuit Currents in Industrial and Commercial Power Systems 2006.
- F. IEEE 1584 - IEEE Guide for Performing Arc-Flash Hazard Calculations 2018, with Errata (2019).
- G. NEMA MG 1 - Motors and Generators 2018.
- H. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- I. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- J. NFPA 70E - Standard for Electrical Safety in the Workplace 2021.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Existing Installations: Coordinate with equipment manufacturer(s) to obtain data necessary for completion of studies.
 - 2. Coordinate the work to provide equipment and associated protective devices complying with criteria for selection and adjustment, as determined by studies to be performed.
 - 3. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Pre-Study Meeting: Conduct meeting with Owner to discuss system operating modes and conditions to be considered in studies.
- C. Sequencing:
 - 1. Submit study reports prior to product submittals.
 - 2. Do not order equipment until matching study reports and product submittals have both been evaluated by Engineer.
 - 3. Verify naming convention for equipment identification prior to creation of final drawings, reports, and arc flash hazard warning labels (where applicable).
- D. Scheduling:
 - 1. Arrange access to existing facility for data collection with Owner.

2. Where work of this section involves interruption of existing electrical service, arrange service interruption with Owner.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Study preparer's qualifications.
- C. Field testing agency's qualifications.
- D. Study reports, stamped or sealed and signed by study preparer.
- E. Product Data: In addition to submittal requirements specified in other sections, include manufacturer's standard catalog pages and data sheets for equipment and protective devices indicating information relevant to studies.
 1. Include characteristic time-current trip curves for protective devices.
 2. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
 3. Identify modifications made in accordance with studies that:
 - a. Can be made at no additional cost to Owner.
 - b. As submitted will involve a change to the contract sum.
- F. Arc Flash Hazard Warning Label Samples: One of each type and legend specified.
- G. Site-specific arc flash hazard warning labels.
- H. Field quality control reports.
- I. Certification that field adjustable protective devices have been set in accordance with requirements of studies.
- J. Project Record Documents: Revise studies as required to reflect as-built conditions.
 1. Include hard copies with operation and maintenance data submittals.
 2. Include computer software files used to prepare studies with file name(s) cross-referenced to specific pieces of equipment and systems.

1.7 POWER SYSTEM STUDIES

- A. Scope of Studies:
 1. Perform analysis of both new and existing portions of electrical distribution system as indicated on drawings.

2. Except where study descriptions below indicate exclusions, analyze system at each bus from primary protective devices of utility source down to each piece of equipment involved, including parts of system affecting calculations being performed (e.g. fault current contribution from motors).
 3. Include in analysis alternate sources and operating modes (including known future configurations) to determine worst case conditions.
- B. General Study Requirements:
1. Comply with NFPA 70.
 2. Perform studies utilizing computer software complying with specified requirements; manual calculations are not permitted.
- C. Data Collection:
1. Compile information on project-specific characteristics of actual installed equipment, protective devices, feeders, etc. as necessary to develop single-line diagram of electrical distribution system and associated input data for use in system modeling.
 - a. Utility Source Data: Include primary voltage, maximum and minimum three-phase and line-to-ground fault currents, impedance, X/R ratio, and primary protective device information.
 - 1) Obtain up-to-date information from Utility Company.
 - 2) Utility Company: EVERSOURCE.
 - (a) Point of Contact: Alisha Saxby.
 - (b) Address: 705 West Johnson Ave, Cheshire, CT 06410.
 - (c) Phone: Office: (203) 271-4770, Fax: (203) 271-4754.
 - (d) Email: alisha.mikulak-saxby@eversource.com.
 - (e) Utility Company Project Reference Number: 662-2663.
 - b. Generators: Include manufacturer/model, kW and voltage ratings, and impedance.
 - c. Motors: Include manufacturer/model, type (e.g. induction, synchronous), horsepower rating, voltage rating, full load amps, and locked rotor current or NEMA MG 1 code letter designation.
 - d. Transformers: Include primary and secondary voltage ratings, kVA rating, winding configuration, percent impedance, and X/R ratio.
 - e. Protective Devices:

- 1) Circuit Breakers: Include manufacturer/model, type (e.g. thermal magnetic, electronic trip), frame size, trip rating, voltage rating, interrupting rating, available field-adjustable trip response settings, and features (e.g. zone selective interlocking).
 - 2) Fuses: Include manufacturer/model, type/class (e.g. Class J), size/rating, and speed (e.g. time delay, fast acting).
 - f. Protective Relays: Include manufacturer/model, type, settings, current/potential transformer ratio, and associated protective device.
 - g. Conductors: Include feeder size, material (e.g. copper, aluminum), insulation type, voltage rating, number per phase, raceway type, and actual length.
 2. Existing Installations:
 - a. Collect data on existing electrical distribution system necessary for completion of studies, including field verification of available existing data (e.g. construction documents, previous studies). Include actual settings for field-adjustable devices.
- D. Short-Circuit Study:
1. Comply with IEEE 551 and applicable portions of IEEE 141, IEEE 242, and IEEE 399.
 2. For purposes of determining equipment short circuit current ratings, consider conditions that may result in maximum available fault current, including but not limited to:
 - a. Maximum utility fault currents.
 - b. Maximum motor contribution.
 - c. Known operating modes (e.g. utility as source, generator as source, utility/generator in parallel, bus tie breaker open/close positions).
 3. For each bus location, calculate the maximum available three-phase bolted symmetrical and asymmetrical fault currents. For grounded systems, also calculate the maximum available line-to-ground bolted fault currents.
- E. Protective Device Coordination Study:
1. Comply with applicable portions of IEEE 242 and IEEE 399.
 2. Analyze alternate scenarios considering known operating modes (e.g. utility as source, generator as source, utility/generator in parallel, bus tie breaker open/close positions).
 3. Analyze protective devices and associated settings for suitable margins between time-current curves to achieve full selective coordination while providing adequate protection for equipment and conductors.
- F. Arc Flash and Shock Risk Assessment:

1. Comply with NFPA 70E.
2. Perform incident energy and arc flash boundary calculations in accordance with IEEE 1584 (as referenced in NFPA 70E Annex D), where applicable.
3. For equipment with main devices mounted in separate compartmentalized sections, perform calculations on both the line and load side of the main device.
4. Analyze alternate scenarios considering conditions that may result in maximum incident energy, including but not limited to:
 - a. Maximum and minimum utility fault currents.
 - b. Maximum and minimum motor contribution.
 - c. Known operating modes (e.g. utility as source, generator as source, utility/generator in parallel, bus tie breaker open/close positions).

G. Study Reports:

1. General Requirements:
 - a. Identify date of study and study preparer.
 - b. Identify study methodology and software product(s) used.
 - c. Identify scope of studies, assumptions made, implications of possible alternate scenarios, and any exclusions from studies.
 - d. Identify base used for per unit values.
 - e. Include single-line diagram and associated input data used for studies; identify buses on single-line diagram as referenced in reports, and indicate bus voltage.
 - f. Include conclusions and recommendations.
2. Short-Circuit Study:
 - a. For each scenario, identify at each bus location:
 - 1) Calculated maximum available symmetrical and asymmetrical fault currents (both three-phase and line-to-ground where applicable).
 - 2) Fault point X/R ratio.
 - 3) Associated equipment short circuit current ratings.
 - b. Identify locations where the available fault current exceeds the equipment short circuit current rating, along with recommendations.
3. Protective Device Coordination Study:

- a. For each scenario, include time-current coordination curves plotted on log-log scale graphs.
 - b. For each graph include (where applicable):
 - 1) Partial single-line diagram identifying the portion of the system illustrated.
 - 2) Protective Devices: Time-current curves with applicable tolerance bands for each protective device in series back to the source, plotted up to the maximum available fault current at the associated bus.
 - 3) Conductors: Damage curves.
 - 4) Transformers: Inrush points and damage curves.
 - 5) Generators: Full load current, overload curves, decrement curves, and short circuit withstand points.
 - 6) Motors: Full load current, starting curves, and damage curves.
 - 7) Capacitors: Full load current and damage curves.
 - c. For each protective device, identify fixed and adjustable characteristics with available ranges and recommended settings.
 - 1) Circuit Breakers: Include long time pickup and delay, short time pickup and delay, and instantaneous pickup.
 - 2) Include ground fault pickup and delay.
 - 3) Include fuse ratings.
 - 4) Protective Relays: Include current/potential transformer ratios, tap, time dial, and instantaneous pickup.
 - d. Identify cases where either full selective coordination or adequate protection is not achieved, along with recommendations.
4. Arc Flash and Shock Risk Assessment:
- a. For the worst case for each scenario, identify at each bus location:
 - 1) Calculated incident energy and associated working distance.
 - 2) Calculated arc flash boundary.
 - 3) Bolted fault current.
 - 4) Arcing fault current.
 - 5) Clearing time.

6) Arc gap distance.

- b. For purposes of producing arc flash hazard warning labels, summarize the maximum incident energy and associated data reflecting the worst case condition of all scenarios at each bus location.

1.8 QUALITY ASSURANCE

- A. Study Preparer Qualifications: Professional electrical engineer licensed in the State in which the Project is located and with minimum five years experience in the preparation of studies of similar type and complexity using specified computer software.
 - 1. Study preparer may be employed by the manufacturer of the electrical distribution equipment.
 - 2. Study preparer may be employed by field testing agency.
- B. Field Testing Agency Qualifications: Independent testing organization specializing in testing, analysis, and maintenance of electrical systems with minimum five years experience; NETA Accredited Company.
 - 1. Field Supervisor: Certified electrical testing technician; NETA ETT Level III.
- C. Computer Software for Study Preparation: Use the latest edition of commercially available software utilizing specified methodologies.
 - 1. Acceptable Software Products:
 - a. EasyPower LLC: www.easypower.com/#sle.
 - b. ETAP/Operation Technology, Inc: www.etap.com/#sle.
 - c. Power Analytics Corporation: www.poweranalytics.com/#sle.
 - d. SKM Systems Analysis, Inc: www.skm.com/#sle.
 - e. Substitutions: See Section 01 60 00 - Product Requirements.

PART 2 PRODUCTS

2.1 ARC FLASH HAZARD WARNING LABELS

- A. Provide warning labels complying with ANSI Z535.4 to identify arc flash hazards for each work location analyzed by the arc flash and shock risk assessment.
 - 1. Materials: Comply with Section 26 05 53.
 - 2. Minimum Size: 4 by 6 inches.
 - 3. Legend: Provide custom legend in accordance with NFPA 70E based on equipment-specific data as determined by arc flash and shock risk assessment.

- a. Include orange header that reads "WARNING" unless otherwise indicated.
- b. Include the text "Arc Flash and Shock Hazard; Appropriate PPE Required" or approved equivalent.
- c. Include the following information:
 - 1) Arc flash boundary.
 - 2) Available incident energy and corresponding working distance.
 - 3) Site-specific PPE (personnel protective equipment) requirements.
 - 4) Nominal system voltage.
 - 5) Limited approach boundary.
 - 6) Restricted approach boundary.
 - 7) Equipment identification.
 - 8) Date calculations were performed.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install arc flash warning labels in accordance with Section 26 05 53.

3.2 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Provide the services of field testing agency or equipment manufacturer's representative to perform inspection, testing, and adjusting.
- C. Inspect and test in accordance with NETA ATS, except Section 4.
- D. Adjust equipment and protective devices for compliance with studies and recommended settings.
- E. Notify Engineer of any conflicts with or deviations from studies. Obtain direction before proceeding.
- F. Submit detailed reports indicating inspection and testing results, and final adjusted settings.

3.3 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 - Demonstration and Training, for additional requirements.

- C. Training: Include as part of the base bid training for Owner's personnel on electrical safety pertaining to arc flash and shock hazards.
1. Use site-specific arc flash and shock risk assessment report as training reference, supplemented with additional training materials as required.
 2. Provide minimum of four hours of training.
 3. Instructor: Representative of entity performing study.
 4. Location: At project site.

END OF SECTION 26 05 73

SECTION 26 05 83 - WIRING CONNECTIONS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Electrical connections to equipment.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
- B. Section 26 05 33.13 - Conduit for Electrical Systems.
- C. Section 26 05 33.16 - Boxes for Electrical Systems.
- D. Section 26 27 26 - Wiring Devices.
- E. Section 26 28 16.16 - Enclosed Switches.

1.4 REFERENCE STANDARDS

- A. NEMA WD 1 - General Color Requirements for Wiring Devices 1999 (Reaffirmed 2020).
- B. NEMA WD 6 - Wiring Devices - Dimensional Specifications 2016.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
 - 2. Determine connection locations and requirements.
- B. Sequencing:
 - 1. Install rough-in of electrical connections before installation of equipment is required.
 - 2. Make electrical connections before required start-up of equipment.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide wiring device manufacturer's catalog information showing dimensions, configurations, and construction.
- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.7 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Cords and Caps: NEMA WD 6; match receptacle configuration at outlet provided for equipment.
 - 1. Colors: Comply with NEMA WD 1.
 - 2. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
 - 3. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.
- B. Disconnect Switches: As specified in Section 26 28 16.16 and in individual equipment sections.
- C. Wiring Devices: As specified in Section 26 27 26.
- D. Flexible Conduit: As specified in Section 26 05 33.13.
- E. Wire and Cable: As specified in Section 26 05 19.
- F. Boxes: As specified in Section 26 05 33.16.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.2 ELECTRICAL CONNECTIONS

- A. Make electrical connections in accordance with equipment manufacturer's instructions.
- B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.
- C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- D. Provide receptacle outlet to accommodate connection with attachment plug.
- E. Provide cord and cap where field-supplied attachment plug is required.
- F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
- G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.
- H. Install terminal block jumpers to complete equipment wiring requirements.
- I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.
- J. Coolers and Freezers: Cut and seal conduit openings in freezer and cooler walls, floor, and ceilings.

END OF SECTION 26 05 83

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SECTION 260800 - COMMISSIONING OF ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SUMMARY

- A. This section includes commissioning process requirements for Electrical systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
- C. In addition, provide the following:
 - 1. Certificates of readiness
 - 2. Certificates of completion of installation, prestart, and startup activities.
 - 3. O&M manuals
 - 4. Test reports

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the electrical contractor of Division 26 shall ultimately be responsible for all standard testing equipment for the electrical systems and controls systems in Division 26. A sufficient quantity of two-way radios shall be provided by each contractor.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.
- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems
- B. Red-lined Drawings:
 - 1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
 - 2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
 - 3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
 - 4. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. Operation and Maintenance Data:
 - 1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
 - 2. The CxA will review the O&M literature once for conformance to project requirements.
 - 3. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.
- D. Demonstration and Training:
 - 1. Contractor will provide demonstration and training as required by the specifications.
 - 2. A complete training plan and schedule must be submitted by the Contractor to the CxA four weeks (4) prior to any training.
 - 3. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.
 - 4. The CA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CA and Owner's representative. A copy of the test record shall be provided to the CA, Owner, and Architect.
 - 5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
 - 6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
 - 7. Review data in O&M Manuals.
- E. Systems manual requirements:
 - 1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.

2. The GC shall include final approved versions of the following information for the Systems Manual:
 - a. As-Built System Schematics
 - b. Verified Record Drawings
 - c. Test Results (not otherwise included in Cx Record)
 - d. Periodic Maintenance Information for computer maintenance management system
 - e. Recommendations for recalibration frequency of sensors and actuators
 - f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
 - g. Training Records, Information on training provided, attendees list, and any on-going training
3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.
4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning tests at the direction of the CxA.
- B. Attend construction phase controls coordination meetings.
- C. Participate in Electrical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- D. Provide information requested by the CxA for final commissioning documentation.
- E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- F. Prepare preliminary schedule for Electrical system orientations and inspections, operation and maintenance manual submissions, training sessions, equipment start-up and task completion for owner. Distribute preliminary schedule to commissioning team members.
- G. Update schedule as required throughout the construction period.
- H. During the startup and initial checkout process, execute the related portions of the prefunctional checklists for all commissioned equipment.
- I. Assist the CxA in all verification and functional performance tests.
- J. 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.
- K. Gather operation and maintenance literature on all equipment and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.

- L. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- M. Notify the CxA a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.
- N. Participate in, and schedule vendors and contractors to participate in the training sessions.
- O. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 - 1. Electrical equipment including switchgear, panel boards, motor control centers, lighting, receptacles, dimmers and all other equipment furnished under this Division.
 - 2. Emergency generators, ATS switches and emergency power systems.
 - 3. Fire alarm system
 - 4. Lightning protection
 - 5. UPS systems
- P. The equipment supplier shall document the performance of his equipment.
- Q. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- R. Provide training of the Owner's operating staff using expert qualified personnel, as specified.
- S. Equipment Suppliers
 - 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 - 2. Assist in equipment testing per agreements with contractors.
 - 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- T. Refer to Division 01 Section "General Commissioning Requirements" for additional Contractor responsibilities.

3.3 OWNER'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Design Professional's Responsibilities.

3.5 CxA'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

3.6 TESTING PREPARATION

- A. Certify in writing to the CxA that Electrical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that Electrical 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 in writing that testing procedures have been completed and that testing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Place 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 identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of Electrical testing shall include the entire Electrical installation, from the incoming power equipment throughout the distribution system. Testing shall include measuring, but not limited to resistance, voltage, and amperage of system(s) and devices.
- 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 Electrical contractor and other contracted subcontractors, including the fire alarm Subcontractor shall prepare detailed testing plans, procedures, and checklists for Electrical systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.

- F. 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.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. 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.
- I. If tests cannot be completed because of a deficiency outside the scope of the Electrical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.8 ELECTRICAL SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 26 sections. Provide submittals, test data, inspector record, infrared camera and certifications to the CA.
- B. Electrical Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 26 Sections "Instrumentation and Control" and "Sequence of Operations" Assist the CxA with preparation of testing plans.
- C. Emergency Generator Testing and Acceptance Procedures: Provide technicians, load banks, infrared cameras, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- D. Fire Detection and Alarm System Testing: Provide technicians, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- E. Electrical Distribution System Testing: Provide technicians, load banks, infrared cameras, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested
- F. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.
- G. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. Automatic temperature controls integrated with the electrical systems
2. Coordination and functionality with the Building Automation System/Building Management Controls System
3. Access Control
4. Automatic Transfer Switch
5. Battery Monitoring System
6. Emergency Generator
7. Emergency Power System
8. EPO System
9. Fire Alarm System
10. Lighting Controls
11. Low Voltage Switchgear
12. Security System
13. UPS System

3.9 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.10 APPROVAL

- A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.11 DEFERRED TESTING

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.12 OPERATION AND MAINTENANCE MANUALS

- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
- B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.13 TRAINING OF OWNER PERSONNEL

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

- B. Electrical Contractor. The electrical contractor shall have the following training responsibilities:
1. Provide the CA with a training plan two weeks before the planned training.
 2. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.
 3. Training shall start with classroom sessions, if necessary, followed by hands on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
 4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
 5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
 6. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
 7. Training shall include:
 - a. Use the printed installation, operation and maintenance instruction material included in the O&M manuals.
 - b. Include a review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
 - c. Discuss relevant health and safety issues and concerns.
 - d. Discuss warranties and guarantees.
 - e. Cover common troubleshooting problems and solutions.
 - f. Explain information included in the O&M manuals and the location of all plans and manuals in the facility.
 - g. Discuss any peculiarities of equipment installation or operation.
 8. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance of all pieces of equipment.
 9. The electrical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

10. Training shall occur after functional testing is complete, unless approved otherwise by the Owner's.

END OF SECTION 26 08 00

SECTION 26 09 23 - LIGHTING CONTROL DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Occupancy sensors.
- B. Outdoor motion sensors.
- C. Time switches.
- D. In-wall time switches.
- E. Outdoor photo controls.
- F. Daylighting controls.
- G. Lighting contactors.
- H. Accessories.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 05 29 - Hangers and Supports for Electrical Systems
- B. Section 26 05 33.16 - Boxes for Electrical Systems.
- C. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 26 05 73 - Power System Studies.
- E. Section 26 27 26 - Wiring Devices: Devices for manual control of lighting, including wall switches, wall dimmers, and fan speed controllers.
 - 1. Includes finish requirements for wall controls specified in this section.

1.4 REFERENCE STANDARDS

- A. 47 CFR 15 - Radio Frequency Devices current edition.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NECA 130 - Standard for Installing and Maintaining Wiring Devices 2016.

- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- E. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts 2008 (Reaffirmed 2020).
- F. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices 2017.
- G. NEMA ICS 6 - Industrial Control and Systems: Enclosures 1993 (Reaffirmed 2016).
- H. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. UL 916 - Energy Management Equipment Current Edition, Including All Revisions.
- J. UL 917 - Clock-Operated Switches Current Edition, Including All Revisions.
- K. UL 1472 - Solid-State Dimming Controls Current Edition, Including All Revisions.
- L. UL 60947-1 - Low-Voltage Switchgear and Controlgear - Part 1: General Rules Current Edition, Including All Revisions.
- M. UL 60947-4-1 - Low-Voltage Switchgear and Controlgear - Part 4-1: Contactors and Motor-starters - Electromechanical Contactors and Motor-starters Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the placement of lighting control devices with millwork, furniture, equipment, etc. installed under other sections or by others.
 - 2. Coordinate the placement of wall switch occupancy sensors with actual installed door swings.
 - 3. Coordinate the placement of occupancy sensors with millwork, furniture, equipment or other potential obstructions to motion detection coverage installed under other sections or by others.
 - 4. Coordinate the placement of photo sensors for daylighting controls with windows, skylights, and luminaires to achieve optimum operation. Coordinate placement with ductwork, piping, equipment, or other potential obstructions to light level measurement installed under other sections or by others.
 - 5. Notify Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

- B. Product Data: Include ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features.
 - 1. Occupancy Sensors: Include detailed motion detection coverage range diagrams.
 - C. Shop Drawings:
 - 1. Occupancy Sensors: Provide lighting plan indicating location, model number, and orientation of each occupancy sensor and associated system component.
 - 2. Daylighting Controls: Provide lighting plan indicating location, model number, and orientation of each photo sensor and associated system component.
 - D. Samples:
 - 1. Occupancy Sensors: One for each type and color specified.
 - 2. In-Wall Time Switches: One for each type and color specified.
 - 3. In-Wall Interval Timers: One for each type and color specified.
 - 4. Daylighting Control Photo Sensors: One for each type and color specified.
 - E. Field Quality Control Reports.
 - F. Manufacturer's Installation Instructions: Include application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
 - G. Operation and Maintenance Data: Include detailed information on device programming and setup.
 - H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.
 - 2. Extra Locking Receptacle-Mounted Outdoor Photo Controls: Five percent of total quantity installed for each type, but not less than two of each type.
 - 3. Electronic Trip Circuit Breakers: Provide one portable test set.
 - 4. Indicating Lights: Two of each different type.
 - I. Project Record Documents: Record actual installed locations and settings for lighting control devices.
- 1.7 QUALITY ASSURANCE
- A. Comply with requirements of NFPA 70.

- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND PROTECTION

- A. Store products in a clean, dry space in original manufacturer's packaging in accordance with manufacturer's written instructions until ready for installation.

1.9 FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.10 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for all occupancy sensors.
- C. Provide five year manufacturer warranty for utility grade locking receptacle-mounted outdoor photo controls.
- D. Provide two year manufacturer warranty for all daylighting controls.

PART 2 PRODUCTS

2.1 LIGHTING CONTROL DEVICES - GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless specifically indicated to be excluded, provide all required conduit, wiring, connectors, hardware, components, accessories, etc. as required for a complete operating system.

2.2 OCCUPANCY SENSORS

- A. Manufacturers:
 - 1. Basis Of Design: As indicated on plans.
 - 2. Hubbell Incorporated; [_____]: www.hubbell.com/#sle.
 - 3. Sensor Switch Inc; [_____]: www.sensorswitch.com/#sle.
 - 4. WattStopper; [_____]: www.wattstopper.com/#sle.

5. [_____].

6. Source Limitations: Furnish products produced by a single manufacturer and obtained from a single supplier.

B. All Occupancy Sensors:

1. Description: Factory-assembled commercial specification grade devices for indoor use capable of sensing both major motion, such as walking, and minor motion, such as small desktop level movements, according to published coverage areas, for automatic control of load indicated.
2. Sensor Technology:
 - a. Passive Infrared/Ultrasonic Dual Technology Occupancy Sensors: Designed to detect occupancy using a combination of both passive infrared and ultrasonic technologies.
 - b. Passive Infrared/Acoustic Dual Technology Occupancy Sensors: Designed to detect occupancy using a combination of both passive infrared and audible sound sensing technologies.
3. Provide LED to visually indicate motion detection with separate color LEDs for each sensor type in dual technology units.
4. Operation:
 - a. AUTO-ON: Unless otherwise indicated, occupancy sensor to turn load 100% on when occupant presence is detected and to turn load off when no occupant presence is detected during an adjustable turn-off delay time interval.
 - b. VACANCY MODE: Unless otherwise indicated, load manually turned on and occupancy sensor to turn load off when no occupant presence is detected during an adjustable turn-off delay time interval.
5. Dual Technology Occupancy Sensors: Field configurable turn-on and hold-on activation with settings for activation by either or both sensing technologies.
6. Passive Infrared Lens Field of View: Field customizable by addition of factory masking material, adjustment of integral blinders, or similar means to block motion detection in selected areas.
7. Turn-Off Delay: Field adjustable, with time delay settings up to 30 minutes.
8. Sensitivity: Field adjustable.
9. Adaptive Technology: Field selectable; capable of self-adjusting sensitivity and time delay according to conditions.
10. Integral Photocell: For field selectable and adjustable inhibition of automatic turn-on of load when ambient lighting is above the selected level.

11. Compatibility (Non-Dimming Sensors): Suitable for controlling incandescent lighting, low-voltage lighting with electronic and magnetic transformers, fluorescent lighting with electronic and magnetic ballasts, and fractional motor loads, with no minimum load requirements.
 12. Where wired sensors are indicated, wireless sensors are acceptable provided that all components and wiring modifications necessary for proper operation are included.
 13. Wireless Sensors:
 - a. RF Range: 30 feet through typical construction materials.
 - b. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of 47 CFR 15, for Class B application.
 - c. Power: Battery-operated with minimum ten-year battery life.
- C. Wall Switch Occupancy Sensors:
1. All Wall Switch Occupancy Sensors:
 - a. Description: Occupancy sensors designed for installation in standard wall box at standard wall switch mounting height with a field of view of 180 degrees, integrated manual control capability, and no leakage current to load in off mode.
 - b. Operation: Field selectable to operate either as occupancy sensor (automatic on/off) or as vacancy sensor (manual-on/automatic off).
 - c. Manual-Off Override Control: When used to turn off load while in automatic-on mode, unit to revert back to automatic mode after no occupant presence is detected during the delayed-off time interval.
 - d. Finish: Match finishes specified for wiring devices in Section 26 27 26, unless otherwise indicated.
 - e. Provide vandal resistant lenses for passive infrared (PIR) and dual technology wall switch occupancy sensors where indicated.
- D. Wall Dimmer Occupancy Sensors:
1. General Requirements:
 - a. Description: Occupancy sensors designed for installation in standard wall box at standard wall switch mounting height with a field of view of 180 degrees, integrated dimming control capability, and no leakage current to load in off mode.
 - b. Manual-Off Override Control Capability: When used to turn off load while in automatic-on mode, unit to revert back to automatic mode after no occupant presence is detected during the delayed-off time interval.

- c. Dimmer: Solid-state with continuous full-range even control following square law dimming curve, integral radio frequency interference filtering, power failure preset memory, air gap switch accessible without removing wall plate, and listed as complying with UL 1472; type and rating suitable for load controlled.
 - d. Finish: Match finishes specified for wiring devices in Section 26 27 26, unless otherwise indicated.
- E. Ceiling Mounted Occupancy Sensors:
- 1. All Ceiling Mounted Occupancy Sensors:
 - a. Description: Low profile occupancy sensors designed for ceiling installation.
 - b. Unless otherwise indicated or required to control the load indicated on drawings, provide low voltage units, for use with separate compatible accessory power packs.
 - c. Occupancy sensor to be field selectable as either manual-on/automatic-off or automatic on/off.
 - d. Finish: White unless otherwise indicated.
 - 2. Passive Infrared (PIR) Ceiling Mounted Occupancy Sensors:
 - a. Standard Range Sensors: Capable of detecting motion within an area of 450 square feet at a mounting height of 9 feet, with a field of view of 360 degrees.
 - b. Extended Range Sensors: Capable of detecting motion within an area of 1,200 square feet at a mounting height of 9 feet, with a field of view of 360 degrees.
 - 3. Ultrasonic Ceiling Mounted Occupancy Sensors:
 - a. Standard Range Sensors: Capable of detecting motion within an area of 500 square feet at a mounting height of 9 feet, with a field of view of 360 degrees.
 - b. Medium Range Sensors: Capable of detecting motion within an area of 1,000 square feet at a mounting height of 9 feet, with a field of view of 360 degrees.
 - c. Extended Range Sensors: Capable of detecting motion within an area of 2,000 square feet at a mounting height of 9 feet.
 - 4. Passive Infrared/Ultrasonic Dual Technology Ceiling Mounted Occupancy Sensors:
 - a. Standard Range Sensors: Capable of detecting motion within an area of 450 square feet at a mounting height of 9 feet, with a field of view of 360 degrees.
 - b. Extended Range Sensors: Capable of detecting motion within an area of 1,200 square feet at a mounting height of 9 feet, with a field of view of 360 degrees.
 - 5. Passive Infrared/Acoustic Dual Technology Ceiling Mounted Occupancy Sensors:

- a. Standard Range Sensors: Capable of detecting motion within an area of 450 square feet at a mounting height of 9 feet, with a field of view of 360 degrees.
 - b. Extended Range Sensors: Capable of detecting motion within an area of 1,200 square feet at a mounting height of 9 feet.
- F. Directional Occupancy Sensors:
 1. All Directional Occupancy Sensors: Designed for wall or ceiling mounting, with integral swivel for field adjustment of motion detection coverage.
 - a. Unless otherwise indicated or required to control the load indicated on drawings, provide low voltage units, for use with separate compatible accessory power packs.
 2. Passive Infrared (PIR) Directional Occupancy Sensors:
 - a. Standard Range Sensors: Capable of detecting motion within a distance of 40 feet at a mounting height of 10 feet.
 - b. Long Range Sensors: Capable of detecting motion within a distance of 80 feet at a mounting height of 10 feet.
 - c. High Bay Sensors: Capable of detecting motion within a distance of 50 feet at a mounting height of 30 feet.
 3. Passive Infrared/Ultrasonic Dual Technology Directional Occupancy Sensors: Capable of detecting motion within a distance of 40 feet at a mounting height of 10 feet.
- G. Luminaire Mounted Occupancy Sensors: Designed for direct luminaire installation and control, suitable for use with specified luminaires.
- H. Power Packs for Low Voltage Occupancy Sensors:
 1. Description: Plenum rated, self-contained low voltage class 2 transformer and relay compatible with specified low voltage occupancy sensors for switching of line voltage loads.
 2. Provide quantity and configuration of power and slave packs with all associated wiring and accessories as required to control the load indicated on drawings.
 3. Input Supply Voltage: Dual rated for 120/277 V ac.
 4. Load Rating: As required to control the load indicated on drawings.
- I. Power Packs for Wireless Occupancy Sensors:
 1. Description: Plenum rated, self-contained relay compatible with specified wireless occupancy sensors for switching of line voltage loads.
 2. Input Supply Voltage: Dual rated for 120/277 V ac.

3. Load Rating: As required to control the load indicated on drawings.

J. Accessories:

1. Provide heavy duty coated steel wire protective guards compatible with specified occupancy sensors where indicated.

2.3 OUTDOOR MOTION SENSORS

- A. Description: Factory-assembled wet location listed device suitable for wall or ceiling/eave mounting, with integral swivel for field adjustment of coverage, capable of detecting motion for automatic control of load indicated.
- B. Sensor Technology: Passive Infrared (PIR) designed to detect occupancy by sensing movement of thermal energy between zones.
- C. Operation: Unless otherwise indicated, motion sensor to turn load on when motion is detected and to turn load off when no motion is detected during an adjustable turn-off delay time interval.
- D. Turn-Off Delay: Field adjustable, with time delay settings available up to 15 minutes.
- E. Integral Photocell: For dusk to dawn operation.
- F. Manual Override: Activated by switching power off to unit and then back on.
- G. Load Rating: 1,000 W incandescent and fluorescent load at 120 V ac.
- H. Coverage: Capable of detecting motion within a distance of 50 feet at a mounting height of 8 feet, with a field of view of 270 degrees.

2.4 TIME SWITCHES

A. Manufacturers:

1. Intermatic, Inc; [_____]: www.intermatic.com/#sle.
2. Tork, a division of NSI Industries LLC; [_____]: www.tork.com/#sle.
3. Substitutions: See Section 01 60 00 - Product Requirements.

B. Digital Electronic Time Switches:

1. Description: Factory-assembled solid state programmable controller with LCD display, listed and labeled as complying with UL 916 or UL 917.
2. Program Capability:
 - a. 24-Hour Time Switches: Single channel, with same schedule for each day of the week and skip-a-day feature to omit selected days.

- b. 7-Day Time Switches: Single channel, capable of different schedule for each day of the week with additional holiday schedule available to override normal schedule for selected days.
 3. Schedule Capacity: Not less than 16 programmable on/off operations.
 4. Provide automatic daylight savings time and leap year compensation.
 5. Provide power outage backup to retain programming and maintain clock.
 6. Manual override: Capable of overriding current schedule both permanently and temporarily until next scheduled event.
 7. Provide remote photocell input with light level adjustment.
 8. Input Supply Voltage: As indicated on the drawings.
 9. Output Switch Configuration: As required to control the load indicated on drawings.
 10. Provide lockable enclosure; environmental type per NEMA 250 as specified for the following installation locations:
 - a. Indoor clean, dry locations: Type 1.
 - b. Outdoor locations: Type 3R.
 11. Provide flush-mounted unit where indicated, where mounted in public areas, or where mounted adjacent to flush-mounted equipment.
- C. Electromechanical Time Switches:
 1. Description: Factory-assembled controller with motor-operated timing dial mechanism and adjustable trippers for setting on/off operations, listed and labeled as complying with UL 917.
 2. Program Capability:
 - a. 24-Hour Time Switches: With same schedule for each day of the week and skip-a-day feature to omit selected days.
 - b. 7-Day Time Switches: Capable of different schedule for each day of the week.
 - c. Astronomic Time Switches: With same schedule for each day of the week and skip-a-day feature to omit selected days with automatic adjustment for seasonal changes in sunrise and sunset times.
 3. Schedule Capacity:
 - a. 24-Hour Time Switches: Accommodating not less than 12 pairs of selected on/off operations per day.

- b. 7-Day Time Switches: Accommodating not less than two pairs of selected on/off operations per day.
 - c. Astronomic Time Switches: Capable of turning load on at sunset and off at either sunrise or selected fixed time.
- 4. Provide spring reserve backup to maintain clock during power outage.
 - 5. Manual override: Capable of overriding current schedule both permanently and temporarily until next scheduled event.
 - 6. Input Supply Voltage: As indicated on the drawings.
 - 7. Output Switch Configuration: As required to control the load indicated on drawings.
 - 8. Provide lockable enclosure; environmental type per NEMA 250 as specified for the following installation locations:

2.5 IN-WALL TIME SWITCHES

A. Manufacturers:

- 1. Intermatic, Inc; [_____]: www.intermatic.com/#sle.
- 2. Tork, a division of NSI Industries LLC; [_____]: www.tork.com/#sle.
- 3. Substitutions: See Section 01 60 00 - Product Requirements.
- 4. Source Limitations: Furnish products produced by a single manufacturer and obtained from a single supplier.

2.6 OUTDOOR PHOTO CONTROLS

A. Manufacturers:

- 1. Intermatic, Inc; [_____]: www.intermatic.com/#sle.
- 2. Tork, a division of NSI Industries LLC; [_____]: www.tork.com/#sle.
- 3. Substitutions: See Section 01 60 00 - Product Requirements.
- 4. Source Limitations: Furnish products produced by a single manufacturer and obtained from a single supplier.

2.7 DAYLIGHTING CONTROLS

A. Manufacturers:

- 1. Basis Of Design: As indicated on plans
- 2. Hubbell Control Solutions; [_____]:

3. Lutron Electronics Company, Inc; [_____]: www.lutron.com/#sle.
 4. Sensor Switch Inc; [_____]: www.sensorswitch.com/#sle.
 5. WattStopper; [_____]: www.wattstopper.com/#sle.
 6. Substitutions: See Section 01 60 00 - Product Requirements.
 7. Source Limitations: Furnish products produced by a single manufacturer and obtained from a single supplier.
- B. System Description: Control system consisting of photo sensors and compatible control modules and power packs, contactors, or relays as required for automatic control of load indicated according to available natural light; capable of integrating with occupancy sensors and manual override controls.
- C. Daylighting Control Photo Sensors: Low voltage class 2 photo sensor units with output signal proportional to the measured light level and provision for zero or offset based signal.
1. Sensor Type: Filtered silicon photo diode.
 2. Sensor Range:
- D. Daylighting Control Switching Modules for Wireless Sensors:
1. Description: Plenum rated, self-contained relay compatible with specified wireless photo sensors for switching of line voltage loads in response to changes in measured light levels according to selected settings.
 2. Operation: Unless otherwise indicated, load to be turned on when light level is below selected low set point and load to be turned off when light level is above selected high set point, with a no switching dead band between set points to prevent unwanted cycling.
 3. Input Delay: To prevent unwanted cycling due to intermittent light level fluctuations.
 4. Control Capability: Capable of controlling one programmable channel.
 5. Input Supply Voltage: Dual rated for 120/277 V ac.
- E. Daylighting Control Dimming Modules for Low Voltage Sensors: Low voltage class 2 control unit compatible with specified photo sensors and with specified dimming ballasts, for both continuous dimming of compatible dimming ballasts and switching of compatible power packs, contactors, or relays in response to changes in measured light levels according to selected settings.
1. Operation: Unless otherwise indicated, specified load to be continuously brightened as not enough daylight becomes available and continuously dimmed as enough daylight becomes available.

2. Control Capability: Capable of controlling up to three separately programmable channels, with up to 50 ballasts per channel.
3. Dimming and Fade Rates: Adjustable from 5 to 60 seconds.
4. Cut-Off Delay: Selectable and adjustable from 0 to 20 minutes.

F. Daylighting Control Dimming Modules for Wireless Sensors:

1. Description: Plenum rated control unit compatible with specified wireless photo sensors and with specified dimming ballasts, for continuous dimming of compatible dimming ballasts in response to changes in measured light levels according to selected settings.
2. Operation: Unless otherwise indicated, specified load to be continuously brightened as not enough daylight becomes available and continuously dimmed as enough daylight becomes available.
3. Load to be turned off when available daylight is sufficient to fully dim the load, after the selected time delay.
4. Control Capability: Capable of controlling up to 32 ballasts with up to two separately programmable daylighting zones.

G. Power Packs for Low Voltage Daylighting Control Modules:

1. Description: Plenum rated, self-contained low voltage class 2 transformer and relay compatible with specified low voltage daylighting control modules for switching of line voltage loads. Provide quantity and configuration of power and slave packs with all associated wiring and accessories as required to control the load indicated on drawings.
2. Input Supply Voltage: Dual rated for 120/277 V ac.
3. Load Ratings: As required to control the load indicated on drawings.

2.8 LIGHTING CONTACTORS

A. Manufacturers:

1. ABB/GE; [____]: www.geindustrial.com/#sle.
2. Eaton Corporation; [____]: www.eaton.com/#sle.
3. Schneider Electric; Square D Products; [____]: www.schneider-electric.us/#sle.

B. Description: Magnetic lighting contactors complying with NEMA ICS 2, and listed and labeled as complying with UL 60947-1 and UL 60947-4-1; noncombination type unless otherwise indicated; ratings, configurations and features as indicated on the drawings.

C. Short Circuit Current Rating:

1. Provide contactors with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73.

D. Enclosures:

1. Comply with NEMA ICS 6.
2. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
3. Finish: Manufacturer's standard unless otherwise indicated.

2.9 ACCESSORIES

A. Auxiliary Contacts:

1. Comply with NEMA ICS 5.
2. Provide number and type of contacts indicated or required to perform necessary functions, including holding (seal-in) circuit and interlocking, plus one normally open (NO) and one normally closed (NC) spare contact for each lighting contactor, minimum.

B. Pilot Devices:

1. Comply with NEMA ICS 5; heavy-duty type.
2. Pushbuttons: Unless otherwise indicated, provide momentary, non-illuminated type with flush button operator; normally open or normally closed as indicated or as required.
3. Selector Switches: Unless otherwise indicated, provide maintained, non-illuminated type with knob operator; number of switch positions as indicated or as required.
4. Indicating Lights: Push-to-test type unless otherwise indicated.
5. Provide LED lamp source for indicating lights and illuminated devices.

C. Control and Timing Relays:

1. Comply with NEMA ICS 5.
2. Provide number and type of relays indicated or required to perform necessary functions.

D. Fire-Rated Device Enclosures:

1. Provide as required to preserve fire resistance rating of building elements.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that openings for outlet boxes are neatly cut and will be completely covered by devices or wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to lighting control devices.
- F. Verify that the service voltage and ratings of lighting control devices are appropriate for the service voltage and load requirements at the location to be installed.
- G. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

- A. Install lighting control devices in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 26 05 33.16 as required for installation of lighting control devices provided under this section.
 - 1. Orient outlet boxes for vertical installation of lighting control devices unless otherwise indicated.
 - 2. Locate wall switch occupancy sensors on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify Engineer to obtain direction prior to proceeding with work.
- C. Install lighting control devices in accordance with manufacturer's instructions.
- D. Unless otherwise indicated, connect lighting control device grounding terminal or conductor to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- E. Install lighting control devices plumb and level, and held securely in place.

- F. Where required and not furnished with lighting control device, provide wall plate in accordance with Section 26 07 26.
- G. Provide required supports in accordance with Section 26 05 29.
- H. Where applicable, install lighting control devices and associated wall plates to fit completely flush to mounting surface with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
- I. Identify lighting control devices in accordance with Section 26 05 53.
- J. Occupancy Sensor Locations:
 - 1. Location Adjustments: Locations indicated are diagrammatic and only intended to indicate which rooms or areas require devices. Provide quantity and locations as required for complete coverage of respective room or area based on manufacturer's recommendations for installed devices.
 - 2. Locate ultrasonic and dual technology passive infrared/ultrasonic occupancy sensors a minimum of 4 feet from air supply ducts or other sources of heavy air flow and as per manufacturer's recommendations, in order to minimize false triggers.
- K. Outdoor Photo Control Locations:
 - 1. Where possible, locate outdoor photo controls with photo sensor facing north. If north facing photo sensor is not possible, install with photo sensor facing east, west, or down.
 - 2. Locate outdoor photo controls so that photo sensors do not face artificial light sources, including light sources controlled by the photo control itself.
- L. Install outdoor photo controls so that connections are weatherproof. Do not install photo controls with conduit stem facing up in order to prevent infiltration of water into the photo control.
- M. Daylighting Control Photo Sensor Locations:
 - 1. Location Adjustments: Locations indicated are diagrammatic and only intended to indicate which rooms or areas require devices. Provide quantity and locations as required for proper control of respective room or area based on manufacturer's recommendations for installed devices.
 - 2. Unless otherwise indicated, locate photo sensors for closed loop systems to accurately measure the light level controlled at the designated task location, while minimizing the measured amount of direct light from natural or artificial sources such as windows or pendant luminaires.
 - 3. Unless otherwise indicated, locate photo sensors for open loop systems to accurately measure the level of daylight coming into the space, while minimizing the measured

amount of lighting from artificial sources.

- N. Lamp Burn-In: Operate lamps at full output for minimum of 100 hours or prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.

3.4 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect each lighting control device for damage and defects.
- C. Test occupancy sensors to verify proper operation, including time delays and ambient light thresholds where applicable. Verify optimal coverage for entire room or area. Record test results in written report to be included with submittals.
- D. Test time switches to verify proper operation.
- E. Test outdoor photo controls to verify proper operation, including time delays where applicable.
- F. Test daylighting controls to verify proper operation, including light level measurements and time delays where applicable. Record test results in written report to be included with submittals.
- G. Correct wiring deficiencies and replace damaged or defective lighting control devices.

3.5 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.
- B. Adjust occupancy sensor settings to minimize undesired activations while optimizing energy savings, and to achieve desired function as indicated or as directed by Engineer.
- C. Adjust position of directional occupancy sensors and outdoor motion sensors to achieve optimal coverage as required.
- D. Where indicated or as directed by Architect, install factory masking material or adjust integral blinders on passive infrared (PIR) and dual technology occupancy sensor lenses to block undesired motion detection.
- E. Adjust time switch settings to achieve desired operation schedule as indicated or as directed by Engineer. Record settings in written report to be included with submittals.
- F. Adjust external sliding shields on outdoor photo controls under optimum lighting conditions to achieve desired turn-on and turn-off activation as indicated or as directed by Engineer.
- G. Adjust daylighting controls under optimum lighting conditions after all room finishes, furniture, and window treatments have been installed to achieve desired operation as indicated or as directed by Architect. Record settings in written report to be included with submittals. Readjust controls calibrated prior to installation of final room finishes, furniture, and window treatments

that do not function properly as determined by Engineer.

3.6 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.7 COMMISSIONING

- A. See Section 01 91 13 - General Commissioning Requirements for commissioning requirements.

3.8 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 - Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of lighting control devices to Engineer, and correct deficiencies or make adjustments as directed.
- D. Training: Train Owner's personnel on operation, adjustment, programming, and maintenance of lighting control devices.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.
 - 3. Instructor: Qualified contractor familiar with the project and with sufficient knowledge of the installed lighting control devices.
 - 4. Location: At project site.

END OF SECTION 26 09 23

SECTION 26 21 00 - LOW-VOLTAGE ELECTRICAL SERVICE ENTRANCE

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Electrical service requirements.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 03 30 00 - Cast-in-Place Concrete: Materials and installation requirements for cast-in-place concrete equipment pads.
- B. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
- C. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- D. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- E. Section 26 05 33.13 - Conduit for Electrical Systems.
- F. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- G. Section 26 24 13 - Switchboards: Service entrance equipment.
- H. Section 26 24 16 - Panelboards: Service entrance equipment.
- I. Section 26 27 13 - Electricity Metering: Non-utility electrical metering.
- J. Section 26 28 16.16 - Enclosed Switches: Service entrance equipment.
- K. Section 26 36 00 - Transfer Switches: Service entrance equipment.
- L. Section 26 43 00 - Surge Protective Devices: Service entrance surge protective devices.
- M. Section 31 23 16.13 - Trenching: Excavating, bedding, and backfilling.

1.4 PRICE AND PAYMENT PROCEDURES

- A. Unit Prices:
 - 1. See Section 01 22 00 - Unit Prices, for additional unit price requirements.
 - 2. Primary:

- a. Basis of Measurement: By the lineal foot, for each configuration.
 - b. Basis of Payment: Includes all work designated to be provided by Contractor in "Division of Responsibility" under Part 2 article "Electrical Service Requirements" below, including purchase, delivery, and installation, and as indicated on plans.
3. Secondary:
- a. Basis of Measurement: By the lineal foot, for each configuration.
 - b. Basis of Payment: Includes all work designated to be provided by Contractor in "Division of Responsibility" under Part 2 article "Electrical Service Requirements" below, including purchase, delivery, and installation, and as indicated on plans.
4. Transformer Pad/Vault:
- a. Basis of Measurement: Per unit, for each type.
 - b. Basis of Payment: Includes purchase, delivery, and installation.

1.5 DEFINITIONS

- A. Service Point: The point of connection between the facilities of the serving utility and the premises wiring as defined in NFPA 70, and as designated by the Utility Company.

1.6 REFERENCE STANDARDS

- A. IEEE C2 - National Electrical Safety Code 2017.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.7 ADMINISTRATIVE REQUIREMENTS

- A. No later than two weeks following date of the Agreement, notify Utility Company of anticipated date of service.
- B. Coordination:
 1. Verify the following with Utility Company representative:
 - a. Utility Company requirements, including division of responsibility.
 - b. Exact location and details of utility point of connection.
 - c. Utility easement requirements.
 - d. Utility Company charges associated with providing service.

2. Coordinate the work with other trades to avoid placement of other utilities or obstructions within the spaces dedicated for electrical service and associated equipment.
 3. Coordinate arrangement of service entrance equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 4. Coordinate the work with other installers to provide communication lines required for Utility Company meters.
 5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- C. Arrange for Utility Company to provide permanent electrical service. Prepare and submit documentation required by Utility Company.
- D. Utility Company charges associated with providing permanent service to be paid by Owner.
- E. Preinstallation Meeting: Convene one week prior to commencing work of this section to review service requirements and details with Utility Company representative.
- F. Scheduling:
1. Where work of this section involves interruption of existing electrical service, arrange service interruption with Owner.
 2. Arrange for inspections necessary to obtain Utility Company approval of installation.

1.8 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product. Include ratings, configurations, standard wiring diagrams, outline and support point dimensions, finishes, weights, service condition requirements, and installed features.
- C. Shop Drawings: Include dimensioned plan views and sections indicating locations and arrangement of Utility Company and service entrance equipment, metering provisions, required clearances, and proposed service routing.
1. Obtain Utility company approval of shop drawings prior to submittal.
- D. Project Record Documents: Record actual locations of equipment and installed service routing.

1.9 QUALITY ASSURANCE

- A. Comply with the following:
1. IEEE C2 (National Electrical Safety Code).
 2. NFPA 70 (National Electrical Code).

3. The requirements of the Utility Company.
 4. The requirements of the local authorities having jurisdiction.
 - B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
 - C. Products: Listed, classified, and labeled as suitable for the purpose intended.
 - D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.
- 1.10 DELIVERY, STORAGE, AND HANDLING
- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.
 - B. Store products indoors in a clean, dry space having a uniform temperature to prevent condensation (including outdoor rated products which are not weatherproof until completely and properly installed). Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
 - C. Handle products carefully to avoid damage to internal components, enclosure, and finish.

PART 2 PRODUCTS

2.1 ELECTRICAL SERVICE REQUIREMENTS

- A. Provide new electrical service consisting of all required conduits, conductors, equipment, metering provisions, supports, accessories, etc. as necessary for connection between Utility Company point of supply and service entrance equipment.
- B. Provide all work to disconnect and re-energize existing 208Y/120V electric service as required for installation of new second service to the building.
- C. Electrical Service Characteristics: As indicated on drawings.
- D. Utility Company: As indicated on drawings.
- E. Division of Responsibility:
 1. Pad-Mounted Utility Transformers:
 - a. Transformer Vaults and Pads: Furnished and installed by Contractor per Utility Company requirements.
 - b. Transformers: Furnished and installed by Utility Company.
 - c. Transformer Grounding Provisions: Furnished and installed by Contractor per Utility Company requirements.

- d. Transformer Protective Bollards: Furnished and installed by Contractor per Utility Company requirements.
- e. Primary:
 - 1) Trenching and Backfilling: Provided by Contractor.
 - 2) Conduits: Furnished and installed by Contractor.
 - 3) Conductors: Furnished and installed by Utility Company.
- f. Secondary:
 - 1) Trenching and Backfilling: Provided by Contractor.
 - 2) Conduits: Furnished and installed by Contractor.
 - 3) Conductors: Furnished and installed by Contractor (Service Point at transformer).
- 2. Terminations at Service Point: Provided by Utility Company.
- 3. Metering Provisions:
 - a. Meter Bases: Furnished and installed by Contractor per Utility Company requirements.
 - b. Metering Transformer Cabinets: Furnished and installed by Contractor per Utility Company requirements.
 - c. Metering Transformers: Furnished and installed by Utility Company.
 - d. Conduits Between Metering Transformers and Meters: Furnished and installed by Contractor per Utility Company requirements.
 - e. Wiring Between Metering Transformers and Meters: Furnished and installed by Utility Company.
 - f. Communications Conduits for Meters: Furnished and installed by Contractor per Utility Company requirements.

F. Products Furnished by Contractor: Comply with Utility Company requirements.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that ratings and configurations of service entrance equipment are consistent with the indicated requirements.

- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A. Verify and mark locations of existing underground utilities.

3.3 INSTALLATION

- A. Install products in accordance with manufacturer's instructions and Utility Company requirements.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances and required maintenance access.
- D. Provide required trenching and backfilling in accordance with Division 31.
- E. Construct cast-in-place concrete pads for utility equipment in accordance with Utility Company requirements and Section 03 30 00.
- F. Provide required protective bollards in accordance with Utility Company requirements.
- G. Provide required support and attachment components in accordance with Section 26 05 29.
- H. Provide grounding and bonding for service entrance equipment in accordance with Section 26 05 26.
- I. Identify service entrance equipment, including main service disconnect(s) in accordance with Section 26 05 53.

3.4 PROTECTION

- A. Protect installed equipment from subsequent construction operations.

END OF SECTION 26 21 00

SECTION 26 22 00 - LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. General purpose transformers.

1.2 RELATED REQUIREMENTS

- A. Section 03 30 00 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- C. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- D. Section 26 05 33.13 - Conduit for Electrical Systems: Flexible conduit connections.
- E. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
 - 1. Includes requirements for the seismic qualification of equipment specified in this section.
- F. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.

1.3 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.4 REFERENCE STANDARDS

- A. 10 CFR 431, Subpart K - Energy Efficiency Program for Certain Commercial and Industrial Equipment - Distribution Transformers Current Edition.
- B. IEEE C57.94 - IEEE Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type Distribution and Power Transformers 2015.
- C. IEEE C57.96 - IEEE Standard Guide for Loading Dry-Type Distribution and Power Transformers 2013.
- D. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- E. NECA 409 - Standard for Installing and Maintaining Dry-Type Transformers 2015.
- F. NEMA ST 20 - Dry-Type Transformers for General Applications 2014.
- G. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.

- H. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- I. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- J. UL 506 - Standard for Specialty Transformers Current Edition, Including All Revisions.
- K. UL 1561 - Standard for Dry-Type General Purpose and Power Transformers Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate the work with placement of supports, anchors, etc. required for mounting.
 - 4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Include voltage, kVA, impedance, tap configurations, insulation system class and rated temperature rise, efficiency, sound level, enclosure ratings, outline and support point dimensions, weight, required clearances, service condition requirements, and installed features.
 - 1. Vibration Isolators: Include attachment method and rated load and deflection.
- C. Shop Drawings: Provide dimensioned plan and elevation views of transformers and adjacent equipment with all required clearances indicated.
 - 1. Identify mounting conditions required for equipment seismic qualification.
- D. Manufacturer's equipment seismic qualification certification.
- E. Source Quality Control Test Reports: Include reports for tests designated in NEMA ST 20 as design and routine tests.
- F. Field Quality Control Test Reports.

- G. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- H. Maintenance Data: Include recommended maintenance procedures and intervals.
- I. Project Record Documents: Record actual locations of transformers.

1.7 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.

1.9 FIELD CONDITIONS

- A. Ambient Temperature: Do not exceed the following maximum temperatures during and after installation of transformers.
 - 1. Greater than 10 kVA: 104 degrees F maximum.
 - 2. Less than 10 kVA: 77 degrees F maximum.

1.10 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Eaton Corporation; [____]: www.eaton.com/#sle.
- B. Schneider Electric; Square D Products; BASIS OF DESIGN: www.schneider-electric.us/#sle.

- C. Siemens Industry, Inc; [____]: www.usa.siemens.com/#sle.
- D. Substitutions: See Section 01 60 00 - Product Requirements.
- E. Source Limitations: Furnish transformers produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.2 TRANSFORMERS - GENERAL REQUIREMENTS

- A. Description: Factory-assembled, dry type transformers for 60 Hz operation designed and manufactured in accordance with NEMA ST 20 and listed, classified, and labeled as suitable for the purpose intended.
- B. Seismic Qualification: Provide transformers suitable for application under seismic design criteria in accordance with Section 26 05 48 where required. Include certification of compliance with submittals.
- C. Unless noted otherwise, transformer ratings indicated are for continuous loading according to IEEE C57.96 under the following service conditions:
 - 1. Altitude: Less than 3,300 feet.
 - 2. Ambient Temperature:
 - a. Greater than 10 kVA: Not exceeding 104 degrees F.
 - b. Less than 10 kVA: Not exceeding 77 degrees F.
- D. Core: High grade, non-aging silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Keep magnetic flux densities substantially below saturation point, even at 10 percent primary overvoltage. Tightly clamp core laminations to prevent plate movement and maintain consistent pressure throughout core length.
- E. Impregnate core and coil assembly with non-hydroscopic thermo-setting varnish to effectively seal out moisture and other contaminants.
- F. Basic Impulse Level: 10 kV.
- G. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.
- H. Isolate core and coil from enclosure using vibration-absorbing mounts.
- I. Nameplate: Include transformer connection data, ratings, wiring diagrams, and overload capacity based on rated winding temperature rise.

2.3 GENERAL PURPOSE TRANSFORMERS

- A. Description: Self-cooled, two winding transformers listed and labeled as complying with UL 506 or UL 1561; ratings as indicated on the drawings.

- B. Insulation System and Allowable Average Winding Temperature Rise:
 - 1. Less than 15 kVA: Class 180 degrees C insulation system with 115 degrees C average winding temperature rise.
 - 2. 15 kVA and Larger: Class 220 degrees C insulation system with 150 degrees C average winding temperature rise.
- C. Coil Conductors: Continuous aluminum windings with terminations brazed or welded.
- D. Winding Taps:
 - 1. Less than 3 kVA: None.
 - 2. 3 kVA through 15 kVA: Two 5 percent full capacity primary taps below rated voltage.
 - 3. 15 kVA through 300 kVA: Two 2.5 percent full capacity primary taps above and four 2.5 percent full capacity primary taps below rated voltage.
 - 4. 500 kVA and Larger: Two 2.5 percent full capacity primary taps above and two 2.5 percent full capacity primary taps below rated voltage.
- E. Energy Efficiency: Comply with 10 CFR 431, Subpart K.
- F. Sound Levels: Standard sound levels complying with NEMA ST 20
- G. Mounting Provisions:
 - 1. Less than 15 kVA: Suitable for wall mounting.
 - 2. 15 kVA through 75 kVA: Suitable for wall, floor, or trapeze mounting.
 - 3. Larger than 75 kVA: Suitable for floor mounting.
- H. Transformer Enclosure: Comply with NEMA ST 20.
 - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - 2. Construction: Steel.
 - a. Less than 15 kVA: Totally enclosed, non-ventilated.
 - b. 15 kVA and Larger: Ventilated.
 - 3. Finish: Manufacturer's standard grey, suitable for outdoor installations.
 - 4. Provide lifting eyes or brackets.
- I. Accessories:
 - 1. Mounting Brackets: Provide manufacturer's standard brackets.

2. Lug Kits: Sized as required for termination of conductors as indicated on the drawings.

2.4 SOURCE QUALITY CONTROL

- A. Factory test transformers according to NEMA ST 20.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that suitable support frames and anchors are installed where required and that mounting surfaces are ready to receive transformers.
- C. Perform pre-installation tests and inspections on transformers per manufacturer's instructions and as specified in NECA 409. Correct deficiencies prior to installation.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install transformers in accordance with NECA 409 and IEEE C57.94.
- D. Use flexible conduit, under the provisions of Section 26 05 33.13, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.
- E. Arrange equipment to provide minimum clearances as specified on transformer nameplate and in accordance with manufacturer's instructions and NFPA 70.
- F. Install transformers plumb and level.
- G. Transformer Support:
 1. Provide required support and attachment in accordance with Section 26 05 29, where not furnished by transformer manufacturer.
 2. Use integral transformer flanges, accessory brackets furnished by manufacturer, or field-fabricated supports to support wall-mounted transformers.
 3. Unless otherwise indicated, mount floor-mounted transformers on properly sized 3 inch high concrete pad constructed in accordance with Section 03 30 00.
 4. Use trapeze hangers assembled from threaded rods and metal channel (strut) to support suspended transformers. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.

- H. Provide grounding and bonding in accordance with Section 26 05 26.
- I. Remove shipping braces and adjust bolts that attach the core and coil mounting bracket to the enclosure according to manufacturer's recommendations in order to reduce audible noise transmission.
- J. Where not factory-installed, install lugs sized as required for termination of conductors as indicated.
- K. Identify transformers in accordance with Section 26 05 53.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS Sections 7.2.1.1 and 7.2.1.2. Tests and inspections listed as optional are not required.

3.4 ADJUSTING

- A. Measure primary and secondary voltages and make appropriate tap adjustments.
- B. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.5 CLEANING

- A. Clean dirt and debris from transformer components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION 26 22 00

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SECTION 26 24 13 - SWITCHBOARDS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Low-voltage (600 V and less) switchboards and associated accessories for service and distribution applications.
- B. Overcurrent protective devices for switchboards.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 03 30 00 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- C. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- D. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
 - 1. Includes requirements for the seismic qualification of equipment specified in this section.
- E. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 26 05 73 - Power System Studies: Additional criteria for the selection and adjustment of equipment and associated protective devices specified in this section.
- G. Section 26 21 00 - Low-Voltage Electrical Service Entrance.
- H. Section 26 27 13 - Electricity Metering: For interface with equipment specified in this section.
- I. Section 26 43 00 - Surge Protective Devices.

1.4 REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service 2013e (Amended 2017).
- B. IEEE C57.13 - IEEE Standard Requirements for Instrument Transformers 2016.
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- D. NECA 400 - Standard for Installing and Maintaining Switchboards 2007.

- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- F. NEMA PB 2 - Deadfront Distribution Switchboards 2011.
- G. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less 2013.
- H. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- I. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- J. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures Current Edition, Including All Revisions.
- K. UL 869A - Reference Standard for Service Equipment Current Edition, Including All Revisions.
- L. UL 891 - Switchboards Current Edition, Including All Revisions.
- M. UL 1053 - Ground-Fault Sensing and Relaying Equipment Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
4. Coordinate with manufacturer to provide shipping splits suitable for the dimensional constraints of the installation.
5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Service Entrance Switchboards:

1. Coordinate with Utility Company to provide switchboards with suitable provisions for electrical service and utility metering, where applicable.

2. Coordinate with Owner to arrange for Utility Company required access to equipment for installation and maintenance.
3. Obtain Utility Company approval of switchboard prior to fabrication.
4. Preinstallation Meeting: Convene one week prior to commencing work of this section to review requirements with Utility Company representative.
5. Arrange for inspections necessary to obtain Utility Company approval of installation.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for switchboards, enclosures, overcurrent protective devices, and other installed components and accessories.
 1. Include characteristic trip curves for each type and rating of overcurrent protective device upon request.
- C. Shop Drawings: Indicate dimensions, voltage, bus ampacities, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 1. Include dimensioned plan and elevation views of switchboards and adjacent equipment with all required clearances indicated.
 2. Identify mounting conditions required for equipment seismic qualification.
 3. Shop drawing will not be reviewed prior to final review and acceptance of Power System Study by Engineer.
- D. Manufacturer's equipment seismic qualification certification.
- E. Service Entrance Switchboards: Include documentation of Utility Company approval of switchboard.
- F. Source Quality Control Test Reports: Include reports for tests designated in NEMA PB 2 as production (routine) tests.
- G. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- H. Field Quality Control Test Reports.
- I. Project Record Documents: Record actual installed locations of switchboards and final equipment settings.

- J. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.
- K. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.
 - 2. Enclosure Keys: Two of each different key.
 - 3. Electronic Trip Circuit Breakers: Provide one portable test set.

1.7 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store switchboards in accordance with manufacturer's instructions, NECA 400, and NEMA PB 2.1.
- B. Store in a clean, dry space having a uniform temperature to prevent condensation (including outdoor switchboards, which are not weatherproof until completely and properly installed). Where necessary, provide temporary enclosure space heaters or temporary power for permanent factory-installed space heaters.
- C. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- D. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.9 FIELD CONDITIONS

- A. Maintain field conditions within required service conditions during and after installation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Switchboards - Basis of Design: Schneider Electric; Square D Products<>: www.schneider-electric.us/#sle..

- B. Switchboards - Other Acceptable Manufacturers:
 - 1. Eaton Corporation; [_____]: www.eaton.com/#sle.
 - 2. Siemens Industry, Inc: www.usa.siemens.com/#sle.
- C. Substitutions: See Section 01 60 00 - Product Requirements.
- D. Products other than basis of design are subject to compliance with specified requirements and prior approval of Engineer. By using products other than basis of design, Contractor accepts responsibility for costs associated with any necessary modifications to related work, including any design fees.
- E. Source Limitations: Furnish switchboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.2 SWITCHBOARDS

- A. Provide switchboards consisting of all required components, control power transformers, instrumentation and control wiring, accessories, etc. as necessary for a complete operating system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Description: Dead-front switchboard assemblies complying with NEMA PB 2, and listed and labeled as complying with UL 891; ratings, configurations and features as indicated on the drawings.
- D. Service Entrance Switchboards:
 - 1. Listed and labeled as suitable for use as service equipment according to UL 869A.
 - 2. For solidly-grounded wye systems, provide factory-installed main bonding jumper between neutral and ground busses, and removable neutral disconnecting link for testing purposes.
 - 3. Comply with Utility Company requirements for electrical service.
 - 4. Utility Metering Provisions: Provide separate barriered compartment complying with Utility Company requirements where indicated or where required by Utility Company. Include hinged sealable door and provisions for Utility Company current transformers (CTs), potential transformers (PTs), or potential taps as required.
 - 5. See Section 26 21 00 for additional requirements.
- E. Seismic Qualification: Provide switchboards and associated components suitable for application under the seismic design criteria specified in Section 26 05 48 where required. Include certification of compliance with submittals.

F. Service Conditions:

1. Provide switchboards and associated components suitable for operation under the following service conditions without derating:
 - a. Altitude: Less than 6,600 feet.
 - b. Ambient Temperature:
 - 1) Switchboards Containing Molded Case or Insulated Case Circuit Breakers: Between 23 degrees F and 104 degrees F.
 - 2) Switchboards Containing Fusible Switches: Between -22 degrees F and 104 degrees F.
2. Provide switchboards and associated components suitable for operation at indicated ratings under the service conditions at the installed location.

G. Short Circuit Current Rating:

1. Provide switchboards with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73.
2. Minimum Rating: 65,000 rms symmetrical amperes.
3. Listed series ratings are not acceptable.
4. Label equipment utilizing series ratings as required by NFPA 70.

H. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.

I. Main Devices: Configure for top or bottom incoming feed as indicated or as required for the installation. Provide separate pull section and/or top-mounted pullbox as indicated or as required to facilitate installation of incoming feed.

J. Bussing: Sized in accordance with UL 891 temperature rise requirements.

1. Through bus (horizontal cross bus) to be fully rated through full length of switchboard (non-tapered). Tapered bus is not permitted.
2. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
3. Provide solidly bonded equipment ground bus through full length of switchboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
4. Phase and Neutral Bus Material: Aluminum.
5. Ground Bus Material: Aluminum.

- K. Conductor Terminations: Suitable for use with the conductors to be installed.
1. Line Conductor Terminations:
 - a. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - b. Main and Neutral Lug Type: Mechanical.
 2. Load Conductor Terminations:
 - a. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - b. Lug Type:
 - 1) Provide mechanical lugs unless otherwise indicated.

- L. Enclosures:
1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1 or Type 2 (drip-proof).
 - b. Outdoor Locations: Type 3R.
 2. Finish: Manufacturer's standard unless otherwise indicated.
 3. Enclosure Space Heaters:
 - a. Provide in each switchboard section installed outdoors and in unconditioned indoor spaces.
 - b. Size according to manufacturer's recommendations for worst case ambient temperature to prevent condensation.
 - c. Heater Control: Thermostat.
 - d. Heater Power Source: Provide connection to transformer factory-installed in switchboard or suitable external branch circuit as indicated or as required.
 4. Outdoor Enclosures:
 - a. Color: Manufacturer's standard.
 - b. Access Doors: Lockable, with all locks keyed alike.

- M. Future Provisions:
1. Prepare designated spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.

2. Equip distribution sections with full height vertical bussing to accommodate maximum utilization of space for devices.
 3. Arrange and equip through bus and ground bus to accommodate future installation of additional switchboard sections.
- N. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 43 00, list switchboards as a complete assembly including surge protective device.
- O. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
1. Where overcurrent protective devices equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
 2. Where accessory ground fault sensing and relaying equipment is used, equip companion overcurrent protective devices with ground-fault shunt trips.
 - a. Use zero sequence or residual ground fault detection method unless otherwise indicated.
 - b. Provide test panel and field-adjustable ground fault pick-up and delay settings.
- P. Arc Flash Energy-Reducing Maintenance Switching: For circuit breakers rated 1200 A or higher, provide a local accessory switch with status indicator light that permits selection of a maintenance mode with alternate electronic trip unit settings for reduced fault clearing time.
- Q. Owner Metering: Comply with Section 26 27 13.
- R. Instrument Transformers:
1. Comply with IEEE C57.13.
 2. Select suitable ratio, burden, and accuracy as required for connected devices.
 3. Current Transformers: Connect secondaries to shorting terminal blocks.
 4. Potential Transformers: Include primary and secondary fuses with disconnecting means.

2.3 OVERCURRENT PROTECTIVE DEVICES

A. Circuit Breakers:

1. Interrupting Capacity:
 - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than specified minimum requirements.
 - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.

2. Molded Case Circuit Breakers:

- a. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers; listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
 - 1) Provide thermal magnetic circuit breakers unless otherwise indicated.
 - 2) Provide electronic trip circuit breakers for circuit breaker frame sizes 225 amperes and above.
- b. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
 - 1) Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
- c. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
 - 1) Provide the following field-adjustable trip response settings:
 - (a) Long time pickup, adjustable by setting dial.
 - (b) Long time delay.
 - (c) Short time pickup and delay.
 - (d) Instantaneous pickup.
 - (e) Ground fault pickup and delay where ground fault protection is indicated.
- d. Provide the following circuit breaker types where indicated:
 - 1) 100 Percent Rated Circuit Breakers: Listed for application within the switchboard where installed at 100 percent of the continuous current rating.
 - 2) Current Limiting Circuit Breakers: Without using fusible elements, designed to limit the let-through energy to a value less than the energy of a one-half cycle wave of the symmetrical prospective current when operating within its current limiting range.
- e. Provide the following features and accessories where indicated or where required to complete installation:
 - 1) Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.

- 2) Pad-Lock Provision: For locking circuit breaker handle in OFF position.
 - 3) Auxiliary Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped or been turned off.
 - 4) Alarm Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped.
3. Insulated Case Circuit Breakers:
- a. Description: Quick-make, quick-break, trip-free circuit breakers with two-step stored energy closing mechanism; standard 80 percent rated unless otherwise indicated; listed and labeled as complying with UL 489; ratings, configurations, and features as indicated on the drawings.
 - b. Trip Units: Solid state, microprocessor-based, true rms sensing.
 - 1) Provide the following field-adjustable trip response settings:
 - (a) Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.
 - (b) Long time delay.
 - (c) Short time pickup and delay.
 - (d) Instantaneous pickup.
 - (e) Ground fault pickup and delay where ground fault protection is indicated.
 - c. Provide the following circuit breaker types where indicated:
 - 1) 100 Percent Rated Circuit Breakers: Listed for application within the switchboard where installed at 100 percent of the continuous current rating.
 - 2) Current Limiting Circuit Breakers: Without using fusible elements, designed to limit the let-through energy to a value less than the energy of a one-half cycle wave of the symmetrical prospective current when operating within its current limiting range.
 - d. Provide the following features and accessories where indicated or where required to complete installation:
 - 1) Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.
 - 2) Auxiliary Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped or been turned off.

- 3) Alarm Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped.

2.4 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Factory test switchboards according to NEMA PB 2, including the following production (routine) tests on each switchboard assembly or component:
 1. Dielectric tests.
 2. Mechanical operation tests.
 3. Grounding of instrument transformer cases test.
 4. Electrical operation and control wiring tests, including polarity and sequence tests.
 5. Ground-fault sensing equipment test.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of the switchboards and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive switchboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install switchboards in accordance with NECA 1 (general workmanship), NECA 400, and NEMA PB 2.1.
- C. Arrange equipment to provide required clearances and maintenance access, including accommodations for any drawout devices.
- D. Where switchboard is indicated to be mounted with inaccessible side against wall, provide minimum clearance of 1/2 inch between switchboard and wall.
- E. Provide required support and attachment in accordance with Section 26 05 29.
- F. Install switchboards plumb and level.

- G. Unless otherwise indicated, mount switchboards on properly sized 4 inch high concrete pad constructed in accordance with Section 03 30 00.
- H. Provide grounding and bonding in accordance with Section 26 05 26.
- I. Install all field-installed devices, components, and accessories.
- J. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- K. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed in accordance with Section 26 05 73.
- L. Set field-adjustable ground fault protection pickup and time delay settings as indicated.
- M. Provide filler plates to cover unused spaces in switchboards.
- N. Identify switchboards in accordance with Section 26 05 53.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Disconnect surge protective devices (SPDs) prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPDs connected.
- C. Before energizing switchboard, perform insulation resistance testing in accordance with NECA 400 and NEMA PB 2.1.
- D. Inspect and test in accordance with NETA ATS, except Section 4.
- E. Perform inspections and tests listed in NETA ATS, Section 7.1.
- F. Molded Case and Insulated Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than [] amperes. Tests listed as optional are not required.
- G. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
 - 1. Perform inspections and tests listed in NETA ATS, Section 7.14. The insulation-resistance test on control wiring listed as optional is not required.
- H. Instrument Transformers: Perform inspections and tests listed in NETA ATS, Section 7.10. The dielectric withstand tests on primary windings with secondary windings connected to ground listed as optional are not required.
- I. Test shunt trips to verify proper operation.
- J. Correct deficiencies and replace damaged or defective switchboards or associated components.

3.4 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of switchboard covers and doors.

3.5 CLEANING

- A. Clean dirt and debris from switchboard enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred surfaces to match original factory finish.

3.6 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 - Demonstration and Training, for additional requirements.
- C. Training: Train Owner's personnel on operation, adjustment, and maintenance of switchboard and associated devices.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.
 - 3. Instructor: Manufacturer's authorized representative.
 - 4. Location: At project site.

3.7 PROTECTION

- A. Protect installed switchboards from subsequent construction operations.

END OF SECTION 26 24 13

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SECTION 26 24 16 - PANELBOARDS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Power distribution panelboards.
- B. Lighting and appliance panelboards.
- C. Overcurrent protective devices for panelboards.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 03 30 00 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- C. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- D. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
 - 1. Includes requirements for the seismic qualification of equipment specified in this section.
- E. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 26 05 73 - Power System Studies: Additional criteria for the selection and adjustment of equipment and associated protective devices specified in this section.
- G. Section 26 43 00 - Surge Protective Devices.

1.4 REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service 2013e (Amended 2017).
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NECA 407 - Standard for Installing and Maintaining Panelboards 2015.
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- E. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts 2008 (Reaffirmed 2020).

- F. NEMA PB 1 - Panelboards 2011.
 - G. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less 2013.
 - H. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
 - I. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
 - J. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
 - K. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
 - L. UL 67 - Panelboards Current Edition, Including All Revisions.
 - M. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures Current Edition, Including All Revisions.
 - N. UL 869A - Reference Standard for Service Equipment Current Edition, Including All Revisions.
 - O. UL 943 - Ground-Fault Circuit-Interrupters Current Edition, Including All Revisions.
 - P. UL 1053 - Ground-Fault Sensing and Relaying Equipment Current Edition, Including All Revisions.
 - Q. UL 1699 - Arc-Fault Circuit-Interrupters Current Edition, Including All Revisions.
- 1.5 SUBMITTALS
- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
 - B. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
 - C. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 - 1. Include dimensioned plan and elevation views of panelboards and adjacent equipment with all required clearances indicated.
 - 2. Include wiring diagrams showing all factory and field connections.
 - 3. Identify mounting conditions required for equipment seismic qualification.

4. Shop drawing will not be reviewed prior to final review and acceptance of Power System Study by Engineer.

- D. Manufacturer's equipment seismic qualification certification.
- E. Source Quality Control Test Reports: Include reports for tests designated in NEMA PB 1 as routine tests.
- F. Field Quality Control Test Reports.
- G. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- H. Project Record Documents: Record actual installed locations of panelboards and actual installed circuiting arrangements.
- I. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.
- J. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.
 - 2. Panelboard Keys: Two of each different key.

1.6 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

1.8 FIELD CONDITIONS

- A. Maintain ambient temperature within the following limits during and after installation of panelboards:

1. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Eaton Corporation; [____]: www.eaton.com/#sle.
- B. Schneider Electric; Square D Products; BASIS OF DESIGN: www.schneider-electric.us/#sle.
- C. Siemens Industry, Inc; [____]: www.usa.siemens.com/#sle.
- D. Substitutions: See Section 01 60 00 - Product Requirements.
- E. Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.2 PANELBOARDS - GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Seismic Qualification: Provide panelboards and associated components suitable for application under the seismic design criteria specified in Section 26 05 48 where required. Include certification of compliance with submittals.
- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
1. Altitude: Less than 6,600 feet.
2. Ambient Temperature:
- a. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.
- b. Panelboards Containing Fusible Switches: Between -22 degrees F and 104 degrees F.
- D. Short Circuit Current Rating:
1. Provide panelboards with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73.
2. Listed series ratings are not acceptable.

- E. Panelboards Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- F. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.
- G. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.
- H. Bussing: Sized in accordance with UL 67 temperature rise requirements.
 - 1. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
 - 2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
- I. Conductor Terminations: Suitable for use with the conductors to be installed.
- J. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
 - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R.
 - 2. Boxes: Galvanized steel unless otherwise indicated.
 - a. Provide wiring gutters sized to accommodate the conductors to be installed.
 - b. Increase gutter space as required where sub-feed lugs, feed-through lugs, gutter taps, or oversized lugs are provided.
 - c. Provide painted steel boxes for surface-mounted panelboards where indicated, finish to match fronts.
 - 3. Fronts:
 - a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
 - b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
 - c. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
 - 4. Lockable Doors: All locks keyed alike unless otherwise indicated.

- K. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
- L. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 43 00, list and label panelboards as a complete assembly including surge protective device.
- M. Panelboard Contactors: Where panelboard contactors are indicated, provide electrically operated, mechanically held magnetic contactor complying with NEMA ICS 2.
 - 1. Ampere Rating: Not less than ampere rating of panelboard bus.
 - 2. Short Circuit Current Rating: Not less than the panelboard short circuit current rating.
 - 3. Coil Voltage: As required for connection to control system indicated.
- N. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
 - 1. Where electronic circuit breakers equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
 - 2. Where accessory ground fault sensing and relaying equipment is used, equip companion overcurrent protective devices with ground-fault shunt trips.
 - a. Use zero sequence ground fault detection method unless otherwise indicated.
 - b. Provide test panel and field-adjustable ground fault pick-up and delay settings.
- O. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.
- P. Multi-Section Panelboards: Provide enclosures of the same height, with feed-through lugs or sub-feed lugs and feeders as indicated or as required to interconnect sections.
- Q. Load centers are not acceptable.
- R. Provide the following features and accessories where indicated or where required to complete installation:
 - 1. Feed-through lugs.
 - 2. Sub-feed lugs.

2.3 POWER DISTRIBUTION PANELBOARDS

- A. Description: Panelboards complying with NEMA PB 1, power and feeder distribution type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Conductor Terminations:

1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
2. Main and Neutral Lug Type: Mechanical.
- C. Bussing:
 1. Phase and Neutral Bus Material: Aluminum.
 2. Ground Bus Material: Aluminum.
- D. Circuit Breakers:
 1. Provide bolt-on type or plug-in type secured with locking mechanical restraints.
- E. Enclosures:
 1. Provide surface-mounted or flush-mounted enclosures as indicated.
 2. Fronts: Provide door-in-door trim with hinged cover for access to load terminals and wiring gutters, and separate lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
 3. Provide clear plastic circuit directory holder mounted on inside of door.

2.4 LIGHTING AND APPLIANCE PANELBOARDS

- A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Conductor Terminations:
 1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 2. Main and Neutral Lug Type: Mechanical.
- C. Bussing:
 1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
 2. Phase and Neutral Bus Material: Aluminum.
 3. Ground Bus Material: Aluminum.
- D. Circuit Breakers: Thermal magnetic bolt-on type unless otherwise indicated.
- E. Enclosures:

1. Provide surface-mounted or flush-mounted enclosures as indicated.
2. Fronts: Provide door-in-door trim with hinged cover for access to load terminals and wiring gutters, and separate lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
3. Provide clear plastic circuit directory holder mounted on inside of door.

2.5 OVERCURRENT PROTECTIVE DEVICES

A. Molded Case Circuit Breakers:

1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
2. Interrupting Capacity:
 - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
 - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
3. Conductor Terminations:
 - a. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
5. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
 - a. Provide the following field-adjustable trip response settings:
 - 1) Long time pickup, adjustable by setting dial.
 - 2) Long time delay.
 - 3) Short time pickup and delay.
 - 4) Instantaneous pickup.
 - 5) Ground fault pickup and delay where ground fault protection is indicated.
6. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
7. Provide the following circuit breaker types where indicated:

- a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
 - b. Ground Fault Equipment Protection Circuit Breakers: Designed to trip at 30 mA for protection of equipment.
 - c. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Combination type listed as complying with UL 1699.
 - d. 100 Percent Rated Circuit Breakers: Listed for application within the panelboard where installed at 100 percent of the continuous current rating.
 - e. Current Limiting Circuit Breakers: Without using fusible elements, designed to limit the let-through energy to a value less than the energy of a one-half cycle wave of the symmetrical prospective current when operating within its current limiting range.
8. Provide listed switching duty rated circuit breakers with SWD marking where indicated.
 9. Do not use tandem circuit breakers.
 10. Do not use handle ties in lieu of multi-pole circuit breakers.
 11. Provide multi-pole circuit breakers for multi-wire branch circuits as required by NFPA 70.
 12. Provide the following features and accessories where indicated or where required to complete installation:
 - a. Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.
 - b. Handle Pad-Lock Provision: For locking circuit breaker handle in OFF position.
 - c. Auxiliary Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped or been turned off.
 - d. Alarm Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped.

2.6 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Factory test panelboards according to NEMA PB 1.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.

- C. Verify that mounting surfaces are ready to receive panelboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- E. Provide required support and attachment in accordance with Section 26 05 29.
- F. Install panelboards plumb.
- G. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.
- H. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.
- I. Mount floor-mounted power distribution panelboards on properly sized 3 inch high concrete pad constructed in accordance with Section 03 30 00.
- J. Provide minimum of six spare 1 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling and below floor.
- K. Provide grounding and bonding in accordance with Section 26 05 26.
 - 1. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on isolated/insulated ground bus.
 - 2. Terminate branch circuit isolated grounding conductors on isolated/insulated ground bus only. Do not terminate on solidly bonded equipment ground bus.
- L. Install all field-installed branch devices, components, and accessories.
- M. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed according to Section 26 05 73.
- N. Set field-adjustable ground fault protection pickup and time delay settings as indicated.
- O. Provide filler plates to cover unused spaces in panelboards.
- P. Provide circuit breaker lock-on devices to prevent unauthorized personnel from de-energizing essential loads where indicated. Also provide for the following:

1. Emergency and night lighting circuits.
2. Fire detection and alarm circuits.
3. Communications equipment circuits.
4. Intrusion detection and access control system circuits.
5. Video surveillance system circuits.

Q. Identify panelboards in accordance with Section 26 05 53.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Molded Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than [] amperes. Tests listed as optional are not required.
- D. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
 1. Perform inspections and tests listed in NETA ATS, Section 7.14. The insulation-resistance test on control wiring listed as optional is not required.
- E. Test GFCI circuit breakers to verify proper operation.
- F. Test AFCI circuit breakers to verify proper operation.
- G. Test shunt trips to verify proper operation.
- H. Correct deficiencies and replace damaged or defective panelboards or associated components.

3.4 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of panelboard fronts.
- C. Load Balancing: For each panelboard, rearrange circuits such that the difference between each measured steady state phase load does not exceed 20 percent and adjust circuit directories accordingly. Maintain proper phasing for multi-wire branch circuits.

3.5 CLEANING

- A. Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.

- B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION 26 24 16

SECTION 26 27 13.01 - ELECTRICAL MULTI-CHANNEL SUBMETERING

PART 1 GENERAL

1.1 SCOPE

- A. The work under this section defines power & energy submeters, related current sensors and accessories.

B. RELATED DOCUMENTS

1. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."
2. All required drawings, bills of materials (BOM), installation & operations manuals and related technical documents.

C. SUBMITTALS

1. Division 01 – General Requirements
2. Product Data: Submit for the following:
 - a. Meter, and all expansion modules
 - b. Touch screen display
 - c. Enclosure
 - d. Current sensors
 - e. Conductors

D. RELATED STANDARDS

1. The metering unit shall be UL Listed or UL Recognized (installation type dependent)
2. Meters shall be certified by California Type Evaluation Program as complying with Title 4, California Code of Regulations, Article 2.2

E. QUALITY ASSURANCE

1. The manufacturer of this equipment shall have a minimum of 10 years' experience in the design and manufacturing of similar or related electrical equipment.
2. Compliant and certified to ISO-9001, Quality Management Systems
3. Compliant and certified to ISO-17025, General requirements for the competence of testing and calibration laboratories

4. Compliant with requirements of the latest revisions of applicable industry standards.

F. DELIVERY, STORAGE AND HANDLING

1. Deliver material in manufacturer's original unopened protective packaging unless it is built into new distribution equipment.
2. Securely store materials in original packaging in a manner to prevent soiling, physical damage, incursion of moisture or corrosion prior to installation.
3. Handle in a manner to prevent damage to finished surfaces.
4. Maintain protective coverings until installation is complete and remove such covers as part of final clean-up.

G. PROJECT CONDITIONS & COORDINATION

1. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities unless permitted by building owner's representative or construction manager. Two days' notice is required. Do not proceed without written permission.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. The following manufacturers are approved for this application:

1. Basis of Design: SATEC, Inc.
2. Veris
3. E-Mon by Honeywell
4. Substitutions: Refer to Division 01

B. SUBMETERING HARDWARE

1. Each submeter shall include three voltage input channels for the measurement of a three-phase system.
2. The submeter shall support PT inputs as well as direct measurement of 120/208Vac or 277/480Vac input without hardware change or modification.
 - a. The submeter can only operate under one of the reference voltages listed. Projects with metered loads operating at different reference voltages will need a submeter for each reference voltage.
3. Each submeter shall include a minimum of 18 current channel expandable (modular) to 54 channels capable of reading any mix of single or three-phase loads on the same voltage bus

4. Any combination of single or three-phase circuits will be user configurable using any current channels
 - a. Total number of current channels required: as indicated on plans, plus 3 spare.
 - b. Each current channel shall support any configuration of the following split-core current sensors as below:
 - 1) 100A
 - 2) 200A
 - 3) 400A
 - 4) 800A
 - 5) 1,200A
5. The output wires of each current sensors may be spliced with extension cables to a length up to 200 meters without loss of accuracy of the measurements.
6. Meter shall meet the following accuracy standards:
 - a. ANSI C12.20-2010 0.2 Accuracy Class
 - b. EN50470 Class C
7. Primary meter power shall be provided from the voltage sense line and not from a separate source
8. Each submeter shall be capable of both DIN rail or pan mounting for maximum flexibility
9. Each submeter be capable of being embedded in the control panel, distribution panel or separate, external enclosure.
10. Environmental
 - a. Accuracy Operational ambient temperature range: -25 to +60 degrees C
 - b. Operating altitude <3000 meters
11. The meter will be factory-mounted in an enclosure built to NEMA Std. 250, Type 4 and will include circuit protection devices on the voltage channels
12. The metering shall offer the following modular options as required accommodate the specified metering shown on the contract documents:
 - a. Digital input (18 channels) module with 1mS resolution for pulse counting or status inputs (max 4 modules)
 - b. Relay (9 outputs) output module (max 2 modules)

- c. Analog (4 inputs) input module (max 4 modules)
 - d. Redundant power supply for redundant power distribution systems
 - e. Cellular communications (GSM)
 - f. Cellular communications (CDMA)
13. Meter shall include a touch-screen display and shall provide:
- a. Real-time oscillography and vector diagram
 - b. Latest 20 events with date and timestamps
 - c. Customize each submeter or circuit names for easy identification
14. A minimum of 256MB of non-volatile memory is required for remote numeric and waveform data collection or loss of network connection to central energy management system (buffer for latter transmission)
15. All meters shall be factory calibrated with precision test equipment and shall remain accurate for the life of the product eliminating the need for in-service calibration or adjustments.
16. Metering shall be provided for the following loads, and shall be provided at each panel or the output of each specific breaker serving each load, as required:
- a. All HVAC loads
 - b. All Lighting loads
 - c. All general receptacle loads
 - d. All Kitchen loads
 - e. Each Elevator
 - f. All Emergency loads
 - g. All Optional Standby loads
 - h. Load side of Main Service Disconnect

C. SUBMETERING MONITORING & MEASUREMENT CAPABILITIES

- 1. Time-of-use (TOU) supported with 8 energy/demand registers x 8 tariffs, 4 seasons x and 4 types of day, 8 tariff changes per day.
- 2. Automatic 120-day daily profile for energy and maximum demand reading (total and tariff registers) for each submeter

3. Internal event and data recorder
4. Embedded programmable controller (4 control setpoints, programmable thresholds and delays) for each submeter
5. The submeter shall store energy profile information for each metering point in nonvolatile memory. The demand profile period shall be adjustable from 1, 5, 15, 30 and 60 minutes for fixed method and 1, 5, and 15 minutes for sliding method. The meter shall have the ability to sync with external input to the on-board demand input. The meter shall be able to save a minimum of one (1) year of load profile data for all 60-meter points on a 15-minute basis.

D. SOFTWARE

1. Software for meter configuration, power quality analysis and data collection shall be provided at no additional cost.
 - a. Software shall be able to load a previously saved configuration, save a configuration, and re-use a configuration
 - b. Software shall permit configuration of the meters both on line when connected and off line when not connected
 - c. Software shall be able to configure the service type, set PT and CT ratios, set demand type and intervals along with reset capability on a specific day, configure inputs and outputs, set time, add admin and users with different authorization levels, assign meters to tenants, set alarms and limits, and set network parameters
2. Meter shall be compatible with any building or energy management, energy intelligence or SCADA systems that support industry-standard communications protocols

E. COMMUNICATION CAPABILITIES

1. The meter shall provide the following as standard: RS485, Ethernet, USB
2. The meter shall communicate using industry-standard protocols DNP3.0 and/or Modbus.

PART 3 EXECUTION

3.1 INSTALLATION

- A. The contractor shall furnish, install all equipment specified in the contract documents, including all required hardware, wiring, raceways, etc.
- B. All current sensor wiring shall be in minimum 3/4" conduit. (multiple sensors wires routed to same sensor location shall be permitted to occupy same raceway, in accordance with meter mfg installation requirements for proper functionality.)
- C. TESTING

1. Perform factory-specified configuration, validation and installation testing in accordance with applicable agency requirements. A report shall be provided documenting the actions and results of these tests within 30 days of test completion.

D. TRAINING

1. Provide 8 hours of factory training to owner.

E. WARRANTY

1. All equipment shall be free from defect in materials and workmanship under normal use and service for the minimum period of thirty-six (36) months from the date of shipment from factory.

END OF SECTION 26 27 13.01

SECTION 26 27 17 - EQUIPMENT WIRING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Electrical connections to equipment.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 05 33.13 - Conduit for Electrical Systems.
- B. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables (600 V and Less).
- C. Section 26 05 33.16 - Boxes for Electrical Systems.
- D. Section 26 27 26 - Wiring Devices.
- E. Section 26 28 16.16 - Enclosed Switches.

1.4 REFERENCE STANDARDS

- A. NEMA WD 1 - General Color Requirements for Wiring Devices 1999 (Reaffirmed 2020).
- B. NEMA WD 6 - Wiring Devices - Dimensional Specifications 2016.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
 - 2. Determine connection locations and requirements.
- B. Sequencing:
 - 1. Install rough-in of electrical connections before installation of equipment is required.
 - 2. Make electrical connections before required start-up of equipment.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide wiring device manufacturer's catalog information showing dimensions, configurations, and construction.
- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.7 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Cords and Caps: NEMA WD 6; match receptacle configuration at outlet provided for equipment.
 - 1. Colors: Conform to NEMA WD 1.
 - 2. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
 - 3. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Disconnect Switches: As specified in Section 262818 and in individual equipment sections.
- C. Wiring Devices: As specified in Section 26 27 26.
- D. Flexible Conduit: As specified in Section 26 05 33.13.
- E. Wire and Cable: As specified in Section 26 05 19.
- F. Boxes: As specified in Section 26 05 33.16.

2.2 EQUIPMENT CONNECTIONS

- A. Provide field-installed disconnect switch.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.2 ELECTRICAL CONNECTIONS

- A. Make electrical connections in accordance with equipment manufacturer's instructions.
- B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.
- C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- D. Provide receptacle outlet to accommodate connection with attachment plug.
- E. Provide cord and cap where field-supplied attachment plug is required.
- F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
- G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.
- H. Install terminal block jumpers to complete equipment wiring requirements.
- I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

END OF SECTION 26 27 17

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SECTION 26 27 26 - WIRING DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Wall switches.
- B. Receptacles.
- C. Wall plates.
- D. Floor box service fittings.
- E. Poke-through assemblies.
- F. Access floor boxes.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 09 69 00 - Access Flooring.
- B. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables: Manufactured wiring systems for use with access floor boxes with compatible pre-wired connectors.
- C. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- D. Section 26 05 33.16 - Boxes for Electrical Systems.
- E. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 27 10 00 - Structured Cabling: Voice and data jacks.

1.4 REFERENCE STANDARDS

- A. FS W-C-596 - Connector, Electrical, Power, General Specification for 2017h.
- B. FS W-S-896 - Switches, Toggle (Toggle and Lock), Flush-mounted (General Specification) 2017g.
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- D. NECA 130 - Standard for Installing and Maintaining Wiring Devices 2016.
- E. NEMA WD 1 - General Color Requirements for Wiring Devices 1999 (Reaffirmed 2020).

- F. NEMA WD 6 - Wiring Devices - Dimensional Specifications 2016.
- G. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. UL 20 - General-Use Snap Switches Current Edition, Including All Revisions.
- I. UL 498 - Attachment Plugs and Receptacles Current Edition, Including All Revisions.
- J. UL 514D - Cover Plates for Flush-Mounted Wiring Devices Current Edition, Including All Revisions.
- K. UL 943 - Ground-Fault Circuit-Interrupters Current Edition, Including All Revisions.
- L. UL 1310 - Class 2 Power Units Current Edition, Including All Revisions.
- M. UL 1449 - Standard for Surge Protective Devices Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
 - 2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
 - 3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.
 - 4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
 - 5. Coordinate the core drilling of holes for poke-through assemblies with the work covered under other sections.
 - 6. Notify Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.
 - 1. Wall Dimmers: Include derating information for ganged multiple devices.
- C. Samples: One for each type and color of device and wall plate specified.

- D. Certificates for Surge Protection Receptacles: Manufacturer's documentation of listing for compliance with UL 1449.
- E. Field Quality Control Test Reports.
- F. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- G. Operation and Maintenance Data:
- H. Project Record Documents: Record actual installed locations of wiring devices.
- I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.
 - 2. Screwdrivers for Tamper-Resistant Screws: Two for each type of screw.
 - 3. Extra Keys for Locking Switches: Two of each type.
 - 4. Extra Surge Protection Receptacles: Two of each type.
 - 5. Extra Flush Floor Service Fittings: Two of each type.
 - 6. Extra Poke-Through Core Hole Closure Plugs: Two for each core size.

1.7 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Products: Listed, classified, and labeled as suitable for the purpose intended.
- E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND PROTECTION

- A. Store in a clean, dry space in original manufacturer's packaging until ready for installation.

PART 2 PRODUCTS

2.1 WIRING DEVICE APPLICATIONS

- A. Provide wiring devices suitable for intended use and with ratings adequate for load served.
- B. For single receptacles installed on an individual branch circuit, provide receptacle with ampere rating not less than that of the branch circuit.
- C. Provide weather resistant GFCI receptacles with specified weatherproof covers for receptacles installed outdoors or in damp or wet locations.
- D. Provide GFCI protection for receptacles installed within 6 feet of sinks.
- E. Provide GFCI protection for receptacles installed in kitchens.
- F. Provide GFCI protection for receptacles serving electric drinking fountains.
- G. Unless noted otherwise, do not use combination switch/receptacle devices.
- H. For flush floor service fittings, use tile rings for installations in tile floors.
- I. For flush floor service fittings, use carpet flanges for installations in carpeted floors.

2.2 WIRING DEVICE FINISHES

- A. Provide wiring device finishes as described below unless otherwise indicated.
- B. Wiring Devices, Unless Otherwise Indicated: White with white nylon wall plate.
- C. Wiring Devices Installed in Finished Spaces: White with white nylon wall plate.
- D. Wiring Devices Installed in Unfinished Spaces: Gray with galvanized steel wall plate.
- E. Wiring Devices Installed in Wet or Damp Locations: White with specified weatherproof cover.
- F. Surge Protection Receptacles: Blue.
- G. Wiring Devices Connected to Emergency Power: Red with red nylon wall plate.
- H. Clock Hanger Receptacles: Brown with stainless steel wall plate.
- I. Above-Floor Service Fittings: Gray wiring devices with satin aluminum housing.
- J. Flush Floor Box Service Fittings: Gray wiring devices with aluminum cover and ring/flange.
- K. Flush Poke-Through Service Fittings: Gray wiring devices with aluminum cover and aluminum flange.
- L. Access Floor Boxes: Gray wiring devices with gray steel cover with insert to match floor covering.

2.3 WALL SWITCHES

A. Manufacturers:

1. Hubbell Incorporated; [____]: www.hubbell-wiring.com.
2. Leviton Manufacturing Company, Inc; [____]: www.leviton.com/#sle.
3. Pass & Seymour, a brand of Legrand North America, Inc; [____]: www.legrand.us/#sle.
4. As indicated on plans..
5. Substitutions: See Section 01 60 00 - Product Requirements.

B. Wall Switches - General Requirements: AC only, quiet operating, general-use snap switches with silver alloy contacts, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 20 and where applicable, FS W-S-896; types as indicated on the drawings.

1. Wiring Provisions: Terminal screws for side wiring and screw actuated binding clamp for back wiring with separate ground terminal screw.

C. Standard Wall Switches: Industrial specification grade, 20 A, 120/277 V with standard toggle type switch actuator and maintained contacts; single pole single throw, double pole single throw, three way, or four way as indicated on the drawings.

D. Lighted Wall Switches: Industrial specification grade, 20 A, 120/277 V with illuminated standard toggle type switch actuator and maintained contacts; illuminated with load off; single pole single throw, double pole single throw, three way, or four way as indicated on the drawings.

E. Pilot Light Wall Switches: Industrial specification grade, 20 A, 120/277 V with red illuminated standard toggle type switch actuator and maintained contacts; illuminated with load on; single pole single throw, double pole single throw, three way, or four way as indicated on the drawings.

F. Locking Wall Switches: Industrial specification grade, 20 A, 120/277 V with lever type keyed switch actuator and maintained contacts; switches keyed alike; single pole single throw, double pole single throw, three way, or four way as indicated on the drawings.

2.4 RECEPTACLES

A. Manufacturers:

1. Hubbell Incorporated; (Basis of Design): www.hubbell.com/#sle.
2. Pass & Seymour, a brand of Legrand North America, Inc; [____]: www.legrand.us/#sle.
3. Eaton / Arrow Hart: <https://www.eaton.com/us/en-us.html>.

4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Receptacles - General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498, and where applicable, FS W-C-596; types as indicated on the drawings.
1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
 2. NEMA configurations specified are according to NEMA WD 6.
 3. Hospital Grade Receptacles: Listed as complying with UL 498 Supplement SD, with green dot hospital grade mark on device face.
- C. Convenience Receptacles:
1. Standard Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R; single or duplex as indicated on the drawings.
 2. Automatically Controlled Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R; controlled receptacle marking on device face per NFPA 70; single or duplex as indicated on the drawings.
 3. Weather Resistant Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations; single or duplex as indicated on the drawings.
 4. Tamper Resistant Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as tamper resistant type; single or duplex as indicated on the drawings.
 5. Tamper Resistant and Weather Resistant Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as tamper resistant type and as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations; single or duplex as indicated on the drawings.
 6. Illuminated Convenience Receptacles: Hospital grade, 20A, 125V, NEMA 5-20R; illuminated face or indicator light to indicate power is being supplied to receptacle; single or duplex as indicated on the drawings.
- D. GFCI Receptacles:
1. GFCI Receptacles - General Requirements: Self-testing, with feed-through protection and light to indicate ground fault tripped condition and loss of protection; listed as complying with UL 943, class A.
 - a. Provide test and reset buttons of same color as device.

2. Standard GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style.
3. Weather Resistant GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style, listed and labeled as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations.
4. Tamper Resistant GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style, listed and labeled as tamper resistant type.
5. Tamper Resistant and Weather Resistant GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style, listed and labeled as tamper resistant type and as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations.

E. USB Charging Devices:

1. USB Charging Devices - General Requirements: Listed as complying with UL 1310.
 - a. Charging Capacity - Two-Port Devices: 2.1 A, minimum.
 - b. Charging Capacity - Four-Port Devices: 4.2 A, minimum.
2. USB Charging/Tamper Resistant Receptacle Combination Devices: Two-port (one Type A & one Type C) USB charging device and receptacle, commercial specification grade, duplex, 20A, 125V, NEMA 5-20R, listed and labeled as tamper resistant type; rectangular decorator style.
3. USB Charging Noncombination Devices: Four-port (Type A); rectangular decorator style.

F. Locking Receptacles: Industrial specification grade, configuration as indicated on the drawings.

1. Standard Locking Convenience Receptacles: Single, 20A, 125V, NEMA L5-20R.

G. Clock Hanger Receptacles: Single, 15A, 125V, NEMA 5-15R.

2.5 WALL PLATES

A. Manufacturers:

1. Hubbell Incorporated; [____]: www.hubbell-wiring.com/#sle.
2. Pass & Seymour, a brand of Legrand North America, Inc; [____]: www.legrand.us/#sle.
3. Eaton / Arrow Hart: <https://www.eaton.com/us/en-us.html>.

B. Wall Plates: Comply with UL 514D.

1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
 2. Size: Standard; [_____].
 3. Screws: Metal with slotted heads finished to match wall plate finish.
- C. Nylon Wall Plates: Smooth finish, high-impact thermoplastic.
- D. Stainless Steel Wall Plates: Brushed satin finish, Type 302 stainless steel.
- E. Galvanized Steel Wall Plates: Rounded corners and edges, with corrosion resistant screws.
- F. Premarked Wall Plates: Factory labeled as indicated; hot stamped for nylon wall plates and engraved for metal wall plates.
- G. Weatherproof Covers for Wet Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

2.6 FLOOR BOX SERVICE FITTINGS

- A. Manufacturers:
1. Hubbell Incorporated; [_____]: www.hubbell.com/#sle.
 2. Thomas & Betts Corporation; [_____]: www.tnb.com/#sle.
 3. Wiremold, a brand of Legrand North America, Inc; [_____]: www.legrand.us/#sle.
 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Description: Service fittings compatible with floor boxes provided under Section 26 05 33.16 with components, adapters, and trims required for complete installation.
- C. Above-Floor Service Fittings:
1. Single Service Pedestal Convenience Receptacles:
 - a. Configuration: One standard convenience duplex receptacle.
 2. Single Service Pedestal Communications Outlets:
 - a. Configuration: One 1 inch bushed opening.
 - b. Voice and Data Jacks: As specified in Section 27 10 00.
 3. Single Service Pedestal Furniture Feed:
 - a. Configuration: One 3/4 inch knockout.
 4. Dual Service Pedestal Combination Outlets:

- a. Configuration:
 - 1) Power: One standard convenience duplex receptacle.
 - 2) Communications: One 1 inch bushed opening.
 - 3) Voice and Data Jacks: As specified in Section 27 10 00.
 - b. Provide barrier to separate line and low voltage compartments.
- D. Flush Floor Service Fittings:
- 1. Single Service Flush Convenience Receptacles:
 - a. Cover: Rectangular.
 - b. Configuration: One standard convenience duplex receptacle(s) with duplex flap opening(s).
 - 2. Single Service Flush Communications Outlets:
 - a. Cover: Rectangular.
 - b. Configuration: [_____].
 - c. Voice and Data Jacks: As specified in Section 27 10 00.
 - 3. Single Service Flush Furniture Feed:
 - a. Cover: Rectangular.
 - b. Configuration: One 2-1/8 inch by 3/4 inch combination threaded opening(s).
 - 4. Dual Service Flush Combination Outlets:
 - a. Cover: Rectangular.
 - b. Configuration:
 - 1) Power: One standard convenience duplex receptacle(s) with duplex flap opening(s).
 - 2) Communications: [_____].
 - 3) Voice and Data Jacks: As specified in Section 27 10 00.
 - 5. Dual Service Flush Furniture Feed:
 - a. Cover: Rectangular.
 - b. Configuration:

- 1) Power: One 2-1/8 inch by 3/4 inch combination threaded opening(s).
 - 2) Communications: One 2-1/8 inch by 1 inch combination threaded opening(s).
6. Accessories:
- a. Tile Rings: Finish to match covers; configuration as required to accommodate specified covers.
 - b. Carpet Flanges: Finish to match covers; configuration as required to accommodate specified covers.
7. Products:
- a. Hubbell Incorporated; [____]: www.hubbell.com/#sle.
 - b. Substitutions: See Section 01 60 00 - Product Requirements.

2.7 POKE-THROUGH ASSEMBLIES

- A. Manufacturers:
1. Hubbell Incorporated; [____]: www.hubbell-wiring.com.
 2. Thomas & Betts Corporation; [____]: www.tnb.com/#sle.
 3. Wiremold, a brand of Legrand North America, Inc; [____]: www.legrand.us/#sle.
 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Description: Assembly comprising floor service fitting, poke-through component, fire stops and smoke barriers, and junction box for conduit termination; fire rating listed to match fire rating of floor and suitable for floor thickness where installed.
- C. Above-Floor Service Fittings:
1. Single Service Pedestal Convenience Receptacles:
 - a. Configuration: One standard convenience duplex receptacle.
 2. Single Service Pedestal Communications Outlets:
 - a. Configuration: One 1 inch bushed opening.
 - b. Voice and Data Jacks: As specified in Section 27 10 00.
 3. Single Service Pedestal Furniture Feed:
 - a. Configuration: One 3/4 inch knockout.
 4. Dual Service Pedestal Combination Outlets:

- a. Configuration:
 - 1) Power: One standard convenience duplex receptacle.
 - 2) Communications: One 1 inch bushed opening.
 - 3) Voice and Data Jacks: As specified in Section 27 10 00.
 - b. Provide barrier to separate line and low voltage compartments.
5. Products:
- a. Hubbell Incorporated; [____]: www.hubbell.com/#sle.
 - b. Substitutions: See Section 01 60 00 - Product Requirements.
- D. Flush Floor Service Fittings:
- 1. Single Service Flush Convenience Receptacles:
 - a. Configuration: One standard convenience duplex receptacle(s) with duplex flap opening(s).
 - 2. Single Service Flush Communications Outlets:
 - a. Configuration: [____].
 - b. Voice and Data Jacks: As specified in Section 27 10 00.
 - 3. Single Service Flush Furniture Feed:
 - a. Configuration: One 2 inch by 1-1/4 inch combination threaded opening(s).
 - 4. Dual Service Flush Combination Outlets:
 - a. Cover: Hinged door(s).
 - b. Configuration:
 - 1) Power: One standard convenience duplex receptacle(s).
 - 2) Communications: [____].
 - 3) Voice and Data Jacks: As specified in Section 27 10 00.
 - 5. Dual Service Flush Furniture Feed:
 - a. Configuration:
 - 1) Power: One 3/4 inch threaded opening(s).
 - 2) Communications: Two 1/2 inch threaded opening(s).

6. Accessories:

- a. Closure Plugs: Size and fire rating as required to seal unused core hole and maintain fire rating of floor.

2.8 ACCESS FLOOR BOXES

A. Manufacturers - Access Floor Boxes:

1. Hubbell Incorporated; [____]: www.hubbell-wiring.com/#sle.
2. Thomas & Betts Corporation; [____]: www.tnb.com/#sle.
3. Wiremold, a brand of Legrand North America, Inc; [____]: www.legrand.us/#sle.
4. Substitutions: See Section 01 60 00 - Product Requirements.

B. Description: Metallic multi-service box suitable for mounting in access floor system specified in Section 09 69 00.

C. Access floor boxes with pre-wired connectors for manufactured wiring systems are permitted only where manufactured wiring systems are permitted as specified in Section 26 05 19.

D. Configuration:

1. Power: Two standard convenience duplex receptacle(s).
2. Communications: [____].
3. Voice and Data Jacks: As specified in Section 27 10 00.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that wall openings are neatly cut and will be completely covered by wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that floor boxes are adjusted properly.
- F. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.
- G. Verify that core drilled holes for poke-through assemblies are in proper locations.
- H. Verify that openings in access floor are in proper locations.

- I. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 26 05 33.16 as required for installation of wiring devices provided under this section.
 1. Mounting Heights: Unless otherwise indicated, as follows:
 - a. Wall Switches: 48 inches above finished floor.
 - b. Wall Dimmers: 48 inches above finished floor.
 - c. Fan Speed Controllers: 48 inches above finished floor.
 - d. Receptacles: 18 inches above finished floor or 6 inches above counter.
 2. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.
 3. Where multiple receptacles, wall switches, or wall dimmers are installed at the same location and at the same mounting height, gang devices together under a common wall plate.
 4. Locate wall switches on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify Engineer to obtain direction prior to proceeding with work.
 5. Locate receptacles for electric drinking fountains concealed behind drinking fountain according to manufacturer's instructions.
 6. Coordinate all mounting locations with architect prior to installation..
- C. Install wiring devices in accordance with manufacturer's instructions.
- D. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- E. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.
- F. Connect wiring devices by wrapping conductor clockwise 3/4 turn around screw terminal and tightening to proper torque specified by the manufacturer. Where present, do not use push-in

pressure terminals that do not rely on screw-actuated binding.

- G. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- H. For isolated ground receptacles, connect wiring device grounding terminal only to identified branch circuit isolated equipment grounding conductor. Do not connect grounding terminal to outlet box or normal branch circuit equipment grounding conductor.
- I. Provide GFCI receptacles with integral GFCI protection at each location indicated. Do not use feed-through wiring to protect downstream devices.
- J. Install wiring devices plumb and level with mounting yoke held rigidly in place.
- K. Install wall switches with OFF position down.
- L. Install vertically mounted receptacles with grounding pole on top and horizontally mounted receptacles with grounding pole on left.
- M. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
- N. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.
- O. Identify wiring devices in accordance with Section 26 05 53.
- P. Install poke-through closure plugs in each unused core holes to maintain fire rating of floor.

3.4 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect each wiring device for damage and defects.
- C. Operate each wall switch, wall dimmer, and fan speed controller with circuit energized to verify proper operation.
- D. Test each receptacle to verify operation and proper polarity.
- E. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.
- F. Inspect each surge protection receptacle to verify surge protection is active.
- G. Correct wiring deficiencies and replace damaged or defective wiring devices.

3.5 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.
- B. Adjust presets for wall dimmers according to manufacturer's instructions as directed by Engineer.

3.6 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION 26 27 26

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SECTION 26 28 13 - FUSES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Fuses.
- B. Spare fuse cabinet.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- B. Section 26 05 73 - Power System Studies: Additional criteria for the selection of protective devices specified in this section.
- C. Section 26 24 13 - Switchboards: Fusible switches.
- D. Section 26 24 16 - Panelboards: Fusible switches.
- E. Section 26 28 16.16 - Enclosed Switches: Fusible switches.
- F. Section 26 29 13 - Enclosed Controllers: Fusible switches.

1.4 REFERENCE STANDARDS

- A. NEMA FU 1 - Low Voltage Cartridge Fuses 2012.
- B. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. UL 248-1 - Low-Voltage Fuses - Part 1: General Requirements Current Edition, Including All Revisions.
- D. UL 248-4 - Low-Voltage Fuses - Part 4: Class CC Fuses Current Edition, Including All Revisions.
- E. UL 248-10 - Low-Voltage Fuses - Part 10: Class L Fuses Current Edition, Including All Revisions.
- F. UL 248-12 - Low-Voltage Fuses - Part 12: Class R Fuses Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate fuse clips furnished in equipment provided under other sections for compatibility with indicated fuses.
 - a. Fusible Enclosed Switches: See Section 26 28 16.16.
 - b. Fusible Switches for Enclosed Motor Controllers: See Section 26 29 13.
2. Coordinate fuse requirements according to manufacturer's recommendations and nameplate data for actual equipment to be installed.
3. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard data sheets including voltage and current ratings, interrupting ratings, time-current curves, and current limitation curves.
 1. Spare Fuse Cabinet: Include dimensions.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. See Section 01 60 00 - Product Requirements, for additional provisions.
 2. Extra Fuses: One set(s) of three for each type and size installed.
 3. Fuse Pullers: One set(s) compatible with each type and size installed.
 4. Spare Fuse Cabinet Keys: Two.

1.7 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Bussmann, a division of Eaton Corporation; [____]: www.cooperindustries.com/#sle.
- B. Littelfuse, Inc; [____]: www.littelfuse.com/#sle.
- C. Mersen; [____]: ep-us.mersen.com/#sle.
- D. Substitutions: See Section 01 60 00 - Product Requirements.

2.2 APPLICATIONS

- A. Service Entrance:
 - 1. Fusible Switches up to 600 Amperes: Class RK1, time-delay.
 - 2. Fusible Switches Larger Than 600 Amperes: Class L, time-delay.
- B. Feeders:
 - 1. Fusible Switches up to 600 Amperes: Class RK1, time-delay.
 - 2. Fusible Switches Larger Than 600 Amperes: Class L, time-delay.
- C. General Purpose Branch Circuits: Class RK1, time-delay.
- D. Individual Motor Branch Circuits: Class RK1, time-delay.
- E. In-Line Protection for Pole-Mounted Luminaires: Class CC, time-delay.
- F. Primary Protection for Control Transformers: Class CC, time-delay.

2.3 FUSES

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless specifically indicated to be excluded, provide fuses for all fusible equipment as required for a complete operating system.
- C. Provide fuses of the same type, rating, and manufacturer within the same switch.
- D. Comply with UL 248-1.
- E. Unless otherwise indicated, provide cartridge type fuses complying with NEMA FU 1, Class and ratings as indicated.
- F. Voltage Rating: Suitable for circuit voltage.
- G. Class R Fuses: Comply with UL 248-12.

- H. Class L Fuses: Comply with UL 248-10.
- I. Class CC Fuses: Comply with UL 248-4.
- J. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.
- K. Provide the following accessories where indicated or where required to complete installation:
 - 1. Fuseholders: Compatible with indicated fuses.
 - 2. Fuse Reducers: For adapting indicated fuses to permit installation in switch designed for fuses with larger ampere ratings.

2.4 SPARE FUSE CABINET

- A. Description: Wall-mounted sheet metal cabinet with shelves and hinged door with cylinder lock, suitably sized to store spare fuses and fuse pullers specified.
- B. Finish: Manufacturer's standard, factory applied grey finish unless otherwise indicated.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that fuse ratings are consistent with circuit voltage and manufacturer's recommendations and nameplate data for equipment.
- B. Verify that mounting surfaces are ready to receive spare fuse cabinet.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Do not install fuses until circuits are ready to be energized.
- B. Install fuses with label oriented such that manufacturer, type, and size are easily read.
- C. Install spare fuse cabinet where indicated.
- D. Identify spare fuse cabinet in accordance with Section 26 05 53.

END OF SECTION 26 28 13

SECTION 26 28 16.13 - ENCLOSED CIRCUIT BREAKERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Enclosed circuit breakers.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- B. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- C. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
 - 1. Includes requirements for the seismic qualification of equipment specified in this section.
- D. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 26 05 73 - Power System Studies: Additional criteria for the selection and adjustment of equipment and associated protective devices specified in this section.

1.4 REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service 2013e (Amended 2017).
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- D. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- E. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
- G. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.

- H. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures Current Edition, Including All Revisions.
- I. UL 869A - Reference Standard for Service Equipment Current Edition, Including All Revisions.
- J. UL 943 - Ground-Fault Circuit-Interrupters Current Edition, Including All Revisions.
- K. UL 1053 - Ground-Fault Sensing and Relaying Equipment Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted enclosed circuit breakers where indicated.
 - 4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for circuit breakers, enclosures, and other installed components and accessories.
 - 1. Include characteristic trip curves for each type and rating of circuit breaker upon request.
- C. Shop Drawings: Indicate outline and support point dimensions, voltage and current ratings, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 - 1. Include dimensioned plan and elevation views of enclosed circuit breakers and adjacent equipment with all required clearances indicated.
 - 2. Identify mounting conditions required for equipment seismic qualification.
- D. Manufacturer's equipment seismic qualification certification.

- E. Field Quality Control Test Reports.
- F. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- G. Project Record Documents: Record actual installed locations of enclosed circuit breakers.
- H. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

1.7 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed circuit breaker internal components, enclosure, and finish.

1.9 FIELD CONDITIONS

- A. Maintain ambient temperature between 23 degrees F and 104 degrees F during and after installation of enclosed circuit breakers.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Eaton Corporation; [____]: www.eaton.com/#sle.
- B. Schneider Electric; Square D Products; [____]: www.schneider-electric.us/#sle.
- C. Siemens Industry, Inc; [____]: www.usa.siemens.com/#sle.
- D. Substitutions: See Section 01 60 00 - Product Requirements.
- E. Source Limitations: Furnish enclosed circuit breakers and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.2 ENCLOSED CIRCUIT BREAKERS

- A. Description: Units consisting of molded case circuit breakers individually mounted in enclosures.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Seismic Qualification: Provide enclosed circuit breakers and associated components suitable for application under the seismic design criteria specified in Section 26 05 48 where required. Include certification of compliance with submittals.
- D. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Altitude: Less than 6,600 feet.
 - 2. Ambient Temperature: Between 23 degrees F and 104 degrees F.
- E. Short Circuit Current Rating:
 - 1. Provide enclosed circuit breakers with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73.
- F. Enclosed Circuit Breakers Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- G. Conductor Terminations: Suitable for use with the conductors to be installed.
- H. Provide thermal magnetic circuit breakers for circuit breaker frame sizes less than 225 amperes.
- I. Provide electronic trip circuit breakers for circuit breaker frame sizes 225 amperes and above.
- J. Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.
- K. Provide solidly bonded equipment ground bus in each enclosed circuit breaker, with a suitable lug for terminating each equipment grounding conductor.
- L. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
 - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R.
 - 2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.

3. Provide surface-mounted enclosures unless otherwise indicated.
 - M. Provide externally operable handle with means for locking in the OFF position.
 - N. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
 1. Where electronic circuit breakers equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
 2. Where accessory ground fault sensing and relaying equipment is used, equip companion circuit breakers with ground-fault shunt trips.
 - a. Use zero sequence ground fault detection method unless otherwise indicated.
 - b. Provide test panel and field-adjustable ground fault pick-up and delay settings.
 - O. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.
- 2.3 MOLDED CASE CIRCUIT BREAKERS
- A. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
 - B. Interrupting Capacity:
 1. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
 2. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
 3. Series Rated Systems: Not used.
 - C. Conductor Terminations:
 1. Provide mechanical lugs unless otherwise indicated.
 2. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - D. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
 1. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
 - E. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.

1. Provide the following field-adjustable trip response settings:
 - a. Long time pickup, adjustable by setting dial.
 - b. Long time delay.
 - c. Short time pickup and delay.
 - d. Instantaneous pickup.
 - e. Ground fault pickup and delay where ground fault protection is indicated.
- F. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
- G. Provide the following circuit breaker types where indicated:
 1. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
 2. Ground Fault Equipment Protection Circuit Breakers: Designed to trip at 30 mA for protection of equipment.
 3. Current Limiting Circuit Breakers: Without using fusible elements, designed to limit the let-through energy to a value less than the energy of a one-half cycle wave of the symmetrical prospective current when operating within its current limiting range.
- H. Provide the following features and accessories where indicated or where required to complete installation:
 1. Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.
 2. Auxiliary Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped or been turned off.
 3. Alarm Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings of the enclosed circuit breakers are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive enclosed circuit breakers.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required support and attachment in accordance with Section 26 05 29.
- E. Provide required seismic controls in accordance with Section 26 05 48.
- F. Install enclosed circuit breakers plumb.
- G. Install flush-mounted enclosed circuit breakers so that trims fit completely flush to wall with no gaps and rough opening completely covered.
- H. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed circuit breakers such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.
- I. Provide grounding and bonding in accordance with Section 26 05 26.
- J. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- K. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed according to Section 26 05 73.
- L. Set field-adjustable ground fault protection pickup and time delay settings as indicated.
- M. Identify enclosed circuit breakers in accordance with Section 26 05 53.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with manufacturer's instructions and NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for circuit breakers used for service entrance and for circuit breakers larger than [] amperes. Tests listed as optional are not required.
- D. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
- E. Test GFCI circuit breakers to verify proper operation.
- F. Test shunt trips to verify proper operation.

- G. Correct deficiencies and replace damaged or defective enclosed circuit breakers.

3.4 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.5 CLEANING

- A. Clean dirt and debris from circuit breaker enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION 26 28 16.13

SECTION 26 28 16.16 - ENCLOSED SWITCHES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Enclosed safety switches.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- B. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- C. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
- D. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 26 05 73 - Power System Studies: Additional criteria for the selection of equipment and associated protective devices specified in this section.
- F. Section 26 28 13 - Fuses.
- G. Section 26 36 00 - Transfer Switches: Automatic and non-automatic switches listed for use as transfer switch equipment.

1.4 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum) 2013.
- D. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- E. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.

- G. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
- H. UL 98 - Enclosed and Dead-Front Switches Current Edition, Including All Revisions.
- I. UL 869A - Reference Standard for Service Equipment Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 4. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.
- C. Shop Drawings: Indicate outline and support point dimensions, voltage and current ratings, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 - 1. Include dimensioned plan and elevation views of enclosed switches and adjacent equipment with all required clearances indicated.
 - 2. Include wiring diagrams showing all factory and field connections.
 - 3. Identify mounting conditions required for equipment seismic qualification.
- D. Manufacturer's equipment seismic qualification certification.
- E. Field Quality Control Test Reports.
- F. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

- G. Project Record Documents: Record actual locations of enclosed switches.
- H. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.
- I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.
 - 2. See Section 26 28 13 for requirements for spare fuses and spare fuse cabinets.

1.7 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed switch internal components, enclosure, and finish.

1.9 FIELD CONDITIONS

- A. Maintain ambient temperature between -22 degrees F and 104 degrees F during and after installation of enclosed switches.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Eaton Corporation; [____]: www.eaton.com/#sle.
- B. Schneider Electric; Square D Products; [____]: www.schneider-electric.us/#sle.
- C. Siemens Industry, Inc; [____]: www.usa.siemens.com/#sle.
- D. Substitutions: See Section 01 60 00 - Product Requirements.
- E. Source Limitations: Furnish enclosed switches and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.2 ENCLOSED SAFETY SWITCHES

- A. Description: Quick-make, quick-break enclosed safety switches listed and labeled as complying with UL 98; heavy duty; ratings, configurations, and features as indicated on the drawings.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Seismic Qualification: Provide enclosed safety switches suitable for application under the seismic design criteria specified in Section 26 05 48 where required. Include certification of compliance with submittals.
- D. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Altitude: Less than 6,600 feet.
 - 2. Ambient Temperature: Between -22 degrees F and 104 degrees F.
- E. Horsepower Rating: Suitable for connected load.
- F. Voltage Rating: Suitable for circuit voltage.
- G. Short Circuit Current Rating:
 - 1. Provide enclosed safety switches, when protected by the fuses or supply side overcurrent protective devices to be installed, with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73.
 - 2. Minimum Ratings:
 - a. Heavy Duty Single Throw Switches Protected by Class R, Class J, Class L, or Class T Fuses: 200,000 rms symmetrical amperes.
 - b. Double Throw Switches Protected by Class R, Class J, or Class T Fuses: 100,000 rms symmetrical amperes.
- H. Enclosed Safety Switches Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- I. Provide with switch blade contact position that is visible when the cover is open.
- J. Fuse Clips for Fusible Switches: As required to accept fuses indicated.
 - 1. Where NEMA Class R fuses are installed, provide rejection feature to prevent installation of fuses other than Class R.
- K. Conductor Terminations: Suitable for use with the conductors to be installed.

- L. Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.
- M. Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.
- N. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
 - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R.
 - 2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.
- O. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.
- P. Heavy Duty Switches:
 - 1. Comply with NEMA KS 1.
 - 2. Conductor Terminations:
 - a. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - 3. Provide externally operable handle with means for locking in the OFF position, capable of accepting three padlocks.
 - a. Provide means for locking handle in the ON position where indicated.
- Q. Provide the following features and accessories where indicated or where required to complete installation:
 - 1. Hubs: As required for environment type; sized to accept conduits to be installed.
 - 2. Integral fuse pullers.
 - 3. Viewing Window: Positioned over switch blades for visual confirmation of contact position with door closed.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.

- B. Verify that the ratings of the enclosed switches are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive enclosed safety switches.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required support and attachment in accordance with Section 26 05 29.
- E. Install enclosed switches plumb.
- F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.
- G. Provide grounding and bonding in accordance with Section 26 05 26.
- H. Provide fuses complying with Section 26 28 13 for fusible switches as indicated or as required by equipment manufacturer's recommendations.
- I. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- J. Identify enclosed switches in accordance with Section 26 05 53.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.
- D. Correct deficiencies and replace damaged or defective enclosed safety switches or associated components.

3.4 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.5 CLEANING

- A. Clean dirt and debris from switch enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION 26 28 16.16

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SECTION 26 29 23 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Variable frequency controllers.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.

1.4 REFERENCE STANDARDS

- A. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems 2014.
- B. NEMA ICS 7 - Industrial Control and Systems: Adjustable-Speed Drives 2020.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- D. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- E. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.
- C. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.
 - 1. Identify mounting conditions required for equipment seismic qualification.
- D. Manufacturer's equipment seismic qualification certification.
- E. Test Reports: Indicate field test and inspection procedures and test results.

- F. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- G. Manufacturer's Field Reports: Indicate start-up inspection findings.
- H. Operation Data: NEMA ICS 7.1. Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.
- I. Maintenance Data: NEMA ICS 7.1. Include routine preventive maintenance schedule.
- J. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.
 - 2. Extra Air Filters: Two of each type.

1.6 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosure, and finish.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Variable Frequency Motor Controllers:
 - 1. ABB/GE: www.geindustrial.com/#sle.
 - 2. Danfoss: www.danfoss.com/#sle.
 - 3. Schneider Electric; Square D Products; [_____]: www.schneider-electric.us/#sle.
- B. Substitutions: See Section 01 60 00 - Product Requirements.
- C. Source Limitations: Furnish variable frequency motor controllers and associated components produced by a single manufacturer and obtained from a single supplier.

2.2 DESCRIPTION

- A. Variable Frequency Controllers: Enclosed controllers suitable for operating the indicated loads, in compliance with requirements of NEMA ICS 7. Select unspecified features and options in accordance with NEMA ICS 3.1.
 - 1. Employ microprocessor-based inverter logic isolated from power circuits.
 - 2. Employ pulse-width-modulated inverter system.
 - 3. Design for ability to operate controller with motor disconnected from output.
 - 4. Design to attempt five automatic restarts following fault condition before locking out and requiring manual restart.
- B. Seismic Qualification: Provide variable frequency controllers and associated components suitable for application under the seismic design criteria specified in Section 26 05 48 where required. Include certification of compliance with submittals.
- C. Enclosures: NEMA 250, Type 1, suitable for equipment application in places regularly open to the public.
- D. Finish: Manufacturer's standard enamel.

2.3 OPERATING REQUIREMENTS

- A. Rated Input Voltage: 208 volts, three phase, 60 Hertz.
- B. Motor Nameplate Voltage: 200 volts, three phase, 60 Hertz.
- C. Displacement Power Factor: Between 1.0 and 0.95, lagging, over entire range of operating speed and load.
- D. Operating Ambient: 0 degrees C to 40 degrees C.
- E. Volts Per Hertz Adjustment: Plus or minus 10 percent.
- F. Current Limit Adjustment: 60 to 110 percent of rated.
- G. Acceleration Rate Adjustment: 0.5 to 30 seconds.
- H. Deceleration Rate Adjustment: 1 to 30 seconds.
- I. Input Signal: 4 to 20 mA DC.

2.4 COMPONENTS

- A. Display: Provide integral digital display to indicate output voltage, output frequency, and output current.

- B. Status Indicators: Separate indicators for overcurrent, overvoltage, ground fault, overtemperature, and input power ON.
- C. Furnish HAND-OFF-AUTOMATIC selector switch and manual speed control.
- D. Include undervoltage release.
- E. Control Power Source: Separate circuit.
- F. Door Interlocks: Furnish mechanical means to prevent opening of equipment with power connected, or to disconnect power if door is opened; include means for defeating interlock by qualified persons.
- G. Safety Interlocks: Furnish terminals for remote contact to inhibit starting under both manual and automatic mode.
- H. Control Interlocks: Furnish terminals for remote contact to allow starting in automatic mode.
- I. Emergency Stop: Use dynamic brakes for emergency stop function.
- J. Disconnecting Means: Include integral fused disconnect switch on the line side of each controller.
- K. Wiring Terminations: Match conductor materials and sizes indicated.

2.5 SOURCE QUALITY CONTROL

- A. Shop inspect and perform standard productions tests for each controller.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that surface is suitable for controller installation.
- B. Do not install controller until building environment can be maintained within the service conditions required by the manufacturer.
- C. Verify that field measurements are as indicated on shop drawings.

3.2 INSTALLATION

- A. Install in accordance with NEMA ICS 7.1 and manufacturer's instructions.
- B. Provide required support and attachment in accordance with Section 26 05 29.
- C. Provide required seismic controls in accordance with Section 26 05 48.
- D. Tighten accessible connections and mechanical fasteners after placing controller.
- E. Provide fuses in fusible switches; refer to Section 26 28 13 for product requirements.

- F. Select and install overload heater elements in motor controllers to match installed motor characteristics.
- G. Identify variable frequency controllers in accordance with Section 26 05 53.

3.3 FIELD QUALITY CONTROL

- A. Provide the service of the manufacturer's field representative to prepare and start controllers.
- B. Perform field inspection and testing in accordance with Section 01 40 00.
- C. Inspect and test in accordance with NETA ATS, except Section 4.
- D. Perform inspections and tests listed in NETA ATS, Section 7.17. The insulation-resistance test on control wiring listed as optional is not required.

3.4 ADJUSTING

- A. Make final adjustments to installed controller to assure proper operation of load system. Obtain performance requirements from installer of driven loads.

3.5 CLOSEOUT ACTIVITIES

- A. Demonstrate operation of controllers in automatic and manual modes.

3.6 MAINTENANCE

- A. See Section 01 70 00 - Execution Requirements, for additional requirements relating to maintenance service.
- B. Provide a separate maintenance contract for specified maintenance service.
- C. Provide service and maintenance of controllers for one year from Date of Substantial Completion.

END OF SECTION 26 29 23

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SECTION 26 33 23 - CENTRAL BATTERY EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Uninterruptible power supply (UPS) centralized emergency lighting inverters.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 25 36 23 - Integrated Automation Battery Monitors.
- B. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- C. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- D. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
 - 1. Includes requirements for the seismic qualification of equipment specified in this section.
- E. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 26 05 73 - Power System Studies: Additional criteria for the selection of equipment and associated protective devices specified in this section.
- G. Section 26 51 00 - Interior Lighting:
- H. Section 26 56 00 - Exterior Lighting: Luminaires for interface with centralized emergency lighting inverters.

1.4 REFERENCE STANDARDS

- A. ISO 9001 - Quality management systems -- Requirements 2015.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate compatibility of centralized emergency lighting inverters to be installed with work provided under other sections or by others.
 - a. Luminaires: See Section 26 51 00.

2. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
 3. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 4. Coordinate the work with placement of supports, anchors, etc. required for mounting.
 5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Preinstallation Meeting: Convene one week before starting work of this section; require attendance of all affected installers.
- C. Where work of this section involves interruption of power to existing emergency lighting, arrange power interruption with Owner.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product, including ratings, configurations, dimensions, finishes, weights, service condition requirements, and installed features.
1. Identify mounting conditions required for equipment seismic qualification.
- C. Shop Drawings: Indicate dimensions, input/output voltages, power ratings, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, and installed features and accessories.
1. Include dimensioned plan and elevation views of inverters and adjacent equipment with all required clearances indicated.
 2. Include wiring diagrams showing all factory and field connections.
 3. Include documentation demonstrating selective coordination upon request.
- D. Derating Calculations: Indicate ratings adjusted for applicable service conditions and/or inverter load restrictions.
- E. Specimen Warranty: Submit sample of manufacturer's warranty.
- F. Evidence of qualifications for manufacturer.
- G. Evidence of qualifications for installer.
- H. Evidence of qualifications for maintenance contractor (if different entity from installer).
- I. Manufacturer's equipment seismic qualification certification.

- J. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
 - K. Manufacturer's certification that products meet or exceed specified requirements.
 - L. Source quality control test reports.
 - M. Provide NFPA 111 required documentation from manufacturer where requested by authorities having jurisdiction.
 - N. Manufacturer's detailed field testing procedures.
 - O. Field quality control test reports.
 - P. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
 - 1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.
 - Q. Executed Warranty: Submit documentation of final executed warranty completed in Owner's name and registered with manufacturer.
 - R. Maintenance contracts.
 - S. Project Record Documents: Record actual locations of system components, installed circuiting arrangements and routing, and final equipment settings.
 - T. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.
 - 2. Enclosure Keys: Two of each different key.
 - 3. Battery Fuses: See Section 26 28 13 for requirements for spare fuses and spare fuse cabinets.
- 1.7 QUALITY ASSURANCE
- A. Comply with the following:
 - 1. NFPA 70 (National Electrical Code).
 - 2. NFPA 101 (Life Safety Code).
 - 3. NFPA 111; meet requirements for Level 1 system.
 - B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
 - 1. Authorized service facilities located within 200 miles of project site.
 - 2. ISO 9001 certified.
 - D. Installer Qualifications: Company specializing in performing the work of this section with minimum three years documented experience with centralized emergency lighting inverter systems of similar size, type, and complexity; manufacturer's authorized installer.
 - E. Maintenance Contractor Qualifications: Same entity as installer or different entity with specified qualifications.
 - 1. Contract maintenance office located within 200 miles of project site.
 - F. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.
- 1.8 DELIVERY, STORAGE, AND HANDLING
- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
 - B. Handle carefully in accordance with manufacturer's instructions to avoid damage to inverter system components, enclosure, and finish.
 - C. Do not exceed maximum ambient temperature requirements for batteries at any time, which reduces battery service life. Replace batteries exposed to temperatures in excess of manufacturer's requirements.
- 1.9 FIELD CONDITIONS
- A. Maintain field conditions within manufacturer's required service conditions during and after installation.
- 1.10 WARRANTY
- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
 - B. Inverter Assemblies: Provide minimum five year manufacturer warranty covering repair or replacement due to defective materials or workmanship.
 - C. Batteries: Provide pro-rata warranty for the duration of rated design life.

PART 2 PRODUCTS

2.1 CENTRALIZED EMERGENCY LIGHTING INVERTERS - GENERAL REQUIREMENTS

- A. Provide complete centralized emergency lighting inverter system consisting of all required equipment, conduit, boxes, wiring, supports, accessories, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Inverter Assemblies: Manufactured units consisting of inverters, batteries, enclosures, and associated components specifically designed for emergency lighting applications; microprocessor-based utilizing pulse width modulation (PWM) with insulated gate bipolar transistors (IGBT's); listed and labeled as complying with UL 924.
 - 1. Battery Run Times of 90 Minutes: Listed as complying with UL 924 for "emergency lighting and power equipment".
- D. Provide inverters and associated components suitable for operation at indicated ratings under the service conditions at the installed location.
- E. Increase indicated power ratings as required to accommodate any applicable inverter load restrictions.
- F. Inverters Installed in Spaces Used for Environmental Air: Plenum rated; listed and labeled as complying with UL 2043, suitable for use in air-handling spaces.
- G. Inverters Supplied by Engine Generators: Compatible with generator set to be installed in accordance with Section 26 32 13; include consideration of slew rate for proper synchronization.
- H. Battery System:
 - 1. Provide battery capacity as required for achieving battery run time indicated.
 - 2. Battery Charger: Microprocessor-controlled, temperature compensated; capable of returning supplied battery(s) from fully discharged to fully charged condition within time required by NFPA 111 and UL 924 unless otherwise indicated.
 - 3. Provide automatic low voltage battery disconnect to prevent battery "deep discharge" damage.
 - 4. Battery Monitor: As specified under Section 25 36 23.
- I. Seismic Qualification: Provide emergency lighting inverters and associated components suitable for application under the seismic design criteria specified in Section 26 05 48 where required. Include certification of compliance with submittals.
- J. Enclosures:

1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1 or Type 12.
 - b. Outdoor Locations: Type 3R or Type 4.
 2. Hinged Doors: Lockable, with all locks keyed alike.
 3. Finish: Manufacturer's standard unless otherwise indicated.
- K. Short Circuit Current Rating: Provide inverter assemblies with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73.
- L. Surge Tolerance: Capable of withstanding characteristic surges according to IEEE C62.41.2, location category B.
- M. Automatic Sequence of Operations:
1. Upon failure or degradation of primary/normal input power, transfer load to battery power.
 2. When primary/normal input power has been restored, retransfer load to primary/normal power and recharge battery.
- N. Input Tolerance:
1. Voltage Range: Plus 10/minus 15 percent of nominal.
 2. Frequency Range: Plus/minus 2.5 percent of nominal.
 3. Total Harmonic Distortion (THD): 3 percent maximum at full load.
- O. Output Requirements:
1. Voltage Regulation: Plus/minus 3 percent.
 2. Frequency Range: Plus/minus 0.5 Hz.
 3. Total Harmonic Distortion (THD): 3 percent maximum for linear load.
 4. Load Power Factor Capability: From 0.8 lagging to 0.8 leading.
- P. Features (Units Less than 500 VA):
1. Control Functions:
 - a. Automatic mode.
 - b. Manual Test Mode: Simulates failure of primary/normal source.

- c. Self-testing/self-diagnostics.
 - 2. Status Indications:
 - a. Connected to primary/normal source.
 - b. Connected to battery power.
 - c. Primary/normal source available.
 - d. Battery charging.
 - 3. Alarm Indications (Units with Self-Testing/Self-Diagnostics):
 - a. General trouble/alarm.
 - 4. Other Features:
- Q. Features (Units 500 VA and Larger):
- 1. Control Functions:
 - a. Automatic mode.
 - b. Automatic Bypass Mode (UPS Inverters Only): Upon applicable inverter circuit trouble/fault static transfer switch removes inverter from circuit and delivers power directly from primary/normal source (when available) to load.
 - c. Automatic Shutdown Mode (IPS Inverters Only): Upon applicable inverter circuit trouble/fault unit shuts down.
 - d. Manual Bypass Mode: Manual bypass switch removes unit from circuit and delivers power directly from primary/normal source to load for unit maintenance purposes.
 - e. Self-testing/self-diagnostics.
 - 2. Status Indications:
 - a. Connected to primary/normal source.
 - b. Connected to battery power.
 - c. Primary/normal source available.
 - d. Battery charging.
 - e. Unit in manual bypass mode.
 - 3. Measured Parameter Indications:
 - a. Battery voltage.

- b. Output voltage (Volts AC); line-to-line and line-to-neutral; per phase.
 - c. Output Current (Amps); per phase.
 - d. Output Frequency (Hz).
 - e. Output real/active power (kW); per phase.
 - f. Output apparent power (kVA); per phase.
 - g. Power factor; per phase.
 - 4. Alarm Indications:
 - a. Output overload/overcurrent.
 - b. High temperature.
 - c. Low battery.
 - d. Output circuit breaker open (supervised circuit breakers only).
 - 5. Other Features:
 - a. Input circuit breaker.
 - b. Event log.
 - c. Communications Capability: Compatible with system indicated. Provide all accessories necessary for proper interface.
- 2.2 UNINTERRUPTIBLE POWER SUPPLY (UPS) CENTRALIZED EMERGENCY LIGHTING INVERTERS
- A. Manufacturers:
 - 1. Uninterruptible Power Supply (UPS) Centralized Emergency Lighting Inverters:
 - a. As indicated on plans.
 - 2. Substitutions: See Section 01 60 00 - Product Requirements.
 - 3. Source Limitations: Furnish inverter assemblies and accessories produced by a single manufacturer and obtained from a single supplier.
 - B. Description: Online, double-conversion type inverters with no transfer time (0 ms) to battery power source upon loss of normal power source; suitable for emergency operation of incandescent, LED, fluorescent, and HID light sources.
 - C. Uninterruptible Power Supply (UPS) Centralized Emergency Lighting Inverter [____]:
 - 1. Nominal Power Rating: As indicated on drawings.

2. Battery Run Time at Full Output: 90 minutes.
3. Output Circuit Breaker(s): As indicated on drawings.
4. Features:
 - a. Internal manual bypass switch; closed transition (make-before-break) transfer.
 - b. Normally off output bus with time delay on retransfer to primary/normal power source.
 - c. Outputs:
 - 1) Contact for power on status.
 - 2) Contacts for power source status (primary/normal or battery).
 - 3) Contact for alarm condition.
 - 4) Contact for maintenance bypass switch status.

2.3 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Perform production tests on inverter assemblies at factory to verify operation and performance characteristics prior to shipment. Include certified test report with submittals.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of inverter assemblies are consistent with the indicated requirements.
- C. Verify that rough-ins for field connections are in the proper locations.
- D. Verify that mounting surfaces are ready to receive inverter assemblies.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install inverter assemblies in accordance with applicable requirements of NECA 416.
- C. Install products in accordance with manufacturer's instructions.
- D. Arrange equipment to provide minimum clearances and required maintenance access.

- E. Provide required support and attachment in accordance with Section 26 05 29.
- F. Provide required seismic controls in accordance with Section 26 05 48.
- G. Install inverter assemblies plumb and level.
- H. Unless otherwise indicated, mount floor-mounted inverter assemblies on properly sized 3 inch high concrete pad constructed in accordance with Section 03 30 00.
- I. Provide grounding and bonding in accordance with Section 26 05 26.
- J. Identify inverter assemblies and associated system wiring in accordance with Section 26 05 53.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Provide services of a manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's detailed testing procedures with submittals.
- C. Notify Owner and Engineer at least two weeks prior to scheduled inspections and tests.
- D. Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.
- E. Provide all equipment, tools, and supplies required to accomplish inspection and testing, including load bank.
- F. Prepare and start system in accordance with manufacturer's instructions.
- G. Perform acceptance test in accordance with NFPA 111.
- H. Inspect and test in accordance with NETA ATS, except Section 4.
- I. Perform inspections and tests listed in NETA ATS, Section 7.22.2.
- J. Batteries and Charger: Perform inspections and tests listed in NETA ATS, Section 7.18.
- K. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.
- L. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.4 CLEANING

- A. See Section 01 74 19 - Construction Waste Management and Disposal, for additional requirements.
- B. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.5 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 - Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of emergency lighting inverter system to Owner, and correct deficiencies or make adjustments as directed.
- D. Training: Train Owner's personnel on operation, adjustment, and maintenance of emergency lighting inverter system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of four hours of training.
 - 3. Instructor: Manufacturer's authorized representative.
 - 4. Location: At project site.

3.6 PROTECTION

- A. Protect installed inverter assemblies from subsequent construction operations.

3.7 MAINTENANCE

- A. See Section 01 70 00 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Provide to Owner a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of emergency lighting inverter system for two years from date of Substantial Completion; Include a complete description of preventive maintenance, systematic examination, adjustment, inspection, and testing, with a detailed schedule.
- C. Conduct site visit at least once every three months to perform inspection, testing, and preventive maintenance. Submit report to Owner indicating maintenance performed along with evaluations and recommendations.
- D. Provide trouble call-back service upon notification by Owner:
 - 1. Provide on-site response within 4 hours of notification.
 - 2. Owner will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.
- E. Maintain an on-site log listing the date and time of each inspection and call-back visit, the condition of the system, nature of the trouble, correction performed, and parts replaced.

END OF SECTION 26 33 23

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SECTION 26 36 00 - TRANSFER SWITCHES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Transfer switches for low-voltage (600 V and less) applications and associated accessories:
 - 1. Automatic transfer switches.
 - 2. Remote annunciators.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 03 30 00 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- C. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- D. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
 - 1. Includes requirements for the seismic qualification of equipment specified in this section.
- E. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 26 05 73 - Power System Studies: Additional criteria for the selection of equipment specified in this section.
- G. Section 26 21 00 - Low-Voltage Electrical Service Entrance.
- H. Section 26 28 16.16 - Enclosed Switches: Safety switches not listed for use as transfer switch equipment.

1.4 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NEMA ICS 10 Part 1 - Industrial Control and Systems Part 1: Electromechanical AC Transfer Switch Equipment 2020.

- D. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- E. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. NFPA 110 - Standard for Emergency and Standby Power Systems 2022.
- G. UL 869A - Reference Standard for Service Equipment Current Edition, Including All Revisions.
- H. UL 1008 - Transfer Switch Equipment Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate compatibility of transfer switches to be installed with work provided under other sections or by others.
 - 2. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
 - 3. Coordinate arrangement of equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 4. Coordinate the work with placement of supports, anchors, etc. required for mounting.
 - 5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Preinstallation Meeting: Convene one week before starting work of this section; require attendance of all affected installers.
- C. Where work of this section involves interruption of existing electrical service, arrange service interruption with Owner.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product, including ratings, configurations, dimensions, finishes, weights, service condition requirements, and installed features.
- C. Shop Drawings: Include dimensioned plan views and sections indicating locations of system components, required clearances, and field connection locations. Include system interconnection schematic diagrams showing all factory and field connections.

1. Clearly indicate whether proposed short circuit current ratings are based on testing with specific overcurrent protective devices or time durations; indicate short-time ratings where applicable.
 2. Identify mounting conditions required for equipment seismic qualification.
 - D. Manufacturer's equipment seismic qualification certification.
 - E. Specimen Warranty: Submit sample of manufacturer's warranty.
 - F. Evidence of qualifications for installer.
 - G. Evidence of qualifications for maintenance contractor (if different entity from installer).
 - H. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
 - I. Manufacturer's certification that products meet or exceed specified requirements.
 - J. Source quality control test reports.
 - K. Manufacturer's detailed field testing procedures.
 - L. Field quality control test reports.
 - M. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
 1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.
 - N. Executed Warranty: Submit documentation of final executed warranty completed in Owner's name and registered with manufacturer.
 - O. Maintenance contracts.
 - P. Project Record Documents: Record actual locations of system components, installed circuiting arrangements and routing, and final equipment settings.
 - Q. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. See Section 01 60 00 - Product Requirements, for additional provisions.
- 1.7 QUALITY ASSURANCE
- A. Comply with the following:
 1. NFPA 70 (National Electrical Code).

2. NFPA 110 (Standard for Emergency and Standby Power Systems).
 - B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
 - C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
 1. Authorized service facilities located within 100 miles of project site.
 - D. Installer Qualifications: Company specializing in performing the work of this section with minimum three years documented experience with power transfer systems of similar size, type, and complexity; manufacturer's authorized installer.
 - E. Maintenance Contractor Qualifications: Same entity as installer or different entity with specified qualifications.
 1. Contract maintenance office located within 100 miles of project site.
 - F. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.
- 1.8 DELIVERY, STORAGE, AND HANDLING
- A. Receive, inspect, handle, and store transfer switches in accordance with manufacturer's instructions.
 - B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
 - C. Handle carefully in accordance with manufacturer's instructions to avoid damage to transfer switch components, enclosure, and finish.
- 1.9 FIELD CONDITIONS
- A. Maintain field conditions within manufacturer's required service conditions during and after installation.
- 1.10 WARRANTY
- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
 - B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Transfer Switches - Basis of Design: ASCO 300 SERIES.

- B. Transfer Switches - Other Acceptable Manufacturers:
 - 1. ABB/GE; [_____]: www.electrification.us.abb.com/#sle.
 - 2. ASCO Power Technologies; [_____]: www.ascopower.com/#sle.
 - 3. Eaton Corporation: www.eaton.com/#sle.
- C. Substitutions: See Section 01 60 00 - Product Requirements.
- D. Products other than basis of design are subject to compliance with specified requirements and prior approval of Engineer. By using products other than basis of design, Contractor accepts responsibility for costs associated with any necessary modifications to related work, including any design fees.
- E. Source Limitations: Furnish transfer switches and accessories produced by a single manufacturer and obtained from a single supplier.

2.2 TRANSFER SWITCHES

- A. Provide complete power transfer system consisting of all required equipment, conduit, boxes, wiring, supports, accessories, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Applications:
 - 1. Utilize open transition transfer unless otherwise indicated or required.
 - 2. For transfer of highly inductive loads (e.g. large motors and transformers), utilize open transition transfer with in-phase monitor or delayed transition transfer.
 - 3. Neutral Switching (Single Phase, Three Wire and Three Phase, Four Wire Systems):
 - a. Unless otherwise indicated or required, provide solid (unswitched) neutral.
- D. Construction Type: Either "contactor type" (open contact) or "breaker type" (enclosed contact) transfer switches complying with specified requirements are acceptable.
- E. Automatic Transfer Switch:
 - 1. Transfer Switch Type: As indicated on the drawings.
 - 2. Transition Configuration: As indicated on the drawings.
 - 3. Voltage: As indicated on the drawings.
 - 4. Ampere Rating: As indicated on the drawings.
 - 5. Neutral Configuration: Solid neutral (unswitched), except as indicated.

6. Load Served: As indicated on the drawings.
7. Primary Source: As indicated on the drawings.
8. Alternate Source: As indicated on the drawings.
9. Features:
 - F. Comply with NEMA ICS 10 Part 1, and list and label as complying with UL 1008 for the classification of the intended application (e.g. emergency, optional standby).
 - G. Do not use double throw safety switches or other equipment not specifically designed for power transfer applications and listed as transfer switch equipment.
 - H. Load Classification: Classified for total system load (any combination of motor, electric discharge lamp, resistive, and tungsten lamp loads with tungsten lamp loads not exceeding 30 percent of the continuous current rating) unless otherwise indicated or required.
 - I. Switching Methods:
 1. Open Transition:
 - a. Provide break-before-make transfer without a neutral position that is not connected to either source, and with interlocks to prevent simultaneous connection of the load to both sources.
 - b. Where in-phase transfer is indicated, utilize in-phase monitor to initiate transfer when phase angle difference between sources is near zero to limit in-rush currents.
 2. Delayed Transition:
 - a. Provide break-before-make transfer with programmable time delay in a neutral position not connected to either source, and with interlocks to prevent simultaneous connection of the load to both sources.
 3. Obtain control power for transfer operation from line side of source to which the load is to be transferred.
 - J. Seismic Qualification: Provide transfer switches and associated components suitable for application under the seismic design criteria specified in Section 26 05 48 where required. Include certification of compliance with submittals.
 - K. Service Conditions: Provide transfer switches suitable for continuous operation at indicated ratings under the service conditions at the installed location.
 - L. Enclosures:
 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:

- a. Indoor Clean, Dry Locations: Type 1 or Type 12.
 - b. Outdoor Locations: Type 3R or Type 4.
 2. Provide lockable door(s) for outdoor locations.
 3. Finish: Manufacturer's standard unless otherwise indicated.
- M. Short Circuit Current Rating:
1. Withstand and Closing Rating: Provide transfer switches, when protected by the supply side overcurrent protective devices to be installed, with listed withstand and closing rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73.
- N. Automatic Transfer Switches:
1. Description: Transfer switches with automatically initiated transfer between sources; electrically operated and mechanically held.
 2. Control Functions:
 - a. Automatic mode.
 - b. Test Mode: Simulates failure of primary/normal source.
 - c. Voltage and Frequency Sensing:
 - 1) Undervoltage sensing for each phase of primary/normal source; adjustable dropout/pickup settings.
 - 2) Undervoltage sensing for alternate/emergency source; adjustable dropout/pickup settings.
 - 3) Underfrequency sensing for alternate/emergency source; adjustable dropout/pickup settings.
 - d. Outputs:
 - 1) Contacts for engine start/shutdown (except where direct generator communication interface is provided).
 - 2) Auxiliary contacts; one set(s) for each switch position.
 - e. Adjustable Time Delays:
 - 1) Engine generator start time delay; delays engine start signal to override momentary primary/normal source failures.
 - 2) Transfer to alternate/emergency source time delay.

- 3) Retransfer to primary/normal source time delay.
- 4) Engine generator cooldown time delay; delays engine shutdown following retransfer to primary/normal source to permit generator to run unloaded for cooldown period.
- f. In-Phase Monitor (Open Transition Transfer Switches): Monitors phase angle difference between sources for initiating in-phase transfer.
- g. Engine Exerciser: Provides programmable scheduled exercising of engine generator selectable with or without transfer to load; provides memory retention during power outage.
3. Status Indications:
 - a. Connected to alternate/emergency source.
 - b. Connected to primary/normal source.
 - c. Alternate/emergency source available.
4. Automatic Sequence of Operations:
 - a. Upon failure of primary/normal source for a programmable time period (engine generator start time delay), initiate starting of engine generator where applicable.
 - b. When alternate/emergency source is available, transfer load to alternate/emergency source after programmable time delay.
 - c. When primary/normal source has been restored, retransfer to primary/normal source after a programmable time delay. Bypass time delay if alternate/emergency source fails and primary/normal source is available.
 - d. Where applicable, initiate shutdown of engine generator after programmable engine cooldown time delay.
- O. Remote Annunciators:
 1. Remote Annunciator Mounting: Wall-mounted; Provide flush-mounted annunciator for finished areas and surface-mounted annunciator for non-finished areas unless otherwise indicated.
 2. Transfer Switch Status Indications:
 - a. Connected to alternate/emergency source.
 - b. Connected to primary/normal source.
 - c. Alternate/emergency source available.
 - d. Primary/normal source available.

P. Interface with Other Work:

1. Interface with building automation system.

2.3 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Perform production tests on transfer switches at factory to verify operation and performance characteristics prior to shipment. Include certified test report with submittals.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of transfer switches are consistent with the indicated requirements.
- C. Verify that rough-ins for field connections are in the proper locations.
- D. Verify that mounting surfaces are ready to receive transfer switches.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Arrange equipment to provide minimum clearances and required maintenance access.
- D. Provide required support and attachment in accordance with Section 26 05 29.
- E. Install transfer switches plumb and level.
- F. Unless otherwise indicated, mount floor-mounted transfer switches on properly sized 3 inch high concrete pad constructed in accordance with Section 03 30 00.
- G. Provide grounding and bonding in accordance with Section 26 05 26.
- H. Identify transfer switches and associated system wiring in accordance with Section 26 05 53.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Prepare and start system in accordance with manufacturer's instructions.
- C. Automatic Transfer Switches:

1. Inspect and test in accordance with NETA ATS, except Section 4.
 2. Perform inspections and tests listed in NETA ATS, Section 7.22.3. The insulation-resistance tests listed as optional are not required.
 - D. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.
 - E. Submit detailed reports indicating inspection and testing results and corrective actions taken.
- 3.4 CLEANING
- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.
- 3.5 CLOSEOUT ACTIVITIES
- A. Demonstration: Demonstrate proper operation of transfer switches to Owner, and correct deficiencies or make adjustments as directed.
 - B. Training: Train Owner's personnel on operation, adjustment, and maintenance of transfer switches.
 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 2. Provide minimum of four hours of training.
 3. Instructor: Manufacturer's authorized representative.
 4. Location: At project site.
- 3.6 PROTECTION
- A. Protect installed transfer switches from subsequent construction operations.
- 3.7 MAINTENANCE
- A. See Section 01 70 00 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
 - B. Provide to Owner a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of transfer switches for two years from date of Substantial Completion; Include a complete description of preventive maintenance, systematic examination, adjustment, inspection, and testing, with a detailed schedule.
 - C. Provide trouble call-back service upon notification by Owner:
 1. Provide on-site response within 4 hours of notification.

2. Include allowance for call-back service during normal working hours at no extra cost to Owner.
 3. Owner will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.
- D. Maintain an on-site log listing the date and time of each inspection and call-back visit, the condition of the system, nature of the trouble, correction performed, and parts replaced.

END OF SECTION 26 36 00

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SECTION 26 41 13 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Strike (air) terminals and interconnecting conductors.
- B. Grounding and bonding for lightning protection.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Surge Protection for Wiring Systems: Specified in individual system requirements.

1.4 REFERENCE STANDARDS

- A. NFPA 780 - Standard for the Installation of Lightning Protection Systems 2020.
- B. UL 96 - Lightning Protection Components Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination with Concrete Work: Coordinate the embedding of lightning protection components in concrete.
- B. Coordination with Roofing Work: Ensure adequate attachment of strike terminals and conductors without damage to roofing.
- C. Preinstallation Meeting: Convene a meeting at least at least two weeks prior to commencement of any work affected by lightning protection system requirements to discuss prerequisites and coordination required by other installers; require attendance by representatives of installers whose work will be affected.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate location and layout of air terminals, grounding electrodes, and bonding connections to structure and other metal objects. Include terminal, electrode, and conductor sizes, and connection and termination details.
 - 1. Where conductors or grounds are to be embedded or concealed in other construction, submit shop drawings at least 30 days prior to start of construction.

2. If concrete-encased grounds are to be used and are not shown in Contract Documents, provide sufficient data to determine concrete encasement dimensions and location.
 3. Include data on actual ground resistance determined by field measurement in accordance with NFPA 780.
 4. Include engineering analysis of equalization of potential to metal bodies within the structure.
 5. Include access panels, test holes, and disconnecting means for maintenance.
- C. Product Data: Provide dimensions and materials of each component, indication of testing agency listing, and installation instructions.
- D. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- E. Installation Certification: Submit copy of certification agency's approval.
- F. Operation and Maintenance Data: Provide recommended inspection and testing plan, including recommended intervals, to achieve periodic maintenance as recommended in NFPA 780; provide customized plan reflecting actual installation configuration with specific installed components identified.
- G. Project Record Documents: Record actual locations of air terminals, grounding electrodes, bonding connections, and routing of system conductors in project record documents.

1.7 QUALITY ASSURANCE

- A. Maintain one copy of each referenced system design standard on site.
- B. Manufacturer Qualifications: Company specializing in lightning protection equipment with minimum three years documented experience.
- C. Designer Qualifications: Person or entity, employed by installer, who specializes in lightning protection system design with minimum three years documented experience.
- D. Installer Qualifications: Company specializing in lightning protection system design with minimum three years documented experience.
- E. Field Quality Control Testing Agency Qualifications: Firm capable of and experienced in grounding and bonding testing with documented experience and minimum of three project references.
- F. Products: Listed, classified, and labeled as suitable for the purpose intended.
- G. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM

- A. Lightning Protection System: Provide complete system complying with NFPA 780, including air terminals, bonding, interconnecting conductors and grounding electrodes.
 - 1. Provide system that protects:
 - a. The entire structure.
 - b. Open air areas within 100 feet of exterior walls at grade level.
 - c. Open air areas within building footprint.
 - d. Antennas & Mounting Systems.
 - e. Weather Data Collection Systems & Mounting Systems.
 - f. Central Courtyard.
 - 2. Coordinate with other grounding and bonding systems specified.
 - 3. Determine ground resistance by field measurement.
 - 4. Provide copper, bronze, or stainless steel components, as applicable; no aluminum.
 - 5. Provide disconnecting means and access panels or similar devices to allow complete periodic inspection and testing as described by NFPA 780 Annex D.
 - 6. Provide system certified by Underwriters Laboratories and provide Master Label Certificate to owner.

2.2 COMPONENTS

- A. All Components: Complying with applicable requirements of UL 96.
- B. Strike (Air) Terminals: Copper, solid, with adhesive bases for single-ply roof installations.
- C. Strike Terminal for Chimney: Lead-coated copper.
- D. Grounding Rods: Solid copper.
- E. Ground Plate: Copper.
- F. Conductors: Copper cable.
- G. Connectors and Splicers: Bronze.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated on shop drawings.
- B. Coordinate work with installation of roofing and exterior and interior finishes.

3.2 INSTALLATION

- A. Install in accordance with referenced system standards and as required for specified certification.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Perform visual inspection as specified in NFPA 780 as if this were a periodic follow-up inspection.
- C. Perform continuity testing as specified in NFPA 780 as if this were testing for periodic maintenance.
- D. Obtain the services of the specified certification agency to provide inspection and certification of the lightning protection system, including performance of any other testing required by that agency.

END OF SECTION 26 41 13

SECTION 26 43 00 - SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Surge protective devices for service entrance locations.
- B. Surge protective devices for distribution locations.
- C. Surge protective devices for branch panelboard locations.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- B. Section 26 24 13 - Switchboards.
- C. Section 26 24 16 - Panelboards.

1.4 ABBREVIATIONS AND ACRONYMS

- A. EMI/RFI: Electromagnetic Interference/Radio Frequency Interference.
- B. SPD: Surge Protective Device.

1.5 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems 2017.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. UL 1449 - Standard for Surge Protective Devices Current Edition, Including All Revisions.

1.6 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate size and location of overcurrent device compatible with the actual surge protective device and location to be installed. Notify Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to ordering equipment.

1.7 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Include detailed component information, voltage, surge current ratings, repetitive surge current capacity, voltage protection rating (VPR) for all protection modes, maximum continuous operating voltage (MCOV), nominal discharge current (I-n), short circuit current rating (SCCR), connection means including any required external overcurrent protection, enclosure ratings, outline and support point dimensions, weight, service condition requirements, and installed features.
 - 1. SPDs with EMI/RFI filter: Include noise attenuation performance.
- C. Shop Drawings Shall Include The Following:
 - 1. Include wiring diagrams showing all factory and field connections with wire and circuit breaker/fuse sizes.
 - 2. Package must include shop drawings complete with all technical information, unit dimensions, detailed installation instructions, maintenance manual, recommended replacement parts list and wiring configuration.
 - 3. Copies of manufacturer's catalog data, technical information and specifications on equipment proposed for use.
 - 4. Copies of documentation stating that the Surge Protective Device is listed by UL to UL1449 4th Edition, category code VZCA.
 - 5. Copies of actual let through voltage data in the form of oscillograph results for both ANSI/IEEE C62.41 Category C3 (combination wave) and B3 (Ring wave) tested in accordance with ANSI/IEEE C6245.
 - 6. Copies of Noise Rejection testing as outlined in NEMA LS1-1992 (R2000) Section 3.11. Noise rejection is to be measured between 50kHz and 100MHz verifying the devices noise attenuation. Must show multiple attenuation levels over a range of frequencies.
 - 7. Copies of test reports from a recognized independent testing laboratory, capable of producing 200kA surge current waveforms, verifying the suppressor components can survive published surge current rating on a per mode basis using the ANSI/IEEE C62.41 impulse waveform C3 (8 x 20 microsecond, 20kV/10kA). Test data on an individual module is not acceptable.
 - 8. Copy of warranty statement clearly establishing the terms and conditions to the building/facility owner/operator.
- D. Certificates: Manufacturer's documentation of listing for compliance with the following standards:
 - 1. UL 1449.

2. UL 1283 (for Type 2 SPDs).

E. Field Quality Control Test Reports.

F. Manufacturer's Installation Instructions: Include application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

G. Operation and Maintenance Data: Include information on status indicators and recommended maintenance procedures and intervals.

H. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.

I. Project Record Documents: Record actual connections and locations of surge protective devices.

1.8 QUALITY ASSURANCE

A. Comply with the latest edition of the applicable provisions and recommendations of the following, except as otherwise stated in this document:

1. Comply with requirements of NFPA 70.

2. UL 1449 4th Edition 2014 Revision (effective 3/26/2016).

3. UL 1283.

4. ANSI/IEEE C62.41, Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.

5. ANSI/IEEE C62.45, Guide for Surge Testing for equipment connected to Low-Voltage AC Power Circuits.

6. UL96A

7. IEEE 1100 Emerald Book.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.9 DELIVERY, STORAGE, AND PROTECTION

A. Store in a clean, dry space in accordance with manufacturer's written instructions.

1.10 FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.11 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Manufacturer's Warranty: Provide minimum 15 year warranty covering repair or replacement of surge protective devices showing evidence of failure due to defective materials or workmanship.
- C. Exclude surge protective devices from any clause limiting warranty responsibility for acts of nature, including lightning, stated elsewhere.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Basis of Design: Current Technology, as indicated under product descriptions below; www..
- B. Field-installed, Externally Mounted Surge Protective Devices - Other Acceptable Manufacturers:
 - 1. Schneider Electric; Square D Brand Surgellogic Products; [____]:
www.surgelogic.com/#sle.
 - 2. Surge Suppression, LLC (SSI); [____]: www.surgesuppression.com/#sle.
 - 3. Eaton.
- C. Factory-installed, Internally Mounted Surge Protective Devices:
 - 1. Same as manufacturer of equipment containing surge protective device, to provide a complete listed assembly including SPD.
- D. Substitutions: See Section 01 60 00 - Product Requirements.
- E. Products other than basis of design are subject to compliance with specified requirements and prior approval of Engineer. By using products other than basis of design, Contractor accepts responsibility for costs associated with any necessary modifications to related work, including any design fees.
- F. Source Limitations: Furnish surge protective devices produced by a single manufacturer and obtained from a single supplier.

2.2 SURGE PROTECTIVE DEVICES - GENERAL REQUIREMENTS

- A. Description: Factory-assembled surge protective devices (SPDs) for 60 Hz service; listed, classified, and labeled as suitable for the purpose intended; system voltage as indicated on the

drawings.

- B. Unless otherwise indicated, provide field-installed, externally-mounted or factory-installed, internally-mounted SPDs.
- C. List and label as complying with UL 1449, Type 1 when connected on line side of service disconnect overcurrent device and Type 1 or 2 when connected on load side of service disconnect overcurrent device.
- D. Protected Modes:
 - 1. Wye Systems: L-N, L-G, N-G, L-L.
 - 2. Delta Systems: L-G, L-L.
 - 3. Single Split Phase Systems: L-N, L-G, N-G, L-L.
- E. UL 1449 Voltage Protection Ratings (VPRs):
 - 1. 208Y/120V System Voltage: Not more than 1,000 V for L-N, L-G, and N-G modes and 1,200 V for L-L mode.
 - 2. 480Y/277V System Voltage: Not more than 1,500 V for L-N, L-G, and N-G modes and 2,000 V for L-L mode.
- F. UL 1449 Maximum Continuous Operating Voltage (MCOV): Not less than 115% of nominal system voltage.
- G. Enclosure Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - 1. Indoor clean, dry locations: Type 1.
 - 2. Outdoor locations: Type 3R.
- H. Mounting for Field-installed, Externally Mounted SPDs: Unless otherwise indicated, as specified for the following locations:
 - 1. Provide surface-mounted SPD where mounted in non-public areas or adjacent to surface-mounted equipment.
 - 2. Provide flush-mounted SPD where mounted in public areas or adjacent to flush-mounted equipment.
- I. Equipment Containing Factory-installed, Internally Mounted SPDs: Listed and labeled as a complete assembly including SPD.
 - 1. Switchboards: See Section 26 24 13.
 - 2. Panelboards: See Section 26 24 16.

2.3 SURGE PROTECTIVE DEVICES:

- A. Locations include SPDs connected to service entrance equipment, switchboards, distribution panelboards, and branch panelboards.
- B. Surge Protective Device - Basis of Design: Current Technology; Model: Transguard-3.
 - 1. Voltage: As indicated on drawings.
 - 2. Minimum Surge Ratings:
 - a. 80 kA - Protection for panelboards rated LESS THAN 225 A.
 - b. 150 kA - Protection for panelboards rated 225 A to 400 A.
 - c. 200 kA - Protection for panelboards rated GREATER THAN 400 A.
 - d. 200 kA - Protection for Service Entrance Equipment.
 - 3. Declared Maximum Continuous Operating Voltage (MCOV) shall be greater than 115 percent of the nominal system operating voltage and in compliance with test and evaluation procedures outlined in the nominal discharge surge current test of UL1449, section 37.7.3. MCOV values claimed based on the component's value or on the 30-minute 115% operational voltage test, section 38 in UL1449 will not be accepted.
 - 4. Unit shall have no more than 10% deterioration or degradation of the UL1449 4th Edition Voltage Protection Rating (VPR) when exposed to a minimum of 5,000 repeated category C3 (20kV/10kA) surges. The SPD manufacturer must provide a test report validating the repetitive surge test was performed.
 - 5. Protection Modes UL1449 4th Edition VPR(6kV, 3kA) for grounded WYE/delta and High Leg Delta circuits with voltages of (480Y/277), (208Y/120), (600Y/347). 3-Phase, 4 wire circuits, (120/240) split phase shall be as follows and comply with test procedures outlined in UL1449 section 37.6:

System Voltage	Mode	MCOV	B3Ringwave 6kV, 500A	C3 Comb. Wave 20kV, 10kA	UL 1449Fourth Edition VPR Rating
120/240, 120/208	L-N	150	490	980	700
	L-G	150	570	980	700
	N-G	150	640	1170	700
	L-L	300	500	1600	1200
277/480	L-N	320	450	1420	1200
	L-G	320	540	1540	1200
	N-G	320	570	1600	1000
	L-L	552	530	2600	2000

6. Electrical Noise Filter: each unit shall include a high performance EMI/RFI noise rejection filter with a maximum attenuation of 54dB per MIL-STD-220B.
 - a. SPD shall include a EMI/RFI noise rejection filter for all L-N modes as well as a removable filter in the N-G mode.
7. Metal Enclosure with Integral Disconnect Switch
 - a. The device shall have an optional NEMA compliant safety interlocked integral disconnect switch with an externally mounted metal manual operator.
 - b. The switch shall disconnect all ungrounded circuit conductors from the distribution system to enable testing and maintenance without interruption to the facility's distribution system.
 - c. The switch shall be rated for 600Vac.
 - d. The SPD device shall be tested to UL1449 4th Edition listed with the integral disconnect switch and the UL1449 VPR ratings shall be provided.
 - e. The integral disconnect switch shall be capable of withstanding, without failure, the published maximum surge current magnitude without failure or damage to the switch.
 - f. The line side of the integral disconnect shall be blocked off so that when the SPD is opened there is no direct access to the voltage present on the line side of the disconnect.
8. The UL1449 Voltage Protective Rating (VPR) shall be permanently affixed to the SPD unit.
9. The UL1449 Nominal Discharge Surge Current Rating shall be 20kA
10. The SCCR rating of the SPD shall be 200kAIC without the need for upstream over current protection.
11. The SPD shall be listed as Type1 SPD, suitable for use in Type1 or Type2 applications.
12. The SPD shall have the following monitoring options:
 - a. Time Date stamp, duration and magnitude for the following power quality events (sags, swells, surges, dropouts, outages, THD, frequency, Volts RMS per phase)
 - b. SPD monitoring shall track surge protection and display it as a percentage
 - c. SPD shall provide a surge counter with three categories to be defined as Low Level surge (100A-500A), Medium Level surge (500A-3,000A), High Level surge (>3,000A)
 - d. Remote communications via ModBus or Ethernet.

13. Warranty on defective material and workmanship shall be for 15 years.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the service voltage and configuration marked on the SPD are consistent with the service voltage and configuration at the location to be installed.
- C. Verify that electrical equipment is ready to accept connection of the SPD and that installed overcurrent device is consistent with requirements of drawings and manufacturer's instructions.
- D. Verify system grounding and bonding is in accordance with Section 26 05 26, including bonding of neutral and ground for service entrance and separately derived systems where applicable. Do not energize SPD until deficiencies have been corrected.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Unless indicated otherwise, connect service entrance surge protective device on load side of service disconnect main overcurrent device.
- E. Unless factory installed with panelboard, connect external SPD to minimum 100A circuit breaker, unless otherwise required by mfg.
- F. Provide conductors with minimum ampacity as indicated on the drawings, as required by NFPA 70, and not less than manufacturer's recommended minimum conductor size.
- G. Install conductors between SPD and equipment terminations as short and straight as possible, not exceeding manufacturer's recommended maximum conductor length. Breaker locations may be reasonably rearranged in order to provide leads as short and straight as possible. Twist conductors together to reduce inductance.
- H. Do not energize SPD until bonding of neutral and ground for service entrance and separately derived systems is complete in accordance with Section 26 05 26 where applicable. Replace SPDs damaged by improper or missing neutral-ground bond.
- I. Disconnect SPD prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPD connected.

- J. The SPD manufacturer's technician shall perform a system checkout and start-up in the field to assure proper installation, operation and to initiate the warranty of the system. The technician will be required to do the following:
1. Verify voltage clamping levels utilizing a diagnostic test kit, comparing factory readings to installed readings.
 2. Verify N-G connection.
 3. Record information to a product signature card for each product installed.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS Section 7.19.1.
- D. Procure services of a qualified manufacturer's representative to observe installation and assist in inspection, testing, and adjusting. Include manufacturer's reports with field quality control submittals.

3.4 CLEANING

- A. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION 26 43 00

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SECTION 26 51 00 - INTERIOR LIGHTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Interior luminaires.
- B. Emergency lighting units.
- C. Exit signs.
- D. Ballasts and drivers.
- E. Lamps.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- B. Section 26 05 33.16 - Boxes for Electrical Systems.
- C. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
- D. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 26 09 23 - Lighting Control Devices.
- F. Section 26 27 26 - Wiring Devices: Manual wall switches and wall dimmers.
- G. Section 26 55 61 - Theatrical Lighting: Stage lighting units and associated controls.
- H. Section 26 56 00 - Exterior Lighting.

1.4 REFERENCE STANDARDS

- A. IES LM-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products 2019.
- B. IES LM-80 - Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays, and Modules 2019.
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- D. NECA/IESNA 500 - Standard for Installing Indoor Lighting Systems 2006.

- E. NECA/IESNA 502 - Standard for Installing Industrial Lighting Systems 2006.
- F. NEMA 410 - Performance Testing for Lighting Controls and Switching Devices 2020.
- G. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. NFPA 101 - Life Safety Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. UL 924 - Emergency Lighting and Power Equipment Current Edition, Including All Revisions.
- J. UL 1598 - Luminaires Current Edition, Including All Revisions.
- K. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the work with placement of supports, anchors, etc. required for mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.
 - 2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
 - 3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.
 - 4. Notify Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings:
 - 1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
 - 2. Provide photometric calculations where luminaires are proposed for substitution and upon request for approved alternate fixtures.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements,

listings, service conditions, photometric performance, installed accessories, and ceiling compatibility; include model number nomenclature clearly marked with all proposed features.

1. All project specific options and features must be clearly indicated on the submittal documents. Generic catalog pages and specification sheets will be rejected without review.
2. All submittal documents shall be clearly legible or will be rejected without review.
3. LED Luminaires:
 - a. Include estimated useful life, calculated based on IES LM-80 test data.
4. Lamps: Include rated life, color temperature, color rendering index (CRI), and initial and mean lumen output.

D. Field quality control reports.

E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

F. Operation and Maintenance Data: Instructions for each product including information on replacement parts.

G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. See Section 01 60 00 - Product Requirements, for additional provisions.
2. Extra Lenses and Louvers: Two percent of total quantity installed for each type, but not less than one of each type.
3. Extra Lamps: Ten percent of total quantity installed for each type, but not less than two of each type.
4. Extra LED Drivers: Two percent of total quantity installed for each type, but not less than one of each type.
5. 1x4, 2x2, & 2x4 Fixtures: Two percent of total quantity installed for each type, but not less than one of each type..

H. Project Record Documents: Record actual connections and locations of luminaires and any associated remote components.

1.7 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND PROTECTION

- A. Receive, handle, and store products according to NECA/IESNA 500 (commercial lighting), NECA/IESNA 502 (industrial lighting), and manufacturer's written instructions.
- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.9 FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.10 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Provide three year manufacturer warranty for LED luminaires, including drivers.

PART 2 PRODUCTS

2.1 LUMINAIRE TYPES

- A. Furnish products as indicated in luminaire schedule included on the drawings.
 - 1. Basis of design - Products represented by Apex Lighting, as shown on fixture schedule.
 - 2. Aproved alternates - EQUALS represented by Lighting Affiliates or Illuminate lighting.
 - a. Alternates must be equal to basis of design in performance, quality, and aesthetics to the satisfaction of the engineer and architect.
 - b. Alternates must have same lumen levels, and minimum efficiency not less than 5% of basis of design.
 - c. Alternates must have same (or better) DLC rating as basis of design.
 - d. Alternates must perform properly with approved control system. All required accessories and additional equipment required to provide proper performance, as indicated on plans, shall be included at no additional cost.
 - e. Alternates shall be provided with photometric calculations to verify performance, upon request.

- B. Substitutions: Not permitted.

2.2 LUMINAIRES

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.
- D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
- E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc. as necessary for a complete operating system.
- F. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- G. LED Luminaires:
 - 1. Components: UL 8750 recognized or listed as applicable.
 - 2. Tested in accordance with IES LM-79 and IES LM-80.
 - 3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.
- H. LED Tape Lighting Systems: Provide all power supplies, drivers, cables, connectors, channels, covers, mounting accessories, and interfaces as necessary to complete installation.
 - 1. LED Tape - General Requirements:
 - a. Listed.
 - b. Designed for field cutting in accordance with listing.
 - 2. White LED Tape:
 - a. Color Rendering Index (CRI): Not less than 90.

2.3 EMERGENCY LIGHTING UNITS

- A. Description: Emergency lighting units complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
- B. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and

automatically recharges battery upon restoration of normal power source.

C. Battery:

1. Size battery to supply all connected lamps, including emergency remote heads where indicated.

D. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.

E. Provide low-voltage disconnect to prevent battery damage from deep discharge.

F. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status.

G. Accessories:

1. Provide compatible accessory mounting brackets where indicated or required to complete installation.
2. Provide compatible accessory high impact polycarbonate vandal shields where indicated.
3. Provide compatible accessory wire guards where indicated.
4. Where indicated, provide emergency remote heads that are compatible with the emergency lighting unit they are connected to and suitable for the installed location.

2.4 EXIT SIGNS

A. Description: Exit signs complying with NFPA 101 and applicable state and local codes, and listed and labeled as complying with UL 924.

1. Number of Faces: Single- or double-face as indicated or as required for installed location.
2. Directional Arrows: As indicated or as required for installed location.

B. Powered Exit Signs: Internally illuminated with LEDs unless otherwise indicated.

1. Self-Powered Exit Signs:

- a. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
- b. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
- c. Provide low-voltage disconnect to prevent battery damage from deep discharge.

- d. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status.

2.5 BALLASTS AND DRIVERS

A. Ballasts/Drivers - General Requirements:

1. Provide ballasts containing no polychlorinated biphenyls (PCBs).
2. Minimum Efficiency/Efficacy: Provide ballasts complying with all current applicable federal and state ballast efficiency/efficacy standards.
3. Electronic Ballasts/Drivers: Inrush currents not exceeding peak currents specified in NEMA 410.

B. Dimmable LED Drivers:

1. Dimming Range: Continuous dimming from 100 percent to one percent relative light output unless dimming capability to lower level is indicated, without flicker.
2. Control Compatibility: Fully compatible with the dimming controls to be installed.

2.6 LAMPS

A. Lamps - General Requirements:

1. Unless explicitly excluded, provide new, compatible, operable lamps in each luminaire.
2. Verify compatibility of specified lamps with luminaires to be installed. Where lamps are not specified, provide lamps per luminaire manufacturer's recommendations.
3. Minimum Efficiency: Provide lamps complying with all current applicable federal and state lamp efficiency standards.
4. Color Temperature Consistency: Unless otherwise indicated, for each type of lamp furnish products which are consistent in perceived color temperature. Replace lamps that are determined by the Engineer to be inconsistent in perceived color temperature.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.
- C. Verify that suitable support frames are installed where required.

- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

- A. Coordinate locations of outlet boxes provided under Section 26 05 33.16 as required for installation of luminaires provided under this section.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install products in accordance with manufacturer's instructions.
- D. Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting) and NECA 502 (industrial lighting).
- E. Provide required support and attachment in accordance with Section 26 05 29.
- F. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- G. Suspended Ceiling Mounted Luminaires:
 - 1. Do not use ceiling tiles to bear weight of luminaires.
 - 2. Do not use ceiling support system to bear weight of luminaires unless ceiling support system is certified as suitable to do so.
 - 3. Secure surface-mounted and recessed luminaires to ceiling support channels or framing members or to building structure.
 - 4. Secure pendant-mounted luminaires to building structure.
 - 5. Secure lay-in luminaires to ceiling support channels using listed safety clips at four corners.
 - 6. In addition to ceiling support wires, provide two galvanized steel safety wire(s), minimum 12 gauge, connected from opposing corners of each recessed luminaire to building structure.
 - 7. See appropriate Division 9 section where suspended grid ceiling is specified for additional requirements.
- H. Recessed Luminaires:

1. Install trims tight to mounting surface with no visible light leakage.
 2. Non-IC Rated Luminaires: Maintain required separation from insulation and combustible materials according to listing.
 3. Luminaires Recessed in Fire-Rated Ceilings: Install using accessories and firestopping materials to meet regulatory requirements for fire rating.
- I. Suspended Luminaires:
1. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
 2. Provide minimum of two supports for each luminaire equal to or exceeding 4 feet nominal length, with no more than 4 feet between supports.
 3. Install canopies tight to mounting surface.
 4. Unless otherwise indicated, support pendants from swivel hangers.
- J. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- K. Install accessories furnished with each luminaire.
- L. Bond products and metal accessories to branch circuit equipment grounding conductor.
- M. Emergency Lighting Units:
1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
 2. Install lock-on device on branch circuit breaker serving units.
- N. Exit Signs:
1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
 2. Install lock-on device on branch circuit breaker serving units.
- O. Identify luminaires connected to emergency power system in accordance with Section 26 05 53.
1. Provide emergency bypass relays as required to monitor normal lighting circuit serving same area and to bypass all lighting controls and fully illuminate luminaires connected to the emergency power system upon loss of the normal power lighting circuit being monitored.
- P. Install lamps in each luminaire.

- Q. Lamp Burn-In: Operate lamps at full output for prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.

3.4 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect each product for damage and defects.
- C. Operate each luminaire after installation and connection to verify proper operation.
- D. Test self-powered exit signs, emergency lighting units, and fluorescent emergency power supply units to verify proper operation upon loss of normal power supply.
- E. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Engineer.

3.5 ADJUSTING

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Engineer. Secure locking fittings in place.
- B. Aim and position adjustable emergency lighting unit lamps to achieve optimum illumination of egress path as required or as directed by Engineer or authority having jurisdiction.
- C. Exit Signs with Field-Selectable Directional Arrows: Set as indicated or as required to properly designate egress path as directed by Engineer or authority having jurisdiction.

3.6 CLEANING

- A. Clean surfaces according to NECA 500 (commercial lighting), NECA 502 (industrial lighting), and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

3.7 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 - Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of luminaires to Engineer, and correct deficiencies or make adjustments as directed.
- D. Just prior to Substantial Completion of each phase, replace all lamps that have failed.

3.8 PROTECTION

- A. Protect installed luminaires from subsequent construction operations.

END OF SECTION 26 51 00

SECTION 26 55 61 - THEATRICAL LIGHTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Stage lighting units and lamps.
- B. Dimmers and control units.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 REFERENCE STANDARDS

- A. IES LM-63 - IESNA Standard File Format for Electronic Transfer of Photometric Data and Related Information 2002 (Reaffirmed 2008).
- B. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate layout of rack-mounted equipment and details and diagrams of interconnecting wiring.
- C. Product Data: Provide for each item of equipment, showing sizes and ratings.
 - 1. Provide electronic files of photometric data certified by a National Voluntary Laboratory Accreditation Program (NVLAP) lab or independent testing agency in IES LM-63 standard format upon request.
- D. Manufacturer's Installation Instructions.
- E. Project Record Documents: Record actual locations of dimmer outlets and circuiting arrangements.
- F. Operation Data:
 - 1. Instructions for operating lighting control system.
 - 2. Instructions for operating system under unusual conditions when emergency life safety conditions exist.
 - 3. Identify limits beyond which operation would result in hazardous or unsafe conditions or in equipment damage.

4. Document ratings of system and of each major component.

G. Maintenance Data:

1. Routine preventive maintenance schedule.
2. Lists of special tools, maintenance materials, and replacement parts.
3. Repair instructions for procedures to check, repair, and test equipment during typical malfunctions.
4. Recommended cleaning methods, frequency, and materials.

H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. See Section 01 60 00 - Product Requirements, for additional provisions.
2. Extra Lamps: One of each type and size.
3. Extra Dimmers: One of each size.
4. Extra Filter Holders: One of each size.
5. Extra Filters: One of each type, size, and color.
6. Extra Patch Connectors: One of each type and size.

1.5 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience and with service facilities within 100 miles of Project.
- C. Supplier Qualifications: Authorized distributor of specified manufacturer with minimum three years documented experience.
- D. Products: Listed, classified, and labeled as suitable for the purpose intended.
- E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.1 GENERAL DESCRIPTION:

- A. Provide complete replacement of existing theatrical lighting system with the following features:
 1. LED luminaires:

- a. Quantity, location, color, and function of new lights to match existing.
- b. Output of new lights to met or exceed existing.
2. Control capabilities and locations to match functionality of existing system.
3. System growth to meet or exceed existing system.

2.2 LIGHTING CONTROL COMPONENTS

- A. Lighting Dimming and Control System: For stage area and house lighting.
- B. Dimmers: Portable dimming unit suitable for mounting at lighting unit.

2.3 STAGE LIGHTING UNITS AND ACCESSORIES

- A. Furnish products as indicated in Schedule included on the Drawings.
- B. Substitutions: See Section 01 60 00 - Product Requirements.

2.4 STAGE LIGHTING UNITS AND ACCESSORIES

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install components in accordance with manufacturer's instructions.
- B. Provide the services of a manufacturer representative to prepare and start systems.
- C. Aim and adjust luminaires as indicated on Drawings.
- D. Clean electrical parts to remove conductive and harmful materials.
- E. Remove dirt and debris from enclosure.
- F. Clean photometric control surfaces as recommended by manufacturer.
- G. Clean finishes and touch up damage.

3.2 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 - Demonstration and Training, for additional requirements.
- C. Demonstrate theatrical lighting system operation to Owner personnel for minimum of two hours.

3.3 SCHEDULE - SEE DRAWINGS

END OF SECTION 26 55 61

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SECTION 26 56 00 - EXTERIOR LIGHTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Exterior luminaires.
- B. Ballasts.
- C. Lamps.
- D. Poles and accessories.
- E. Luminaire accessories.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 03 30 00 - Cast-in-Place Concrete: Materials and installation requirements for concrete bases for poles.
- B. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- C. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- D. Section 26 05 33.16 - Boxes for Electrical Systems.
- E. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.
- F. Section 26 09 23 - Lighting Control Devices.
- G. Section 26 27 26 - Wiring Devices: Receptacles for installation in poles.
- H. Section 26 28 13 - Fuses.

1.4 UNIT PRICES

- A. See Section 01 22 00 - Unit Prices, for additional unit price requirements.
- B. Exterior Lighting Unit:
 - 1. Basis of Measurement: Each.

1.5 REFERENCE STANDARDS

- A. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code) 2013 (Corrigendum 2019).
- B. IEEE C2 - National Electrical Safety Code 2017.
- C. IES LM-63 - IESNA Standard File Format for Electronic Transfer of Photometric Data and Related Information 2002 (Reaffirmed 2008).
- D. IES LM-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products 2019.
- E. IES LM-80 - Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays, and Modules 2019.
- F. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- G. NECA/IESNA 501 - Standard for Installing Exterior Lighting Systems 2006.
- H. NEMA 410 - Performance Testing for Lighting Controls and Switching Devices 2020.
- I. NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility 2012.
- J. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- K. UL 844 - Luminaires for Use in Hazardous (Classified) Locations Current Edition, Including All Revisions.
- L. UL 1598 - Luminaires Current Edition, Including All Revisions.
- M. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products Current Edition, Including All Revisions.

1.6 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate placement of poles and associated foundations with utilities, curbs, sidewalks, trees, walls, fences, striping, etc. installed under other sections or by others. Coordinate elevation to obtain specified foundation height.
 - 2. Notify Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.7 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings:

1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
 2. Provide photometric calculations where luminaires are proposed for substitution upon request.
 3. Provide structural calculations for each pole [_____].
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, weight, effective projected area (EPA), and installed accessories; include model number nomenclature clearly marked with all proposed features.
1. LED Luminaires:
 - a. Include estimated useful life, calculated based on IES LM-80 test data.
 2. Provide electronic files of photometric data certified by a National Voluntary Laboratory Accreditation Program (NVLAP) lab or independent testing agency in IES LM-63 standard format upon request.
 3. Lamps: Include rated life and initial and mean lumen output.
 4. Poles: Include information on maximum supported effective projected area (EPA) and weight for the design wind speed.
- D. Sustainable Design Documentation: Submit manufacturer's product data on lamp mercury content and rated lamp life, showing compliance with specified requirements.
- E. Samples:
1. Provide one sample(s) of each specified luminaire where indicated.
 2. Provide one sample(s) of each custom luminaire.
 3. Provide one sample(s) of each luminaire proposed for substitution upon request.
 4. Provide one sample of each product finish illustrating color and texture upon request.
- F. Certificates for Poles and Accessories: Manufacturer's documentation that products are suitable for the luminaires to be installed and comply with designated structural design criteria.
- G. Field Quality Control Reports.
1. Include test report indicating measured illumination levels.
- H. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

- I. Operation and Maintenance Data: Instructions for each product including information on replacement parts.
 - J. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.
 - 2. Extra Lamps: Ten percent of total quantity installed for each type, but not less than two of each type.
 - 3. Extra Ballasts: Two percent of total quantity installed for each type, but not less than one of each type.
 - 4. Extra Fuses: Five percent of total quantity installed for each type, but not less than two of each type.
 - 5. Touch-Up Paint: 2 gallons, to match color of pole finish.
 - K. Project Record Documents: Record actual connections and locations of pole foundations, luminaires, and any pull or junction boxes.
- 1.8 QUALITY ASSURANCE
- A. Comply with requirements of NFPA 70.
 - B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
 - C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
 - D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.
- 1.9 DELIVERY, STORAGE, AND HANDLING
- A. Receive, handle, and store products according to NECA/IESNA 501 and manufacturer's written instructions.
 - B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.
- 1.10 WARRANTY
- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
 - B. Provide three year manufacturer warranty for all LED luminaires, including drivers.

PART 2 PRODUCTS

2.1 LUMINAIRE TYPES

- A. Furnish products as indicated in luminaire schedule included on the drawings.

2.2 LUMINAIRES

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.
- D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
- E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, poles, foundations, supports, trims, accessories, etc. as necessary for a complete operating system.
- F. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- G. Provide luminaires listed and labeled as suitable for wet locations unless otherwise indicated.
- H. Recessed Luminaires:
 - 1. Ceiling Compatibility: Comply with NEMA LE 4.
 - 2. Luminaires Recessed in Insulated Ceilings: Listed and labeled as IC-rated, suitable for direct contact with insulation and combustible materials.
 - 3. Luminaires Recessed in Sloped Ceilings: Provide suitable sloped ceiling adapters.
- I. Hazardous (Classified) Location Luminaires: Listed and labeled as complying with UL 844 for the classification of the installed location.
- J. Luminaires Mounted in Continuous Rows: Provide quantity of units required for length indicated, with all accessories required for joining and aligning.
- K. LED Luminaires:
 - 1. Components: UL 8750 recognized or listed as applicable.
 - 2. Tested in accordance with IES LM-79 and IES LM-80.
 - 3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.

- L. LED Tape Lighting Systems: Provide all power supplies, drivers, cables, connectors, channels, covers, mounting accessories, and interfaces as necessary to complete installation.

1. LED Tape - General Requirements:

- a. Listed.
- b. Designed for field cutting in accordance with listing.
- c. Wet Location Applications: IEC 60529, IP 68 (waterproof) rated.

2. White LED Tape:

- a. Color Rendering Index (CRI): Not less than 90.

- M. Exposed Hardware: Stainless steel.

2.3 BALLASTS AND DRIVERS

A. Ballasts/Drivers - General Requirements:

- 1. Provide ballasts containing no polychlorinated biphenyls (PCBs).
- 2. Minimum Efficiency/Efficacy: Provide ballasts complying with all current applicable federal and state ballast efficiency/efficacy standards.
- 3. Electronic Ballasts/Drivers: Inrush currents not exceeding peak currents specified in NEMA 410.

B. Dimmable LED Drivers:

- 1. Dimming Range: Continuous dimming from 100 percent to five percent relative light output unless dimming capability to lower level is indicated, without flicker.
- 2. Control Compatibility: Fully compatible with the dimming controls to be installed.

2.4 LAMPS

A. Lamps - General Requirements:

- 1. Unless explicitly excluded, provide new, compatible, operable lamps in each luminaire.
- 2. Verify compatibility of specified lamps with luminaires to be installed. Where lamps are not specified, provide lamps per luminaire manufacturer's recommendations.
- 3. Minimum Efficiency: Provide lamps complying with all current applicable federal and state lamp efficiency standards.
- 4. Color Temperature Consistency: Unless otherwise indicated, for each type of lamp furnish products which are consistent in perceived color temperature. Replace lamps that are determined by the Engineer to be inconsistent in perceived color temperature.

2.5 POLES

A. All Poles:

1. Provide poles and associated support components suitable for the luminaire(s) and associated supports and accessories to be installed.
2. Structural Design Criteria:
 - a. Coordinate requirements with structural engineer..
 - b. Include structural calculations demonstrating compliance with submittals.
3. Material: Steel, unless otherwise indicated.

B. Metal Poles: Provide ground lug, accessible from handhole or transformer base.

2.6 ACCESSORIES

- A. Stems for Suspended Luminaires: Steel tubing, minimum 1/2" size, factory finished to match luminaire or field-painted as directed.
- B. Threaded Rods for Suspended Luminaires: Zinc-plated steel, minimum 1/4" size, field-painted as directed.
- C. Provide accessory plaster frames for luminaires recessed in plaster ceilings.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.
- C. Verify that suitable support frames are installed where required.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

- A. Coordinate locations of outlet boxes provided under Section 26 05 33.16 as required for installation of luminaires provided under this section.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install products in accordance with manufacturer's instructions.
- D. Install luminaires in accordance with NECA/IESNA 501.
- E. Provide required support and attachment in accordance with Section 26 05 29.
- F. Provide required seismic controls in accordance with Section 26 05 48.
- G. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- H. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- I. Pole-Mounted Luminaires:
 - 1. Maintain the following minimum clearances:
 - a. Comply with IEEE C2.
 - b. Comply with utility company requirements.
 - 2. Foundation-Mounted Poles:
 - a. Provide cast-in-place concrete foundations for poles as indicated, in accordance with Section 03 30 00.
 - 1) Install anchor bolts plumb per template furnished by pole manufacturer.
 - 2) Position conduits to enter pole shaft.
 - b. Install foundations plumb.
 - c. Install poles plumb, using leveling nuts or shims as required to adjust to plumb.
 - d. Tighten anchor bolt nuts to manufacturer's recommended torque.
 - e. Install anchor base covers or anchor bolt covers as indicated.
 - 3. Embedded Poles: Install poles plumb as indicated.
 - 4. Grounding:
 - a. Bond luminaires, metal accessories, metal poles, and foundation reinforcement to branch circuit equipment grounding conductor.

- b. Provide supplementary ground rod electrode as specified in Section 26 05 26 at each pole bonded to grounding system as indicated.
 - 5. Install separate service conductors, 12 AWG copper, from each luminaire down to handhole for connection to branch circuit conductors.
 - 6. Install non-breakaway in-line fuse holders and fuses complying with Section 26 28 13 in pole handhole or transformer base for each ungrounded conductor.
 - 7. Install weather resistant GFI duplex receptacle with weatherproof cover as specified in Section 26 27 26 in designated poles.
 - J. Install accessories furnished with each luminaire.
 - K. Bond products and metal accessories to branch circuit equipment grounding conductor.
 - L. Install lamps in each luminaire.
- 3.4 FIELD QUALITY CONTROL
- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
 - B. Inspect each product for damage and defects.
 - C. Operate each luminaire after installation and connection to verify proper operation.
 - D. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Engineer.
- 3.5 ADJUSTING
- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Engineer. Secure locking fittings in place.
 - B. Luminaires with Field-Rotatable Optics: Position optics according to manufacturer's instructions to achieve lighting distribution as indicated or as directed by Engineer.
- 3.6 CLEANING
- A. Clean surfaces according to NECA/IESNA 501 and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.
- 3.7 CLOSEOUT ACTIVITIES
- A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.
 - B. See Section 01 79 00 - Demonstration and Training, for additional requirements.
 - C. Demonstration: Demonstrate proper operation of luminaires to Engineer, and correct deficiencies or make adjustments as directed.

- D. Just prior to Substantial Completion, replace all lamps that have failed.

3.8 PROTECTION

- A. Protect installed luminaires from subsequent construction operations.

END OF SECTION 26 56 00

SECTION 27 10 00 - STRUCTURED CABLING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Communications system design requirements.
- B. Communications pathways.
- C. Fiber optic cable and interconnecting devices.
- D. Communications equipment room fittings.
- E. Communications outlets.
- F. Communications grounding and bonding.
- G. Communications identification.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.
- B. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- C. Section 26 05 33.13 - Conduit for Electrical Systems.
- D. Section 26 05 33.16 - Boxes for Electrical Systems.
- E. Section 26 05 53 - Identification for Electrical Systems: Identification products.

1.4 REFERENCE STANDARDS

- A. BICSI N1 - Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure, 1st Edition 2019.
- B. EIA/ECA-310 - Cabinets, Racks, Panels, and Associated Equipment Revision E, 2005.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. TIA-455-21 - FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices 1988a (Reaffirmed 2012).

- E. TIA-526-7 - Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant 2015a.
- F. TIA-526-14 - Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant 2015c.
- G. TIA-568 (SET) - Commercial Building Telecommunications Cabling Standard Set 2019.
- H. TIA-568.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standards 2009c, with Addendum (2016).
- I. TIA-569 - Telecommunications Pathways and Spaces 2019e.
- J. TIA-606 - Administration Standard for Telecommunications Infrastructure 2017c.
- K. TIA-607 - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises 2019d.
- L. UL 444 - Communications Cables Current Edition, Including All Revisions.
- M. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers Current Edition, Including All Revisions.
- N. UL 1863 - Communications-Circuit Accessories Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate requirements for service entrance and entrance facilities with Communications Service Provider.
 - 2. Coordinate the work with other trades to avoid placement of other utilities or obstructions within the spaces dedicated for communications equipment.
 - 3. Coordinate arrangement of communications equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 4. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Arrange for Communications Service Provider to provide service.
- C. Preinstallation Meeting: Convene one week prior to commencing work of this section to review service requirements and details with Communications Service Provider representative.

1.6 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.

- C. Sustainable Design Documentation: Submit manufacturer's product data on cable and cable insulation showing compliance with specified lead content requirements.
- D. Shop Drawings: Show compliance with requirements on isometric schematic diagram of network layout, showing cable routings, telecommunication closets, rack and enclosure layouts and locations, service entrance, and grounding, prepared and approved by BICSI Registered Communications Distribution Designer (RCDD).
- E. Evidence of qualifications for installer.
- F. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- G. Test Plan: Complete and detailed plan, with list of test equipment, procedures for inspection and testing, and intended test date; submit at least 60 days prior to intended test date.
- H. Field Test Reports.
- I. Project Record Documents: Prepared and approved by BICSI Registered Communications Distribution Designer (RCDD).
 - 1. Record actual locations of outlet boxes and distribution frames.
 - 2. Show as-installed color coding, pair assignment, polarization, and cross-connect layout.
 - 3. Identify distribution frames and equipment rooms by room number on drawings.
- J. Operation and Maintenance Data: List of all components with part numbers, sources of supply, and operation and maintenance instructions; include copy of project record documents.

1.7 QUALITY ASSURANCE

- A. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- B. Manufacturer Qualifications: At least 3 years experience manufacturing products of the type specified.
- C. Installer Qualifications: A company having at least 3 years experience in the installation and testing of the type of system specified, and:
 - 1. Employing a BICSI Registered Communications Distribution Designer (RCDD).
 - 2. Supervisors and installers factory certified by manufacturers of products to be installed.
 - 3. Employing BICSI Registered Cabling Installation Technicians (RCIT) for supervision of all work.
- D. Products: Listed, classified, and labeled as suitable for the purpose intended.

- E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Keep stored products clean and dry.

1.9 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a 2 year period after Date of Substantial Completion.
- C. Data cabling installation shall be certified with 20 year warranty.

PART 2 PRODUCTS

2.1 SYSTEM DESIGN

- A. Provide a complete permanent system of cabling and pathways for voice and data communications, including cables, conduits and wireways, pull wires, support structures, enclosures and cabinets, and outlets.
 - 1. Comply with TIA-568 (SET) (cabling) and TIA-569 (pathways) (commercial standards).
 - 2. Comply with Communications Service Provider requirements.
 - 3. Provide fixed cables and pathways that comply with NFPA 70 and TIA-607 and are UL listed or third party independent testing laboratory certified.
 - 4. Provide connection devices that are rated for operation under conditions of 32 to 140 degrees F at relative humidity of 0 to 95 percent, noncondensing.
 - 5. In this project, the term plenum is defined as return air spaces above ceilings, inside ducts, under raised floors, and other air-handling spaces.
- B. System Description:
 - 1. Building Entrance Cable: Per service provider requirements.
 - 2. Backbones - Within Building: Fiber Optic: 6-strand ARMORED SINGLE-MODE FIBER WITH SC TERMINATIONS.
 - 3. Offices and Work Areas: Provide one 2-port outlet per desk, printer, tv, monitor, and access point in each work area.
 - 4. Classrooms: one 2-port outlet at each: teacher desk, teaching wall, printer, tv, monitor, and access point; one telephone outlet at door..

5. Provide additional outlets where indicated on drawings.
- C. Main Distribution Frame (MDF): Centrally located support structure for terminating horizontal cables that extend to telecommunications outlets, functioning as point of presence to external service provider.
 1. Locate main distribution frame as indicated on the drawings.
 2. Capacity: As required to terminate all cables required by design criteria plus minimum 25 percent spare space.
- D. Intermediate Distribution Frames (IDF): Support structures for terminating horizontal cables that extend to telecommunications outlets.
 1. Locate intermediate distribution frames as indicated on the drawings.
- E. Backbone Cabling: Cabling, pathways, and terminal hardware connecting intermediate distribution frames (IDF's) with main distribution frame (MDF), wired in star topology with main distribution frame at center hub of star.
- F. Cabling to Outlets: Specified horizontal cabling, wired in star topology to distribution frame located at center hub of star; also referred to as "links".

2.2 PATHWAYS

- A. Conduit: As specified in Section 26 05 33.13; provide pull cords in all conduit.
- B. Underground Service Entrance: Rigid polyvinyl chloride (PVC) conduit, Schedule 40.
- C. Firestop Sleeves: Listed; provide as required to preserve fire resistance rating of building elements.

2.3 COPPER CABLE AND TERMINATIONS

- A. Provide cables with lead content less than 300 parts per million.
- B. Copper Horizontal Cable:
 1. Description: 100 ohm, balanced twisted pair cable complying with TIA-568.2 and listed and labeled as complying with UL 444.
 2. Cable Type - Voice and Data: TIA-568.2 Category 6 UTP (unshielded twisted pair); 23 AWG.
 3. Cable Capacity: 4-pair.
 4. Cable Applications: Use listed NFPA 70 Type CMP plenum rated riser cable unless otherwise indicated.
 5. Cable Jacket Color:

- a. PURPLE: General data & Telephone
 - b. YELLOW: Security
 - c. RED: Fire Alarm
 6. Product(s):
 - a. CommScope; SYSTIMAX Twisted Pair Cables; GigaSPEED XL Category 6 U/UTP Cable: www.commscope.com/#sle.
 - b. General Cable Technologies Corporation; GenSPEED Cables: www.generalcable.com/#sle.
 - c. Siemon; Category 6 UTP Plenum rated riser cable..
 - C. Copper Cable Terminations: Insulation displacement connection (IDC) type using appropriate tool; use screw connections only where specifically indicated.
 - D. Jacks and Connectors: Modular RJ-45, non-keyed, terminated with 110-style insulation displacement connectors (IDC); high impact thermoplastic housing; suitable for and complying with same standard as specified horizontal cable; UL 1863 listed.
 1. Performance: 500 mating cycles.
 2. Voice and Data Jacks: 8-position modular jack, color-coded for both T568A and T568B wiring configurations.
 3. Product(s):
 - a. CommScope; SYSTIMAX RJ45 Jacks; MGS400 Series Category 6 U/UTP Modular Jacks: www.commscope.com/#sle.
 - b. CommScope; Uniprise RJ45 Jacks; UNJ600 Series Category 6 U/UTP Modular Jacks: www.commscope.com/#sle.
 - c. Siemon (Basis of Design); Max-6 product family.
 - E. Copper Patch Cords:
 1. Description: Factory-fabricated 4-pair cable assemblies with 8-position modular connectors terminated at each end.
- 2.4 FIBER OPTIC CABLE AND INTERCONNECTING DEVICES
- A. Manufacturers:
 1. CommScope; [_____]: www.commscope.com/#sle.
 2. General Cable Technologies Corporation; [_____]: www.generalcable.com/#sle.

3. Siemon Company; Basis of Design: www.siemon.com/#sle.
4. Substitutions: See Section 01 60 00 - Product Requirements.

B. Fiber Optic Interconnecting Devices:

1. Connector Type: Type SC.
2. Connector Performance: 500 mating cycles, when tested in accordance with TIA-455-21.
3. Maximum Attenuation/Insertion Loss: 0.3 dB.

2.5 COMMUNICATIONS EQUIPMENT ROOM FITTINGS

A. Copper Cross-Connection Equipment:

1. Manufacturers:
 - a. CommScope; [_____]: www.commscope.com/#sle.
 - b. Siemon Company; [_____]: www.siemon.com/#sle.
 - c. Substitutions: See Section 01 60 00 - Product Requirements.
2. Connector Blocks for Category 5e and Up Cabling: Type 110 insulation displacement connectors; capacity sufficient for cables to be terminated plus 25 percent spare.
3. Patch Panels for Copper Cabling: Sized to fit EIA/ECA-310 standard 19 inch wide equipment racks; 0.09 inch thick aluminum; cabling terminated on Type 110 insulation displacement connectors; printed circuit board interface.
 - a. Jacks: Non-keyed RJ-45, suitable for and complying with same standard as cable to be terminated; maximum 48 ports per standard width panel.
 - b. Capacity: Provide ports sufficient for cables to be terminated plus 25 percent spare.
 - c. Labels: Factory installed laminated plastic nameplates above each port, numbered consecutively; comply with TIA-606.
 - d. Provide incoming cable strain relief and routing guides on back of panel.
4. Product(s):
 - a. CommScope; SYSTIMAX Copper Panels; 360-IPR-1100-XX Series Patch Panels: www.commscope.com/#sle.
 - b. CommScope; Uniprise Copper Panels; UNP-XX-DM Series Patch Panels: www.commscope.com/#sle.

B. Backboards: Interior grade plywood without voids, 3/4 inch thick; UL-labeled fire-retardant.

1. Do not paint over UL label.

C. Equipment Frames, Racks and Cabinets:

1. Manufacturers:
 - a. CommScope; [_____]: www.commscope.com/#sle.
 - b. Siemon Company; [_____]: www.siemon.com/#sle.
2. Component Racks: EIA/ECA-310 standard 19 inch wide.
3. Wall Mounted Racks: Steel construction, hinged to allow access to back of installed components.
4. Floor Mounted Racks: Aluminum or steel construction with corrosion resistant finish; vertical and horizontal cable management channels, top and bottom cable troughs, and grounding lug.
5. Freestanding Cabinets: Front and rear doors with locks; removable side panels with locks; vented top and rear door; adjustable leveling feet; cable access in roof and base; grounding bar.
6. Wall Mounted Cabinets: Front doors with locks, louvered side panels, top and bottom cable access, and ground lug.
7. Cabinets: Steel construction with corrosion resistant finish.
8. Locks: Keyed alike.

D. Cable Management:

1. Manufacturers:
 - a. CommScope; [_____]: www.commscope.com/#sle.
 - b. Siemon Company; [_____]: www.siemon.com/#sle.
 - c. Substitutions: See Section 01 60 00 - Product Requirements.
2. Product(s):
 - a. CommScope Cable Runway: www.commscope.com/#sle.
 - b. CommScope Horizontal/Vertical Cable Managers; HCM-SS-XX-XX/VCM-DS-XX-XX Series: www.commscope.com/#sle.
 - c. CommScope FiberGuide Raceway: www.commscope.com/#sle.

2.6 COMMUNICATIONS OUTLETS

A. Manufacturers:

1. CommScope; [_____]: www.commscope.com/#sle.
2. Siemon Company; (Basis of Design): www.siemon.com/#sle.
3. Substitutions: See Section 01 60 00 - Product Requirements.

B. Outlet Boxes: Comply with Section 26 05 33.16.

1. Provide depth as required to accommodate cable manufacturer's recommended minimum conductor bend radius.

C. Wall Plates:

1. Comply with system design standards and UL 514C.
2. Accepts modular jacks/inserts.

2.7 GROUNDING AND BONDING COMPONENTS

A. Comply with TIA-607.

B. Comply with Section 26 05 26.

2.8 IDENTIFICATION PRODUCTS

A. Comply with TIA-606.

B. Comply with Section 26 05 53.

2.9 SOURCE QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Factory test cables according to TIA-568 (SET).

PART 3 EXECUTION

3.1 INSTALLATION - GENERAL

- A. Comply with latest editions and addenda of TIA-568 (SET) (cabling), TIA-569 (pathways), TIA-607 (grounding and bonding), BICSI N1, NFPA 70, and SYSTEM DESIGN as specified in PART 2.
- B. Comply with Communication Service Provider requirements.
- C. Grounding and Bonding: Perform in accordance with TIA-607 and NFPA 70.

- D. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- E. Installation shall be by manufacturer's certified installer, and shall meet all requirements for manufacturer's 20 year certification warranty.

3.2 INSTALLATION OF PATHWAYS

- A. Install pathways with the following minimum clearances:
 - 1. 48 inches from motors, generators, frequency converters, transformers, x-ray equipment, and uninterruptible power systems.
 - 2. 12 inches from power conduits and cables and panelboards.
 - 3. 5 inches from fluorescent and high frequency lighting fixtures.
 - 4. 6 inches from flues, hot water pipes, and steam pipes.
- B. Conduit, in Addition to Requirements of Section 26 05 33.13:
 - 1. Arrange conduit to provide no more than the equivalent of two 90 degree bend(s) between pull points.
 - 2. Conduit Bends: Inside radius not less than 10 times conduit internal diameter.
 - 3. Arrange conduit to provide no more than 100 feet between pull points.
 - 4. Do not use conduit bodies.
 - 5. Minimum Cover - Underground Service Entrance: Comply with NFPA 70 and Communications Service Provider requirements.
- C. Outlet Boxes:
 - 1. Coordinate locations of outlet boxes provided under Section 26 05 33.16 as required for installation of telecommunications outlets provided under this section.
 - a. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.
 - b. Provide minimum of 24 inches horizontal separation between flush mounted outlet boxes installed on opposite sides of fire rated walls.
 - c. Unless otherwise indicated, provide separate outlet boxes for line voltage and low voltage devices.
 - d. Locate outlet boxes so that wall plate does not span different building finishes.
 - e. Locate outlet boxes so that wall plate does not cross masonry joints.

3.3 INSTALLATION OF EQUIPMENT AND CABLING

A. Cabling:

1. Do not bend cable at radius less than manufacturer's recommended bend radius; for unshielded twisted pair use bend radius of not less than 4 times cable diameter.
2. Do not over-cinch or crush cables.
3. Do not exceed manufacturer's recommended cable pull tension.
4. When installing in conduit, use only lubricants approved by cable manufacturer and do not chafe or damage outer jacket.

B. Service Loops (Slack or Excess Length): Provide the following minimum extra length of cable, looped neatly:

1. At Distribution Frames: 120 inches.
2. At Outlets - Copper: 12 inches.
3. At Outlets - Optical Fiber: 39 inches.

C. Copper Cabling:

1. Category 5e and Above: Maintain cable geometry; do not untwist more than 1/2 inch from point of termination.
2. For 4-pair cables in conduit, do not exceed 25 pounds pull tension.
3. Use T568B wiring configuration.

D. Fiber Optic Cabling:

1. Prepare for pulling by cutting outer jacket for 10 inches from end, leaving strength members exposed. Twist strength members together and attach to pulling eye.
2. Support vertical cable at intervals as recommended by manufacturer.

E. Wall-Mounted Racks and Enclosures:

1. Install to plywood backboards only, unless otherwise indicated.
2. Mount so height of topmost panel does not exceed 78 inches above floor.

F. Floor-Mounted Racks and Enclosures: Permanently anchor to floor in accordance with manufacturer's recommendations.

G. Floor-Mounted Enclosures: Connect adjacent cabinets together and remove interior side panels.

H. Identification:

1. Use wire and cable markers to identify cables at each end.
2. Use manufacturer-furnished label inserts, identification labels, or engraved wallplate to identify each jack at communications outlets with unique identifier.
3. Use identification nameplate to identify cross-connection equipment, equipment racks, and cabinets.

3.4 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Comply with inspection and testing requirements of specified installation standards.

C. Visual Inspection:

1. Inspect cable jackets for certification markings.
2. Inspect cable terminations for color coded labels of proper type.
3. Inspect outlet plates and patch panels for complete labels.
4. Inspect patch cords for complete labels.

D. Testing - Copper Cabling and Associated Equipment:

1. Test backbone cables after termination but before cross-connection.
2. Test backbone cables for DC loop resistance, shorts, opens, intermittent faults, and polarity between connectors and between conductors and shield, if cable has overall shield.
3. Test operation of shorting bars in connection blocks.
4. Category 5e and Above Backbone: Perform near end cross talk (NEXT) and attenuation tests.
5. Category 5e and Above Links: Perform tests for wire map, length, attenuation, NEXT, and propagation delay.

E. Testing - Fiber Optic Cabling:

1. Backbone: Perform optical fiber end-to-end attenuation test using an optical time domain reflectometer (OTDR) and manufacturer's recommended test procedures; perform verification acceptance tests and factory reel tests.
2. Multimode Backbone: Perform tests in accordance with TIA-526-14.
3. Single Mode Backbone: Perform tests in accordance with TIA-526-7.

4. Links: Perform optical fiber end-to-end attenuation tests and field reel tests.

F. Final Testing: After all work is complete, including installation of telecommunications outlets, and telephone dial tone service is active, test each voice jack for dial tone.

END OF SECTION 27 10 00

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SECTION 27 51 16 - PUBLIC ADDRESS SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 RELATED REQUIREMENTS

- A. Section 26 05 26 - Grounding and Bonding for Electrical Systems.

1.3 REFERENCE STANDARDS

- A. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 SYSTEM DESCRIPTION

- A. Public address system for voice and music.
- B. Input components:
 - 1. Compact disc player.
 - 2. AM/FM tuner.
 - 3. Microphone.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements. Indicate layout of equipment mounted in racks and cabinets, component interconnecting wiring, and wiring diagrams of field wiring to speakers and remote input devices.
- C. Product Data: Provide data showing electrical characteristics and connection requirements for each component.
- D. Test Reports: Indicate satisfactory completion of each test recommended by the manufacturer.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- F. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

- G. Manufacturer's Field Reports: Indicate that installation is complete and system performs according to specified requirements.
- H. Project Record Documents: Record actual locations of speakers, control equipment, and outlets for input/output connectors.
- I. Operation Data: Include instructions for adjusting, operating, and extending the system.
- J. Maintenance Data: Include repair procedures and spare parts documentation.

1.6 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70 and Federal Communications Commission.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience with service facilities within 100 miles of Project.
- C. Supplier Qualifications: Authorized distributor of specified manufacturer with minimum three years documented experience.
- D. Installer Qualifications: Authorized installer of specified manufacturer with service facilities within 100 miles of Project.
- E. Products: Listed, classified, and labeled as suitable for the purpose intended.
- F. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Bogen Communications, Inc; [____]: www.bogen.com/#sle.
- B. Toa Electronics, Inc; [____]: www.toaelectronics.com/#sle.
- C. Substitutions: See Section 01 60 00 - Product Requirements.

2.2 AMPLIFICATION AND CONTROL EQUIPMENT

- A. Microphone Inputs: Two low impedance inputs with 600 microvolt sensitivity and noise level at least 55 dB below rated output.
- B. Auxiliary Inputs: One high impedance input with 0.4 volt sensitivity and noise level at least 70 dB below rated output.
- C. System Frequency Response: 50 to 15,000 Hz, plus or minus 2 dB.
- D. System Distortion: Less than 1.5 percent, 100 to 100,000 Hz at rated power.

- E. System Output: 4 ohms 25 volts.
- F. Volume Controls: One for each input and one master volume.
- G. Bass Control: Plus 8 dB to minus 12 dB at 50 Hz.
- H. Treble Control: Plus 8 dB to minus 12 dB at 10,000 Hz.
- I. Program Selector: Provide program , listen-talk, and mode selector switches.
- J. System Cabinet: Rack mounted.

2.3 COMPONENTS

- A. Compact Disc Player: [_____].
- B. AM/FM Tuner: Tuner with 525 to 1605 kHz AM and 88 to 108 MHz FM tuning range.
 - 1. AM Performance:
 - a. AM IF Rejection: Over 30 dB.
 - b. AM Selectivity: 7 kHz at minus 6 dB.
 - c. AM Fidelity: 100 to 4500 Hz, plus or minus 3 dB.
 - d. AM Antenna Input: 75 ohms, unbalanced.
 - 2. FM Performance:
 - a. FM IF Rejection: Over 50 dB.
 - b. FM Fidelity: 50 to 15,000 Hz, plus or minus 3 dB.
 - c. FM Antenna Input: 300 ohms, balanced.
 - 3. Substitutions: See Section 01 60 00 - Product Requirements.
- C. Microphone: Desk type low impedance microphone with push-to-talk switch.
- D. Speakers: 8 inch coaxial speaker with integral crossover circuit.
 - 1. Power Rating: 20 watts.
 - 2. Frequency Range: 45 to 18,000 Hz.
 - 3. Sound Pressure Level: 95 dB at 3 feet with 1 watt input.
 - 4. Magnet: Ceramic; 10 ounces low frequency unit; 3 ounces high frequency unit.
 - 5. Dispersion: Minus 3 dB at 90 degrees, minus 5 dB at 110 degrees.
 - 6. Substitutions: See Section 01 60 00 - Product Requirements.

- E. Speaker Baffles and Enclosure: Square, painted steel, with uniform perforations.
 - 1. Size: 12 inch.
 - 2. Finish: White.
 - 3. Speaker Backbox: Insulated with sound-deadening material.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- F. Horns: Wide dispersion indoor/outdoor horn with driver.
 - 1. Power Rating: 60 watts.
 - 2. Low Frequency Cutoff: 250 Hz.
 - 3. Sound Distribution: 20 x 50 degrees.
 - 4. Sound Pressure Level: 120 dB at 4 feet with full range input.
 - 5. Material: Cast aluminum.
 - 6. Substitutions: See Section 01 60 00 - Product Requirements.
- G. Matching Transformers: Tapped from 0.5 to 4 watts in 1 watt steps, with primary/secondary ratio to match amplifier to speaker impedances.
- H. Volume Pads: Transformer type rated 10 watts.
- I. Telephone Interface: 600 ohm - auxiliary input.
- J. Equipment Rack: Floor mounted equipment rack.
 - 1. Equipment Mounting Width: 19 inch.
 - 2. Finish: Gray enamel finish.
 - 3. Include front hinged and latched door.
 - 4. Include six receptacle multioutlet assembly inside rack.
 - 5. Substitutions: See Section 01 60 00 - Product Requirements.
- K. Antenna: Folded dipole FM antenna.
 - 1. Impedance: 300 ohm with matching transformer for 75 ohm coaxial cable.
 - 2. Construction: Use tubular metal elements.
 - 3. Wind Resistance: Withstand 100 miles per hour wind.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.

2.4 WIRE AND CABLE

- A. Microphone Cord: 20 AWG stranded copper conductor, 600 volt insulation, rated 60 degrees C, two conductor shielded cable with rubber jacket.
- B. Input Cable: 22 AWG copper conductor, 300 volt insulation, rated 60 degrees C, paired conductors twisted together, shielded, and covered with a PVC jacket.
- C. Speaker Wire and Cable: 22 AWG copper conductor, 300 volt insulation, rated 60 degrees C, paired conductors twisted together shielded and covered with a PVC jacket.
- D. Plenum Cable for Speaker Circuits: 22 AWG copper conductor, 300 volt insulation, rated 200 degrees C, paired conductors twisted together shielded and covered with a nonmetallic jacket; suitable for use for Class 2 circuits in air handling ducts, hollow spaces used as ducts, and plenums.

2.5 ACCESSORIES

- A. Fire-Rated Speaker Enclosures:
 - 1. Manufacturers:
 - a. Fire Rated Product Specialties Corp; [_____]: www.frpsonline.com/#sle.
 - b. Substitutions: See Section 01 60 00 - Product Requirements.
 - 2. Provide as required to preserve fire resistance rating of building elements.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Mounting Heights: Coordinate locations of outlet boxes specified in Section 26 05 33.16 to obtain mounting heights indicated.
- C. Splice cable only in accessible junction boxes or at terminal block units.
- D. Make cable shields continuous at splices and connect speaker circuit shield to equipment ground only at amplifier.
- E. Install input circuits in separate cables and raceways from output circuits.
- F. Leave 18 inches excess cable at each termination at microphone, volume pad, speaker, and other system outlet.
- G. Leave 6 feet excess cable at each termination at system cabinet
- H. Provide protection for exposed cables where subject to damage.

- I. Use armored cable for outside speaker circuits.
- J. Support cables above accessible ceilings to keep them from resting on ceiling tiles. Use spring metal clips or plastic cable ties to support cables from structure for ceiling suspension system. Include bridle rings or drive rings.
- K. Use suitable cable fittings and connectors.
- L. Connect reproducers to amplifier with matching transformers.
- M. Ground and bond equipment and circuits in accordance with Section 26 05 26.

3.2 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Provide the services of manufacturer's technical representative to prepare and start system.
 - 1. Include making of final wiring connections, inspection and adjusting of completed installation, and systems demonstration.
 - 2. Certify that installation is complete and performs according to specified requirements.
- C. Measure and record sound power levels at designated locations.

3.3 ADJUSTING

- A. Adjust transformer taps for appropriate sound level.
- B. Adjust devices and wall plates to be flush and level.

3.4 CLOSEOUT ACTIVITIES

- A. See Section 01 79 00 - Demonstration and Training, for additional requirements.
- B. Demonstration: Demonstrate operation of system to Owner's personnel.
 - 1. Use operation and maintenance data as reference during demonstration.
 - 2. Conduct walking tour of project.
 - 3. Briefly describe function, operation, and maintenance of each component.
- C. Training: Train Owner's personnel on operation and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of one day of training.
 - 3. Instructor: Manufacturer's training personnel.

4. Location: At project site.

3.5 MAINTENANCE

- A. See Section 01 70 00 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Provide a separate maintenance contract for specified maintenance service.
- C. Provide service and maintenance of public address and music system for one year from Date of Substantial Completion.

END OF SECTION 27 51 16

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SECTION 27 51 23 - INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Intercom equipment.
- B. Intercom cable.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
- B. Section 27 51 29.13 - Rescue Assistance Signal Systems: Two-way emergency communication systems for areas of refuge/rescue assistance.

1.4 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate cable routing and connections.
- C. Product Data: For each item of equipment.
- D. Manufacturer's Installation Instructions.
- E. Project Record Documents: Accurately record actual locations of devices and wiring.
- F. Operation Data: Include instructions for routine operation of master and remote stations.
- G. Maintenance Data: Include instructions for minor troubleshooting, preventive maintenance, and cleaning.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this Section with minimum three years of documented experience.
- B. Supplier Qualifications: Company authorized by manufacturer and specializing in supplying products specified in this Section with minimum three years documented experience.
- C. Installer Qualifications: Company specializing in installing the products specified in this Section with minimum three years documented experience.

- D. Products: Listed, classified, and labeled as suitable for the purpose intended.
- E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.1 INTERCOM SYSTEM

- A. Manufacturers:
 - 1. Alpha Communications; [____]: www.alphacommunications.com/#sle.
 - 2. Clear-Com Intercom Systems; [____]: www.clearcom.com/#sle.
 - 3. Valcom; [____]: www.valcom.com/#sle.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Intercom System: Private voice communication between locations indicated on drawings.
- C. Configuration: Direct-connected, keyed intercom system.
- D. System Capacity: One master station; one speaker/microphone station.
- E. Conversation Paths: Two.
- F. System Capacity: Four lines, two trunks.
- G. Sequence of Operation: Any station calls any other station by dialing the [____] digit number associated with that station.

2.2 COMPONENTS

- A. Direct Connected, Keyed Master Intercom Station: Desk-mounted master intercom unit.
 - 1. Minimum Controls and Indicators:
 - a. POWER ON-OFF selector switch and indicator lamp.
 - b. Selector switch for each master remote station, all call, and each zone call.
 - c. Lighted annunciator lamp for each master and speaker/microphone station.
 - d. Audible signal for incoming calls.
 - e. CALLED STATION BUSY indicator lamp.
 - f. Speaker disconnect by lifting handset.
 - g. PRIVACY switch.

- h. TALK/LISTEN switch.
 - i. Mark each control and indicator with legible and permanent [] nameplates.
 - 2. Sequence of Operation:
 - a. Remote selector switches connect master directly to remote stations.
 - b. Manual momentary switch sets TALK/LISTEN mode.
 - c. Incoming calls actuate annunciator lamp and momentary buzzer.
 - d. Incoming calls are amplified without master selection of calling station.
 - e. Privacy switch turns off microphone.
- B. Central Control Master Intercom Station: Desk-mounted master intercom unit.
 - 1. Speaker Sensitivity: 92 dB.
 - 2. Handset: Standard molded plastic telephone handset with 5 ft long permanently coiled cord.
 - 3. Minimum Controls and Indicators:
 - a. POWER ON-OFF selector switch and indicator lamp.
 - b. Lighted annunciator lamp for each master and speaker/microphone station.
 - c. Audible signal for incoming calls.
 - d. CALLED STATION BUSY indicator lamp.
 - e. SYSTEM BUSY indicator lamp.
 - f. Speaker disconnect by lifting handset.
 - g. PRIVACY switch.
 - h. Mark each control and indicator with legible and permanent [] nameplates.
- C. Intercom Control Unit: Surface wall-mounted intercom control unit.
 - 1. Intercom Amplifier: 2 watts rated output with less than 5 percent total harmonic distortion, frequency response of 100 to 10,000 Hz plus or minus 3 dB, and minimum 60 db signal-to-noise ratio at rated output.
 - 2. All-Call Amplifier: 1 watts rated output for each connected station, with less than 5 percent total harmonic distortion, frequency response of 100 to 10,000 Hz plus or minus 3 dB, and minimum 60 dB signal-to-noise ratio at rated output.

3. Input Sensitivity: Provide adequate input sensitivity to deliver rated amplifier output when no more than 10 dynes per square centimeter impinge on speaker/microphone.
4. Sequence of Operation:
 - a. Intercom Control Unit connects calling station to remote stations.
 - b. Manual momentary switch with sustained TALK position sets TALK/LISTEN mode.
 - c. Incoming calls actuate annunciator lamp at called station.
 - d. Privacy switch turns off microphone.
- D. Speaker/Microphone Intercom Units: Desk-mounted unit.
 1. Sensitivity: 92 dB at one W input, 4 ft on axis of speaker.
 2. Handset: Standard molded plastic telephone handset with 5 ft permanently coiled cord.
 3. Controls and Indicators:
 - a. POWER ON-OFF selector switch and indicator lamp.
 - b. Call in switch for one master station.
 - c. Lighted annunciator lamp for incoming call.
 - d. Recurring audible signal for incoming call.
 - e. CALLED STATION BUSY indicator lamp.
 - f. Speaker disconnect by lifting handset.
 - g. VOLUME control for listen volume level only.
 - h. PRIVACY switch.
 - i. TALK/LISTEN switch.
 - j. Mark each control and indicator with legible and permanent [] nameplates.
 4. Sequence of Operation:
 - a. Master selector switches connect unit directly to master stations.
 - b. Manual momentary switch with sustained TALK position sets TALK/LISTEN mode.
 - c. Incoming calls actuate annunciator lamp.
 - d. Privacy switch turns off microphone.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that surfaces are ready to receive work.
- B. Verify field measurements are as indicated on drawings.
- C. Verify that required utilities are available, in proper location, and ready for use.
- D. Beginning of installation means installer accepts conditions.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Provide the services of the manufacturer's technical representative to make final connections to units, prepare and start systems, and perform field inspection and testing.
- C. Perform operational test on completed installation to verify proper operation.
- D. Replace equipment, components, and wiring to eliminate audible noise, clicks, pops, or hum when system is in standby or operation.

3.4 ADJUSTING

- A. Adjust controls and configuration switches for operation as indicated.

3.5 DEMONSTRATION

- A. Provide systems demonstration and instructions. Allow minimum of 4 hours.
- B. Provide the services of the manufacturer's field representative to demonstrate system operation to designated Owner personnel.
- C. Conduct walking tour of Project and briefly describe function, operation, and maintenance of each component.
- D. Use submitted operation and maintenance manual as reference during demonstration and training.

3.6 MAINTENANCE

- A. See Section 01 70 00 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Provide a separate maintenance contract for specified maintenance service.

- C. Provide service and maintenance of intercom system for one year from Date of Substantial Completion.

END OF SECTION 27 51 23

SECTION 27 53 13 - CLOCK SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.
- B. Section 10 74 13 - Exterior Clocks: For interface with clock system.
- C. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- D. Section 26 05 33.13 - Conduit for Electrical Systems.
- E. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 27 51 16 - Public Address Systems: For interface with clock system.
- G. Section 27 51 23 - Intercommunications and Program Systems: For interface with clock system.

1.3 REFERENCE STANDARDS

- A. 47 CFR 15 - Radio Frequency Devices current edition.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the placement of clocks with potential conflicts and/or view obstructions installed under other sections or by others.
 - 2. Coordinate the work with other installers to provide power for clocks and equipment at required locations.
 - 3. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Preinstallation Meetings:

1. Conduct meeting with facility representative to review clock and equipment locations.
2. Conduct meeting with facility representative and other related equipment manufacturers to discuss clock system interface requirements.

C. Sequencing:

1. Do not install clocks until final surface finishes and painting are complete.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each system component. Include ratings, configurations, standard wiring diagrams, dimensions, finishes, service condition requirements, and installed features.
- C. Shop Drawings: Include plan views indicating locations of system components and proposed size, type, and routing of conduits and/or cables. Include elevations and details of proposed equipment arrangements. Include system interconnection schematic diagrams. Include requirements for interface with other systems.
- D. Design Data:
 1. Wired Clocks: Include clock circuit capacity and voltage drop calculations.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- F. Manufacturer's detailed field testing procedures.
- G. Field quality control test reports.
- H. Maintenance contracts.
- I. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
 1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.
- J. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- K. Project Record Documents: Record actual locations of system components and installed wiring arrangements and routing.
- L. Software: One copy of software not resident in read-only memory.

1.6 QUALITY ASSURANCE

- A. Comply with the following:
 - 1. NFPA 70.
 - 2. Applicable TIA/EIA standards.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Installer Qualifications: Company with minimum three years documented experience with similar clock systems and providing contract maintenance service as a regular part of their business; manufacturer's authorized installer.
 - 1. Contract maintenance office located within 200 miles of project site.
- E. Maintenance Contractor Qualifications: Same entity as installer.
- F. Products: Listed, classified, and labeled as suitable for the purpose intended.
- G. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.
- B. Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

1.8 FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.9 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.1 CLOCK SYSTEM REQUIREMENTS

- A. Provide new clock system consisting of all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Interface with Other Systems:
 - 1. Provide products compatible with other systems requiring interface with clock system.
 - 2. Interface with public address system as specified in Section 27 51 16.
 - a. Capable of initiating selected public address system events according to clock system program schedule.
 - 3. Interface with intercom system as specified in Section 27 51 23.
 - a. Capable of initiating selected intercom system events according to clock system program schedule.
- C. Interface with exterior clock as specified in Section 10 74 13.
- D. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of 47 CFR 15, for Class B, consumer application.

2.2 WIRED CLOCK SYSTEMS

- A. Master Clock Unit:
 - 1. Description: Microprocessor-based controller and associated accessories for maintaining time reference and correcting connected wired secondary indicating clocks.
 - 2. Acceptable Time Reference Source(s): Based on Network Time Protocol (NTP) server time data obtained via local area network (LAN) or Global Positioning System (GPS) satellite antenna/receiver.
 - 3. Wired Secondary Indicating Clock Power and Time Correction Signal Circuit(s): As required for connection to wired secondary clocks, including any existing clocks (where indicated).
- B. Analog Wired Secondary Indicating Clocks:
 - 1. Power Source: As required for connection to master clock unit.
- C. Digital Wired Secondary Indicating Clocks:
 - 1. Power Source: As required for connection to master clock unit.

- D. Provide components and wiring as indicated or as required for connection between master clock unit and wired secondary indicating clocks.

2.3 WIRELESS CLOCK SYSTEMS

A. Master Clock Unit:

1. Description: Microprocessor-based controller and associated accessories for maintaining time reference and correcting connected wireless secondary indicating clocks.
2. Acceptable Time Reference Source(s): Based on Network Time Protocol (NTP) server time data obtained via local area network (LAN) or Global Positioning System (GPS) satellite antenna/receiver.
3. Wireless Time Correction Signal Transmitter/Antenna: Compatible with wireless secondary clocks, including any existing clocks (where indicated).

B. Analog Wireless Secondary Indicating Clocks:

1. Power Source: 120 VAC; provide required transformers.
2. Time Reference Source: Synchronized with master clock unit wireless time correction signal.
3. Clock Movements: Microprocessor-controlled.
4. Clock Face:
 - a. Shape: Round.
 - b. Color: White face with black numerals and markings, unless otherwise indicated or approved by Engineer.
 - c. Hands: For indicating hour, minute, and second.
5. Mounting:
 - a. Single-Face Clocks: Surface.
 - b. Double-Face Clocks: Surface.

- C. Provide components as indicated or as required for extension of wireless time correction signal between master clock unit and wireless secondary indicating clocks.

2.4 ACCESSORIES

- A. Provide components and wiring as indicated or as required for connection to auxiliary devices and other systems indicated.
- B. Protective Covers/Guards for Clocks: Where indicated.

- C. Racks/Cabinets: Provide as indicated or as required for equipment mounting.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that characteristics of system components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive system components.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Wiring Method for NFPA 70 Class 2 and Class 3 Circuits: Unless otherwise indicated, use cables (not in conduit), where permitted by code.
 - 1. Use suitable listed cables in wet locations, including underground raceways.
 - 2. Use suitable listed cables for vertical riser applications.
 - 3. Use listed plenum rated cables in spaces used for environmental air.
 - 4. Install wiring in conduit for the following:
 - a. Where required for rough-in.
 - b. Where required by authorities having jurisdiction.
 - c. Where exposed to damage.
 - d. Where installed outside the building.
 - e. For exposed connections from outlet boxes to devices.
 - 5. Conduit: Comply with Section 26 05 33.13.
 - 6. Conceal all cables unless specifically indicated to be exposed.
 - 7. Route exposed cables parallel or perpendicular to building structural members and surfaces.
 - 8. Do not exceed manufacturer's recommended maximum cable length between components.
- D. Provide grounding and bonding in accordance with Section 26 05 26.

- E. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- F. Identify system wiring and components in accordance with Section 26 05 53.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Provide services of a manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's detailed testing procedures and field reports with submittals.
- C. Prepare and start system in accordance with manufacturer's instructions.
- D. Program system parameters according to requirements of Owner.
- E. Test for proper interface with other systems.
- F. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.
- G. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.4 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.5 CLOSEOUT ACTIVITIES

- A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.
- B. See Section 01 79 00 - Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of system to Owner, and correct deficiencies or make adjustments as directed.
- D. Training: Train Owner's personnel on operation, adjustment, and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.
 - 3. Instructor: Manufacturer's authorized representative.
 - 4. Location: At project site.

3.6 PROTECTION

- A. Protect installed system components from subsequent construction operations.

3.7 MAINTENANCE

- A. See Section 01 70 00 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Conduct site visit upon Owner's request within one year from Date of Substantial Completion to make additional adjustments to system programming.
- C. Provide to Owner, a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of clock system for one year from Date of Substantial Completion; Include a complete description of preventive maintenance, systematic examination, adjustment, cleaning, inspection, and testing, with a detailed schedule.
- D. Conduct site visit at least once every three months to perform inspection, testing, and preventive maintenance. Submit report to Owner indicating maintenance performed along with evaluations and recommendations.
- E. Provide trouble call-back service upon notification by Owner:
 - 1. Include allowance for call-back service during normal working hours at no extra cost to Owner.
 - 2. Owner will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.

END OF SECTION 27 53 13

SECTION 28 46 00 - FIRE DETECTION AND ALARM

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Fire alarm system design and installation, including all components, wiring, and conduit.
- B. Replacement and removal of existing fire alarm system components, wiring, and conduit indicated.

1.2 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.3 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping: Materials and methods for work to be performed by this installer.
- B. Section 08 71 00 - Door Hardware: Electrically operated locks and door holder devices to be monitored and released by fire alarm system.
- C. Section 14 21 00 - Electric Traction Elevators: Elevator systems monitored and controlled by fire alarm system.
- D. Section 14 24 00 - Hydraulic Elevators: Elevator systems monitored and controlled by fire alarm system.
- E. Section 21 13 00 - Fire-Suppression Sprinkler Systems: Supervisory, alarm, and actuating devices installed in sprinkler system.
- F. Section 23 33 00 - Air Duct Accessories: Smoke dampers monitored and controlled by fire alarm system.
- G. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems: Requirements for the seismic qualification of equipment specified in this section.

1.4 REFERENCE STANDARDS

- A. 36 CFR 1191 - Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines current edition.
- B. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design 2010.
- C. IEEE C62.41.2 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits 2002 (Corrigendum 2012).

- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. NFPA 72 - National Fire Alarm and Signaling Code 2016.
- F. NFPA 101 - Life Safety Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.5 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Evidence of designer qualifications.
- C. Design Documents: Submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, riser diagrams, and description of operation:
 - 1. Fire alarm shop drawings shall be inclusive of all requirements listed in 2015 International Building Code section 907.1.2.
 - a. Incomplete submittal packages will be rejected without review.
 - 2. Copy (if any) of list of data required by authority having jurisdiction.
 - 3. NFPA 72 "Record of Completion", filled out to the extent known at the time.
 - 4. Clear and concise description of operation, with input/output matrix similar to that shown in NFPA 72 Appendix A-7-5-2.2(9), and complete listing of software required.
 - 5. System zone boundaries and interfaces to fire safety systems.
 - 6. Location of all components, circuits, and raceways; mark components with identifiers used in control unit programming.
 - 7. Circuit layouts; number, size, and type of raceways and conductors; conduit fill calculations; spare capacity calculations; notification appliance circuit voltage drop calculations.
 - 8. List of all devices on each signaling line circuit, with spare capacity indicated.
 - 9. Manufacturer's detailed data sheet for each component, including wiring diagrams, installation instructions, and circuit length limitations.
 - 10. Description of power supplies; if secondary power is by battery include calculations demonstrating adequate battery power.
 - 11. Certification by either the manufacturer of the control unit or by the manufacturer of each other component that the components are compatible with the control unit.

12. Certification by the manufacturer of the control unit that the system design complies with Contract Documents.
 13. Certification by Contractor that the system design complies with Contract Documents.
 14. Do not show existing components to be removed.
- D. Manufacturer's equipment seismic qualification certification.
- E. Evidence of installer qualifications.
- F. Evidence of instructor qualifications; training lesson plan outline.
- G. Evidence of maintenance contractor qualifications, if different from installer.
- H. Inspection and Test Reports:
1. Submit inspection and test plan prior to closeout demonstration.
 2. Submit documentation of satisfactory inspections and tests.
 3. Submit NFPA 72 "Inspection and Test Form," filled out.
- I. Operating and Maintenance Data: See Section 01 78 00 for additional requirements; revise and resubmit until acceptable; have one set available during closeout demonstration:
1. Complete set of specified design documents, as approved by authority having jurisdiction.
 2. Additional printed set of project record documents and closeout documents, bound or filed in same manuals.
 3. Contact information for firm that will be providing contract maintenance and trouble call-back service.
 4. List of recommended spare parts, tools, and instruments for testing.
 5. Replacement parts list with current prices, and source of supply.
 6. Detailed troubleshooting guide and large scale input/output matrix.
 7. Preventive maintenance, inspection, and testing schedule complying with NFPA 72; provide printed copy and computer format acceptable to Owner.
 8. Detailed but easy to read explanation of procedures to be taken by non-technical administrative personnel in the event of system trouble, when routine testing is being conducted, for fire drills, and when entering into contracts for remodeling.
- J. Project Record Documents: See Section 01 78 00 for additional requirements; have one set available during closeout demonstration:

1. Complete set of floor plans showing actual installed locations of components, conduit, and zones.
2. "As installed" wiring and schematic diagrams, with final terminal identifications.
3. "As programmed" operating sequences, including control events by device, updated input/output chart, and voice messages by event.

K. Closeout Documents:

1. Certification by manufacturer that the system has been installed in compliance with manufacturer's installation requirements, is complete, and is in satisfactory operating condition.
2. NFPA 72 "Record of Completion", filled out completely and signed by installer and authorized representative of authority having jurisdiction.
3. Report on training results.

L. Maintenance Materials, Tools, and Software: Furnish the following for Owner's use in maintenance of project.

1. See Section 01 60 00 - Product Requirements, for additional provisions.
2. Furnish spare parts of same manufacturer and model as those installed; deliver in original packaging, labeled in same manner as in operating and maintenance data and place in spare parts cabinet.
3. In addition to the items in quantities indicated in PART 2, furnish the following:
 - a. All tools, software, and documentation necessary to modify the fire alarm system using Owner's personnel; minimum modification capability to include addition and deletion of devices, circuits, and zones, and changes to system description, operation, and evacuation and instructional messages.
 - b. One copy, on CD-ROM, of all software not resident in read-only-memory.
 - c. Extra Fuses: Two for each installed fuse; store inside applicable control cabinet.
 - d. Printer Paper: [____].
 - e. Replacement Printer Ribbons: [____].

1.6 QUALITY ASSURANCE

- A. Copies of Design Criteria Documents: Maintain at the project site for the duration of the project, bound together, an original copy of NFPA 72, the relevant portions of applicable codes, and instructions and guidelines of authorities having jurisdiction; deliver to Owner upon completion.

- B. Designer Qualifications: NICET Level III or IV (3 or 4) certified fire alarm technician or registered fire protection engineer, employed by fire alarm control panel manufacturer, Contractor, or installer, with experience designing fire alarm systems in the jurisdictional area of the authorities having jurisdiction.
 - C. Installer Qualifications: Firm with minimum 3 years documented experience installing fire alarm systems of the specified type and providing contract maintenance service as a regular part of their business.
 - 1. Authorized representative of control unit manufacturer; submit manufacturer's certification that installer is authorized; include name and title of manufacturer's representative making certification.
 - 2. Installer Personnel: At least 2 years of experience installing fire alarm systems.
 - 3. Supervisor: NICET level III or IV (3 or 4) certified fire alarm technician; furnish name and address.
 - D. Maintenance Contractor Qualifications: Same entity as installer or different entity with specified qualifications.
 - E. Instructor Qualifications: Experienced in technical instruction, understanding fire alarm theory, and able to provide the required training; trained by fire alarm control unit manufacturer.
 - F. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.
- 1.7 WARRANTY
- A. Provide control panel manufacturer's warranty that system components other than wire and conduit are free from defects and will remain so for 1 year after date of Substantial Completion.
 - B. Provide installer's warranty that the installation is free from defects and will remain so for 1 year after date of Substantial Completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Fire Alarm Control Units and Accessories: Notifier by Honeywell:
<https://www.securityandfire.honeywell.com/notifier/en-us>.
- B. Initiating Devices and Notification Appliances:
 - 1. Same manufacturer as control units.
- C. Substitutions: Not permitted.

2.2 FIRE ALARM SYSTEM

- A. Fire Alarm System: Provide a new automatic fire detection and alarm system:
1. Provide all components necessary, regardless of whether shown in Contract Documents or not.
 2. Protected Premises: Entire building shown on drawings.
 3. Comply with the following; where requirements conflict, order of precedence of requirements is as listed:
 - a. ADA Standards.
 - b. The requirements of the State Fire Marshal.
 - c. The requirements of the local authority having jurisdiction .
 - d. Applicable local codes.
 - e. Contract Documents (drawings and specifications).
 - f. NFPA 101.
 - g. NFPA 72; where the word "should" is used consider that provision mandatory; where conflicts between requirements require deviation from NFPA 72, identify deviations clearly on design documents.
 4. Evacuation Alarm: [] general evacuation of entire premises.
 5. Fire Alarm Control Unit: New, located at Main Office Area.
 6. Combined Systems: Do not combine fire alarm system with other non-fire systems.
- B. Supervising Stations and Fire Department Connections:
1. Public Fire Department Notification: By remote supervising station.
- C. Circuits:
1. Initiating Device Circuits (IDC): Class B, Style A.
 2. Signaling Line Circuits (SLC) Within Single Building: Class B, Style 0.5.
 3. Notification Appliance Circuits (NAC): Class B, Style W.
- D. Spare Capacity:
1. Initiating Device Circuits: Minimum 25 percent spare capacity.
 2. Notification Appliance Circuits: Minimum 25 percent spare capacity.

3. Speaker Amplifiers: Minimum 25 percent spare capacity.
4. Fire Alarm Control Units: Capable of handling all circuits utilized to capacity without requiring additional components other than plug-in control modules.

E. Power Sources:

1. Primary: Dedicated branch circuits of the facility power distribution system.
2. Secondary: Storage batteries.
3. Capacity: Sufficient to operate entire system for period specified by NFPA 72.
4. Each Computer System: Provide uninterruptible power supply (UPS).

- F. Seismic Qualification: Provide fire alarm system and associated components suitable for application under the seismic design criteria specified in Section 26 05 48 where required. Include certification of compliance with submittals.

2.3 EXISTING COMPONENTS

- A. Existing Fire Alarm System: Remove existing system completely after new system is fully operational and tested.
- B. Clearly label components that are "Not In Service."
- C. Remove unused existing components and materials from site and dispose of properly.

2.4 FIRE SAFETY SYSTEMS INTERFACES

- A. Supervision: Provide supervisory signals in accordance with NFPA 72 for the following:
 1. Sprinkler water control valves.
 2. Elevator shut-down control circuits.
- B. Alarm: Provide alarm initiation in accordance with NFPA 72 for the following:
 1. Sprinkler water flow.
 2. Kitchen hood suppression activation; also disconnect fuel source from cooking equipment.
 3. Elevator lobby, elevator hoistway, and elevator machine room smoke detectors.
 4. Duct smoke detectors.
- C. Elevators:
 1. Elevator lobby, hoistway, and machine room smoke detectors: Elevator recall for fire fighters' service.

2. Elevator Machine Room Heat Detector: Shut down elevator power prior to hoistway sprinkler activation.
3. Sprinkler pressure or waterflow: Shut down elevator power prior to hoistway sprinkler activation.

D. HVAC:

1. Duct Smoke Detectors: Close dampers indicated; shut down air handlers indicated.

E. Doors:

1. Smoke Barrier Door Magnetic Holders: Release upon activation of smoke detectors in smoke zone on either side of door, upon alarm from manual pull station on same floor, and upon sprinkler activation on same floor. Refer to Section 08 71 00.
2. Electromagnetic Door Locks on Egress Doors: Unlock upon activation of any alarm initiating device or suppression system in smoke zone that doors serve as egress from. Refer to Section 08 71 00.

2.5 COMPONENTS

A. General:

1. Provide flush mounted units where installed in finish areas; in unfinished areas, surface mounted unit are acceptable.
2. Provide legible, permanent labels for each control device, using identification used in operation and maintenance data.

B. Fire Alarm Control Units: Analog, addressable type; listed, classified, and labeled as suitable for the purpose intended.

C. Addressable Fire Alarm Control Unit - Basis of Design:Notifier NFS2-640 with UDACT and Integrated Voice Panel.

D. Master Control Unit: As specified for Basis of Design above, or equivalent.

E. Initiating Devices:

1. Addressable Systems:
 - a. Addressable Devices: Individually identifiable by addressable fire alarm control unit.
 - b. Provide suitable addressable interface modules as indicated or as required for connection to conventional (non-addressable) devices and other components that provide a dry closure output.
2. Manual Pull Stations: [_____].
 - a. Provide 10% + 2 extra.

3. Smoke Detectors: [_____].
 - a. Provide 10% + 2 extra.
 4. Duct Smoke Detectors: [_____].
 - a. Provide 10% + 2 extra.
 5. Heat Detectors: [_____].
 - a. Provide 10% + 2 extra.
 6. Addressable Interface Devices: [_____].
 - a. Provide 10% + 2 extra.
- F. Notification Appliances:
1. Bells: [_____].
 - a. Provide 1 extra.
 2. Speakers: [_____].
 - a. Provide 20% + 2 extra.
 3. Strobes: [_____].
 - a. Provide 20% + 2 extra.
- G. Circuit Conductors: Copper or optical fiber; provide 500 feet extra; color code and label.
- H. Surge Protection: In accordance with IEEE C62.41.2 category B combination waveform and NFPA 70; except for optical fiber conductors.
- I. Locks and Keys: Deliver keys to Owner.
1. Provide the same standard lock and key for each key operated switch and lockable panel and cabinet; provide 5 keys of each type
- J. Instruction Charts: Printed instruction chart for operators, showing steps to be taken when a signal is received (normal, alarm, supervisory, and trouble); easily readable from normal operator's station.
1. Frame: Stainless steel or aluminum with polycarbonate or glass cover.
 2. Provide one for each control unit where operations are to be performed.
 3. Obtain approval of Owner prior to mounting; mount in location acceptable to Owner.
 4. Provide extra copy with operation and maintenance data submittal.

- K. Storage Cabinet for Spare Parts and Tools: Steel with baked enamel finish, size appropriate to quantity of parts and tools.
 - 1. Padlock eye and hasp for lock furnished by Owner.
 - 2. Locate as directed by Owner.
- L. Document Storage Cabinet: Steel with baked enamel finish, size appropriate for all documents.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with applicable codes, NFPA 72, NFPA 70, and Contract Documents.
- B. Conceal all wiring, conduit, boxes, and supports where installed in finished areas.
- C. Obtain Owner's approval of locations of devices, before installation.
- D. Install instruction cards and labels.

3.2 INSPECTION AND TESTING FOR COMPLETION

- A. Notify Owner 7 days prior to beginning completion inspections and tests.
- B. Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.
- C. Provide the services of the installer's supervisor or person with equivalent qualifications to supervise inspection and testing, correction, and adjustments.
- D. Prepare for testing by ensuring that all work is complete and correct; perform preliminary tests as required.
- E. Provide all tools, software, and supplies required to accomplish inspection and testing.
- F. Perform inspection and testing in accordance with NFPA 72 and requirements of local authorities; document each inspection and test.
- G. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.
- H. Diagnostic Period: After successful completion of inspections and tests, Operate system in normal mode for at least 14 days without any system or equipment malfunctions.
 - 1. Record all system operations and malfunctions.
 - 2. If a malfunction occurs, start diagnostic period over after correction of malfunction.
 - 3. At end of successful diagnostic period, fill out and submit NFPA 72 "Inspection and Testing Form."

3.3 OWNER PERSONNEL INSTRUCTION

- A. Provide the following instruction to designated Owner personnel:
 - 1. Hands-On Instruction: On-site, using operational system.
 - 2. Classroom Instruction: Owner furnished classroom, on-site or at other local facility.
 - 3. Factory Instruction: At control unit manufacturer's training facility.
- B. Administrative: Two hour session(s) covering issues necessary for non-technical administrative staff; classroom:
 - 1. Initial Training: 1 session pre-closeout.
 - 2. Refresher Training: 1 session post-occupancy.
- C. Basic Operation: Two hour sessions for attendant personnel, security officers, and engineering staff; combination of classroom and hands-on:
 - 1. Initial Training: 1 session pre-closeout.
 - 2. Refresher Training: 1 session post-occupancy.
- D. Detailed Operation: Two-hour sessions for engineering staff; assume NICET level I qualifications or equivalent; combination of classroom and hands-on:
 - 1. Initial Training: 1 session pre-closeout.
 - 2. Refresher Training: 1 session post-occupancy.
- E. Maintenance Technicians: Detailed training for electrical technicians, on programming, maintaining, repairing, and modifying; factory training:
 - 1. Initial Training: One 3-day session, pre-closeout.
- F. Furnish the services of instructors and teaching aids; have copies of operation and maintenance data available during instruction.
- G. Provide means of evaluation of trainees suitable to type of training given; report results to Owner.

3.4 CLOSEOUT

- A. Closeout Demonstration: Demonstrate proper operation of all functions to Owner.
 - 1. Be prepared to conduct any of the required tests.
 - 2. Have at least one copy of operation and maintenance data, preliminary copy of project record drawings, input/output matrix, and operator instruction chart(s) available during demonstration.

3. Have authorized technical representative of control unit manufacturer present during demonstration.
 4. Demonstration may be combined with inspection and testing required by authority having jurisdiction; notify authority having jurisdiction in time to schedule demonstration.
 5. Repeat demonstration until successful.
- B. Occupancy of the project will not occur prior to Substantial Completion.
- C. Substantial Completion of the project cannot be achieved until inspection and testing is successful and:
1. Specified diagnostic period without malfunction has been completed.
 2. Approved operating and maintenance data has been delivered.
 3. Spare parts, extra materials, and tools have been delivered.
 4. All aspects of operation have been demonstrated to Owner.
 5. Final acceptance of the fire alarm system has been given by authorities having jurisdiction.
 6. Specified pre-closeout instruction is complete.
- D. Perform post-occupancy instruction within 3 months after Substantial Completion.
- 3.5 MAINTENANCE
- A. See Section 01 70 00 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Provide to Owner, a proposal as an alternate to the base bid, for a maintenance contract for entire warranty period, to include the work described below; include the total cost of contract, proposal to be valid at least until 30 days after date of Substantial Completion.
- C. Perform routine inspection, testing, and preventive maintenance required by NFPA 72, including:
1. Maintenance of fire safety interface and supervisory devices connected to fire alarm system.
 2. Repairs required, unless due to improper use, accidents, or negligence beyond the control of the maintenance contractor.
 3. Record keeping required by NFPA 72 and authorities having jurisdiction.
- D. Provide trouble call-back service upon notification by Owner:
1. Provide on-site response within 2 hours of notification.

2. Include allowance for call-back service during normal working hours at no extra cost to Owner.
 3. Owner will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.
- E. Provide a complete description of preventive maintenance, systematic examination, adjustment, cleaning, inspection, and testing, with a detailed schedule.
- F. Maintain a log at each fire alarm control unit, listing the date and time of each inspection and call-back visit, the condition of the system, nature of the trouble, correction performed, and parts replaced. Submit duplicate of each log entry to Owner's representative upon completion of site visit.
- G. Comply with Owner's requirements for access to facility and security.

END OF SECTION 28 46 00

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SECTION 31 10 00 - SITE CLEARING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Protecting existing trees and vegetation to remain including installation of staging fencing and temporary safety barricade.
 - 2. Removing trees and other vegetation.
 - 3. Clearing and grubbing.
 - 4. Topsoil and subsoil stripping and stockpiling.
 - 5. Removing above-grade site improvements and off-site disposal.
 - 6. Removal and/or on-site pulverizing of designated pavements.
- B. Related Sections include the following:
 - 1. Division 01 Section "Execution Requirements".
 - 2. Division 01 Section "Temporary Facilities and Controls".
 - 3. Division 01 Section "Temporary Erosion and Sedimentation Controls".
 - 4. Division 01 Section "Temporary Dust Control".
 - 5. Division 01 Section "Temporary Stormwater Pollution Control".
 - 6. Division 31 Section "Environmental Controls".
 - 7. Division 31 Section "Earth Moving".
 - 8. Division 32 Section "Topsoil".
 - 9. Division 32 Section "Turf and Grasses".

1.3 DEFINITIONS

- A. Topsoil: Natural or cultivated surface-soil layer (typically the A horizon) containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; free of subsoil, clay lumps, gravel, and other objects more than [2 inches] in diameter; and free of weeds, roots, and other deleterious materials.
- B. Subsoil: Naturally occurring weathered moraine material, typical 12"-24" depth located immediately under the topsoil and atop the residual moraine material.
- C. Form 816: "Standard Specifications for Roads, Bridges, and Incidental Construction", State of Connecticut, Department of Transportation, Form 816", 2004 edition, with 2005 supplement.

...

- D. Remove: Detach items from existing construction and legally dispose of them off-site, unless indicated to be removed and salvaged or removed and reinstalled.
- E. Remove and Salvage: Detach items from existing construction and deliver them to Owner.
- F. Remove and Reinstall: Detach items from existing construction, prepare them for reuse, and reinstall them where indicated.
- G. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 MATERIALS OWNERSHIP

- A. Except for materials indicated to be stockpiled or to remain Owner's property, cleared and demolished materials shall become Contractor's property and shall be removed from the site.

1.5 SUBMITTALS

- A. Photographs sufficiently detailed, of existing conditions of trees and plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site clearing.
- B. Record drawings according to Division 1, Section "Project Closeout."
 - 1. Identify and accurately locate capped utilities and other subsurface structural, electrical, and mechanical conditions.
- C. Product data for safety barricade and root inoculant.

1.6 QUALITY ASSURANCE

- A. Preconstruction Conference: Conduct conference at Project site to comply with requirements in Division 1, Section "Project Coordination". Coordinate meeting with project sediment and erosion control requirements.
- B. All work shall comply with all codes, rules, regulations, laws and ordinances for the Town of Newington, the State of Connecticut, and all other authorities having jurisdiction.

1.7 PROJECT CONDITIONS

- A. 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 authorities having jurisdiction.

- B. Improvements on Adjoining Property: Authority for performing indicated removal and alteration work on property adjoining Owner's property will be obtained by Owner before award of Contract.
 - 1. Peripheral areas outside the Contract limit line shall not be disturbed or used for storing materials.
- C. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.
- D. Notify utility locator service for area where Project is located before site clearing.
- E. Review and verify all limits or improvements to be removed prior to commencing demolition operations.
- F. Inspection: Verify existing condition of all items scheduled for demolition or removal. The Owner assumes no responsibility for the actual condition of structures or utilities to be demolished. Do not proceed with any work that will result with unsafe conditions causing a continuing or permanent hazard. Ascertain that all work scheduled for demolition can be safely accomplished in a proper time period.
- G. Benchmarks: Protect all survey monuments, benchmarks, and property boundary pins. Replace if destroyed by Contractor's operations. Relocate designated monuments where and as directed by the Town of Newington. Coordinate and schedule work with Owner.
- H. Permits/Fees: Coordinate with appropriate utility companies and pay any disconnect fees and obtain permits as necessary.
- I. Provide 48 hours notice prior to conducting any site demolition operation.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. Satisfactory Soil Materials: Requirements for satisfactory soil materials are specified in Division 31, Section "Earth Moving."
 - 1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available on-site.

2.2 SAFETY BARRICADE

- A. The Safety Barricade shall be a temporary, polypropylene construction fence, fully stabilized for UV resistance, with 2 inch by 4.5 inch apertures.
 - 1. Color: Orange, height 4'0".
 - 2. Top tension rope – 3/8" braided nylon/polypropylene rope.
- B. POSTS: Heavy gauge channel steel posts 6'0" long.

2.3 STAGING FENCING

- A. Staging Fencing: Chain Link Fence, 8'0" height, 11 gauge with 1-1/2" OD posts at 10'-0" maximum on center spacing. Top tension wire required.

2.4 ROOT INOCULANT

- A. Inoculant shall be rooting growth hormone containing mycorrhizae.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Provide erosion-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways. [Refer to Division 31, Section "Erosion and Sediment Control.]
- C. Protect existing site improvements to remain from damage during construction.
 - 1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TREE PROTECTION

- A. Erect and maintain a safety barricade around drip line of individual trees or around perimeter drip line of groups of trees to remain. Remove fence when construction is complete. Post spacing 6'0". Securely attach fencing to posts, including providing a top tension line, woven through top of fabric.
 - 1. Do not store construction materials, debris, or excavated material within drip line of remaining trees.
 - 2. Do not permit vehicles, equipment, or foot traffic within drip line of remaining trees.
- B. Do not excavate within drip line of trees, unless otherwise indicated.
- C. Where excavation for new construction is required within drip line of trees, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.
 - 1. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.
 - 2. Coat cut faces of roots more than 1-1/2 inches in diameter with emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
 - 3. Cover exposed roots with wet burlap to prevent roots from drying out. Backfill with soil as soon as possible.

- D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.
 - 1. Employ a qualified arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
 - 2. Replace trees that cannot be repaired and restored to full-growth status, as determined by the qualified arborist.

3.3 UTILITIES

- A. Contractor to arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing and demolition.

3.4 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction. Removal includes digging out stumps and obstructions and grubbing roots. Selectively clear trees and prune branches within 20' of clearing limit line or property line. Pruning to conform to Class III Standards.
 - 1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
 - 2. Selectively prune and cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
 - 3. Completely remove stumps, roots, obstructions, and debris typically extending to a depth of 36 inches below any subgrade. In athletic field areas where proposed fills are greater than 12' in height, trees may be smoothly flush cut and no topsoil stripping or grubbing is required.
 - 4. Use only hand methods for grubbing within drip line of remaining trees.
 - 5. Along property lines, notify Architect before beginning clearing operations. Coordinate clearing, grubbing and selective pruning with Architect, to maintain as much existing vegetation as is practical.
- 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 8-inch loose depth, and compact each layer to a density equal to adjacent original ground.

3.5 TOPSOIL STRIPPING

- A. Prepare areas of existing loam so as to provide clump free topsoil. Remove sod and grass before stripping topsoil.
- B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.
 - 1. Strip surface soil of unsuitable topsoil, including trash, debris, weeds, roots, and other waste materials.

2. Where trees are indicated to remain, hold stripping a sufficient distance away to prevent damage to the root system.
 3. No topsoil stripping is required where proposed fills are greater than 12' in height.
- C. Stockpile materials away from edge of excavations without intermixing with other soil materials. Grade and shape stockpiles to drain surface water, in locations approved by the Owner and consistent with sediment and erosion control requirements.
1. Do not stockpile topsoil within drip line of remaining trees.
 2. Stockpile surplus topsoil and allow for respreading entire amount of approved-stripped topsoil or haul excess topsoil to locations designated by the Owner. All excess approved topsoil remains the property of the Owner and shall be delivered to Owner's storage yard, within Town Limits at no additional expense to the contract as indicated in Division 32 "Topsoil".

3.6 SUBSOIL STRIPPING

- A. After topsoil is fully stripped, strip existing subsoil in all proposed pavement areas, within building footprint, in areas of shallow cuts, and in areas of shallow (less than 6' height) fills.
- B. Strip subsoil to whatever depths are encountered in a manner to prevent intermingling with topsoil and general fill.

3.7 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements (full-depth) as indicated and as necessary to facilitate new construction.
- B. Remove all slabs, paving, curbs, gutters, and all base/subbase material as indicated to full depths encountered.
 1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically, perpendicular and parallel to direction of traffic.
 2. It is the Contractor's option to pulverize or remove existing pavements from site.
 3. Specific pulverizing equipment must be approved. Thoroughly break up bituminous pavement to maximize aggregate size of 2". Pulverize all pavements to their full depth. Stockpile all pulverized material only in permitted areas. Submit mechanical/sieve analysis of pulverized/base material. Final pulverized product may be re-used on-site if capable of specified compaction and meeting the requirements of gradation for Form 816, Article M.05.01. If not accepted, remove from site at no additional cost to Owner.
- C. Remove existing site improvements, including pavements fences of various types, and signage.
- D. Remove, salvage, clean, and store any existing memorial stones/plaques encountered for re-installation.

3.8 DISPOSAL

- A. Disposal: Remove unsuitable soil material, cleared and grubbed material, obstructions, demolished materials, and waste materials, including trash and debris, and legally dispose of them off Owner's property. No burning or burying on site is permitted.
- B. Accumulation of disposal/waste materials on-site is not permitted.
- C. All pavement demolition material remains the property of the Contractor except as specifically noted to be retained or permitted to be re-used on-site.

3.9 MAINTENANCE OF EXISTING SITE AREAS

- A. The Contractor shall maintain all areas within the project limits, for the duration of the contract. This maintenance will include the continuous mowing of undisturbed lawn areas within project limits, as well as the removal of any debris within fenced off areas.

END OF SECTION 31 10 00

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SECTION 31 11 00 — CLEARING AND GRUBBING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”
- B. Related Work Specified Elsewhere
 - 1. Earth Moving – Section 31 20 00

1.02 DESCRIPTION

- A. Work Included: cutting trees, shrubs, and bushes; removing stumps; removing other materials; disposal of materials; stripping and stockpiling topsoil.

PART 2 – PRODUCTS

- A. None required by this Section.

PART 3 – EXECUTION

3.01 CLEARING AND GRUBBING

- A. Remove all rubbish and debris from within the Contract limits.
- B. Remove trees, saplings, shrubs, bushes, vines, undergrowth, stumps, and roots from areas to be occupied by buildings, structures, roadways, parking lots, pipelines, and lawns.
- C. The Architect will designate trees and other plants to remain. Protect those trees and plants from damage by erecting barricades, fences, or by other acceptable means. Prevent falling trees from damaging trees and plants designated to remain.
- D. Protect areas outside the limits of clearing from damage by the clearing and grubbing operations.

3.02 STRIPPING AND STOCKPILING TOPSOIL

- A. Strip topsoil from cleared areas. Do not mix topsoil with subsoil. Keep topsoil free of brush, trash, large stones, and other extraneous material.
- B. Stockpile topsoil at areas on the site as directed by the Architect. Protect the stockpiles of topsoil until used for lawns and other plantings under other Sections of these Specifications.

- C. Any topsoil remaining after all work is in place shall become the property of the Contractor. The Contractor shall dispose of the topsoil off the site.
- D. The Contractor shall supply additional topsoil at his expense if there is a shortage from stripping.

3.03 DISPOSAL OF MATERIAL

- A. No burning will be allowed.
- B. All rubbish, debris, logs, stumps, roots, cuttings, and other materials resulting from the clearing and grubbing operations shall become the property of the Contractor and shall be disposed of by him off the site. The manner of disposal shall comply with all applicable local, state, and federal regulations.

END OF SECTION 31 11 00

SECTION 31 20 00 – EARTH MOVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Site excavating, grading, filling, backfilling, compacting, and preparing sub-grades for the entire project including but not limited to: retaining walls, site utility lines and structures, walks, pavements, lawns, and plantings.
 - 2. Granular fill course for walks, curbs, stairs, and other site improvements.
 - 3. Processed aggregate for pavements and other improvements.
 - 4. General fill for establishing project sub-grades.
 - 5. Excavation of rock and/or boulders, including replacement with suitable earthwork materials.
 - 6. Removal of encountered unsatisfactory soils, including lawful off-site disposal and replacement with suitable earthwork fill material.
 - 7. Utility bedding material for site utilities.
 - 8. Construction of edge drains at pavement areas where indicated.
 - 9. Construction of stone slope embankment.
- B. Related Sections include the following:
 - 1. Division 31 Section “Erosion and Sedimentation Control.”
 - 2. Division 31 Section “Trenching and Backfill”
 - 3. Division 31 Section "Site Clearing"
 - 4. Division 32 Section "Turf and Grasses"
 - 5. Division 26 and 33 Sections for excavating and backfilling buried mechanical and electrical utilities and utility structures.

1.3 DEFINITIONS

- A. Backfill: Soil materials 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: Layer placed between the subbase course and proposed improvements.
- C. Bedding Course: Layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow: Satisfactory soil or earthwork products imported from off-site for use as fill or backfill.
- E. Excavation: Removal of material encountered above subgrade elevations.
1. Additional Excavation: Excavation below subgrade elevations as directed by Architect. Additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
 2. Bulk Excavation: Excavations more than 8 feet in width and pits more than 30 feet in either length or width.
 3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.
- F. Fill: Soil materials used to raise existing grades.
- G. Mass Rock or Earth: Excavated material that is greater than 8' in both length and width.
- H. Rock: Excavated rock material in beds, ledges, unstratified masses, and conglomerate deposits and boulders of rock material exceeding 1.5 cu. yd. 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. Excavation of Footings, Trenches, and Pits: Late-model, track-mounted hydraulic excavator; Caterpillar 325D or equal, equipped with a 42-inch wide, short-tip-radius rock bucket.
 2. Mass Excavation: Late-model, track-mounted loader; Caterpillar 963C or equal; or Late-model, track-mounted hydraulic excavator; Caterpillar 325D or equal, equipped with a 42-inch wide, short-tip-radius rock bucket.
- I. Boulder: An excavated, individual rock fragment or natural stone with a volume of 1.5 c.y. to 6 c.y. All boulders exceeding 6 c.y. shall be classified as "rock" and shall fall within "mass" or "trench" subcategory based on definitions in this section. Material classified as "Rock" and excavated and paid for shall not be eligible to be classified as "boulder" for additional payment purposes. All excavated boulder material, to be disposed of on-site, or processed for re-use on-site, is not eligible for compensation under allowance and is part of base bid.
- J. Structures: Retaining walls, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

- K. Subbase Course: Layer placed between the subgrade and base course for pavement or other site improvements.
- L. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.
- M. Trench Rock or Earth: Excavated material from trench excavations that is less than 8' (eight feet) in either length or width.
- N. Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.
- O. Form 818: "Standard Specifications for Roads, Bridges, Facilities, and Incidental Construction", State of Connecticut, Department of Transportation, Form 818, 2020 edition, as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.
- P. Unsatisfactory Soils: Any material generated, excavated and/or collected by earth moving activities or other contract work that does not meet any of the product specifications contained in contract documents.

1.4 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specifications Sections.
- B. Product Data: For the following:
 - 1. Each type of plastic warning tape.
 - 2. Drainage fabric.
 - 3. Separation fabric.
- C. Samples: For the following:
 - 1. 50-lb samples, sealed in airtight containers, of each proposed soil material from on-site or borrow sources, for Owner's independent laboratory testing agency. Samples shall be delivered to the site seven (7) calendar days in advance or time planned on incorporating them into the work. Owner's testing lab will confirm submitted test results and compaction curve data.
 - 2. 12-by-12-inch sample of drainage filter fabric.
 - 3. 12-by-12-inch sample of separation fabric.
 - 4. 4-foot strip of each type of warning tape.
- D. Material Test Reports: From an approved qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
 - 1. Complete mechanical/sieve analysis classification according to Form 818 and ASTM D 2487 for every 400 cubic yards of on-site or borrow soil material proposed for fill and

- backfill.
- 2. Laboratory compaction curve according to ASTM D 1557 for each on-site or borrow soil material proposed for fill and backfill.
- 3. Report of actual unconfined compressive strength and/or results of bearing tests of each stratum tested.
- 4. Test sampling shall conform to the requirements of ASTM D-75, and ASTM D-3665.
- E. Blasting plan approved by authorities having jurisdiction, for record purposes.
- F. Seismic survey agency report, for record purposes.
- G. All installation of materials prior to testing and/or review and response by Architect is at Contractor's risk.

1.5 QUALITY ASSURANCE

- A. Comply with applicable requirements of NFPA 495, "Explosive Materials Code" and Form 818, Paragraph 1.07.08.
- B. Seismic Survey Agency: An independent testing agency, acceptable to authorities having jurisdiction, experienced in seismic surveys and blasting procedures to perform the following services:
 - 1. Prepare plan report types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.
 - 2. Seismographic monitoring services during blasting operations.
 - 3. Prepare a preblast survey of all adjacent properties, including a structural inspection of the buildings and properties and shall include a written and photographic record of existing conditions.
 - 4. Blast operations shall not commence until all reports and plans are received and approved by the Owner and the Architect.
- C. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.
- D. Pre-excavation Conference: Conduct conference at Project site to comply with requirements in Division 1, Section "Project Coordination".
 - 1. Before commencing earthwork, meet with representatives of the governing authorities, Owner, Architect, Engineer, consultants, independent testing agency, and other concerned entities. Review earthwork procedures and responsibilities including testing and inspection procedures and requirements. Notify participants at least 3 working days prior to convening conference. Record discussions and agreements and furnish a copy to each participant.
- E. Testing: Compaction tests will be required by the Owner and will be paid for by the Owner.

No specific testing schedule has been established at this time. If tests indicate that density requirements have not been achieved, the Contractor shall continue compacting.

All retesting in these areas shall be paid for by the Contractor. See Division 1, Section “Quality Control Services”. Contractor is required to compensate testing laboratory, directly, for all material test reports.

- F. Density and Compaction Testing: The Contractor is responsible to schedule compaction tests and to allow adequate time for the proper execution of said tests.
- G. Protect all benchmarks, monuments, and property boundary pins. Replace if destroyed by Contractor’s operations.

1.6 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Architect and then only after arranging to provide temporary utility services according to requirements indicated. Note that school operations must be maintained throughout construction.
 - 1. Notify Architect not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Architect's written permission.
 - 3. Contact utility-locator service for area where Project is located before excavating.
- B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active. Contact **[Call Before You Dig (1-800-922-4455)]** prior to any earthwork or demolition operations.

PART 2 – PRODUCTS

2.1 FILL MATERIAL

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Granular Fill: Form 818 Article M.02.06, Type ‘B’ is to be used for filling under footings, pavements, and improvements, and subbase under pavements that is required to achieve the rough grades indicated.
 - 1. Provide borrow material as required to meet project specifications.

- C. Controlled Fill – 3/8” Crushed Stone (No. 8 Stone Form 818, M.01.01
- D. Crushed Stone: Clean, sound material free of debris, waste, frozen materials and organic material conforming to Form 818, Article M.01.01 size as indicated on Drawings.
- E. Processed Aggregate: Artificially graded mixture of sound coarse and fine aggregates, containing no more than 15 percent by weight of recycled bituminous concrete. Mixture to be free of debris, waste, frozen materials and organic materials and conform to Form 818, Article M.05.01. Maximum size of aggregate shall not exceed 2/3 of lift thickness. Broken stone is required; rounded gravel will not be permitted.
- F. Utility Bedding Material: Sand or sandy soil free of debris, waste, frozen materials and organics with 100 percent passing a 3/8-inch sieve and not more than 10 percent passing a No. 200 sieve or as specifically required by applicable utility authority.
- G. General Fill: Material used to establish subgrade elevations may be either:

- 1. Approved soil material available from excavation on site provided material meets specification for general fill as described below, or approved by Architect prior to placement. Maximum size 8”.
- 2. Approved material, obtained from off-site, certified to conform to the following grain-size gradation:

SQUARE MESH SIEVES	PERCENT PASSING WEIGHT
Pass 5”	100
Pass 3/4”	75-100
Pass #4	25-80

Less than 15% of the material passing the #4 sieve shall pass a #200 sieve.

- 3. All material used for general filling shall be clean, free of clay and organic material and capable of satisfactory compaction.
 - 4. If sufficient approved on-site material is not available to meet site elevations indicated, Contractor shall provide additional approved off-site material at no extra cost to Owner.
- H. Stone Screenings: Form 818, Article M.01.01 “Screenings”.
 - I. Sand: Form 818, Section M.11.04, Grade “B”.
 - J. Subsoil: shall be the existing on site weathered moraine material; typically 12”–24” depth located immediately under the existing topsoil and atop the residual moraine material.
 - K. Modified Fill: a homogeneous mixture (bulk mixed at a 1:1 ratio) of approved topsoil and borrow sand.
 - L. Stone Wedge and Edge Drain Piping: 6” diameter perforated corrugated HDPE conforming to Division 2, Section “Sedimentation and Erosion Control” complete with filter perforated sock.

- M. Stone: An individual rock fragment or natural stone, with a volume of 0.5 cubic yards to 1.5 cubic yards, obtained from on-site excavation, on-site processing of rock or boulders, or an off-site source. All stone obtained from on-site excavation shall be considered Mass Earth or Trench Earth. All excess stone shall be considered “Unsatisfactory Soils” and shall be legally disposed of off-site.

2.2 TRENCH BEDDING AND COVER MATERIALS

- A. For Site Drainage Work: Section 33 40 00 – Storm Drainage Utilities;
- B. For Sanitary Sewers: Section 33 30 00 – Sanitary Sewerage Utilities;
- C. For Water Systems: Section 33 10 00 – Water Utilities.

2.3 SUBBASE AND BASE MATERIALS

- A. Subbase materials, where required, and base materials:
 - 1. For bituminous concrete: Section 32 12 16 – Asphalt Paving;
 - 2. For concrete sidewalks: Section 32 13 13 – Concrete Paving.

2.4 ACCESSORIES

- A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, minimum 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:
 - 1. Red: Electric.
 - 2. Yellow: Gas, oil, steam, and dangerous materials.
 - 3. Orange: Telephone and other communications.
 - 4. Blue: Water systems.
 - 5. Green: Sewer systems.
- B. Drainage Fabric: Non-woven geotextile, specifically manufactured as a drainage geotextile; made from polyolefins, polyesters, or polyamides; and with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
 - 1. Grab Tensile Strength: 110 lb/f; ASTM D 4632.
 - 2. Tear Strength: 40 lb/f; ASTM D 4533.
 - 3. Puncture Resistance: 50 lb/f; ASTM D 4833.
 - 4. Water Flow Rate: 150 gpm per sq. ft.; ASTM D 4491.
 - 5. Apparent Opening Size: No. 50; ASTM D 4751.

- C. Separation Fabric: Woven geotextile, specifically manufactured for use as a separation geotextile; made from polyolefins, polyesters, or polyamides; and with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
 - 1. Grab Tensile Strength: 200 lbf; ASTM D 4632.
 - 2. Tear Strength: 75 lbf; ASTM D 4533.
 - 3. Puncture Resistance: 90 lbf; ASTM D 4833.
 - 4. Water Flow Rate: 4 gpm per sq. ft.; ASTM D 4491.
 - 5. Apparent Opening Size: No. 30; ASTM D 4751.

PART 3 – EXECUTION

3.1 PREPARATION

- A. Review the Geotechnical Report prior to the commencement of work.
- B. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- C. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.
- D. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways. Refer to Division 31, Section “Sedimentation and Erosion Control”.
- E. Provide protective safety barrier around all trees in the work area that are to remain.

3.2 EXPLOSIVES

- A. Explosives: Obtain written permission from authorities having jurisdiction before bringing explosives to Project site or using explosives on Project site. Secure and pay for all permits as required.
- B. Comply with procedures outlined in paragraph “Quality Assurance”, sub-paragraph “Seismic Survey Agency”, above and Form 818, Section 1.07.08. No overnight on-site storage of explosives is permitted.
- C. Do not damage adjacent structures, property, or site improvements or weaken the bearing capacity of rock subgrade when using explosives.
- D. Provide minimum 48-hours notice to Owner, Architect, abutting properties, and all affected utilities. No blasting is permitted prior to 8:00 a.m. or after 4:00 p.m. or on Holidays, Saturdays or Sundays without written permission of the Owner. Blasting is NOT permitted while school is in session unless otherwise noted.

3.3 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area. Coordinate with project sediment and erosion control requirements.
- 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.
 - 2. Install a dewatering system to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.

3.4 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavation to subgrade elevations regardless of the character of the surface and subsurface conditions encountered, including rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
 - 1. If excavated materials intended for fill and backfill include unsatisfactory materials and rock, replace with satisfactory soil materials.
 - 2. Contractor will not be entitled to additional time to complete the project or additional compensation, when rock removal is required.

3.5 STABILITY OF EXCAVATIONS

- A. Comply with local codes, ordinances and requirements of authorities having jurisdiction to maintain stable excavations.

3.6 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing porous fill. Trim bottoms to required lines and grades to leave solid base to receive other work. See Division 31, Structural Fill specification for building footings and foundations.
2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended for bearing surface.

3.7 EXCAVATION FOR WALKS AND PAVEMENTS AND SLABS ON GRADE

- A. Excavate surfaces under walks and pavements to indicated cross sections, elevations, and grades.
- B. Rock will be removed to a depth of 24 inches below subgrade.

3.8 APPROVAL OF SUBGRADE

- A. Notify Architect and Owner's Representative when excavations have reached required subgrade.
- B. If unsatisfactory soil is present at sub-grade elevation, continue excavation and replace with compacted backfill or fill material as directed. Get approval before continuing work.
- C. Proof roll subgrade with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof roll wet or saturated subgrades. Conform to Form 818, Section 2.09. Subgrade must be approved prior to application of any borrow materials.
- D. If it is determined that unsatisfactory soil or excess moisture content is present, continue excavation and replace with compacted free draining backfill or fill material as directed.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect.
- F. Proof roll all areas under running track with minimum six (6) passes by vibratory roller with minimum 20 tons of dynamic force.

3.9 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. Lean concrete fill may be used when approved by Architect.
 1. Fill unauthorized excavations under other construction or utility pipe as directed by Architect.

3.10 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow materials and satisfactory excavated soil materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover with tarps to prevent windblown dust or temporarily seed as per Division 31 Section “Erosion and Sedimentation Controls”.
 - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.
 - 2. Contamination/intermixing of soil materials is just cause for rejection of material.

3.11 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
 - 1. Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation and drainage.
 - 2. Surveying locations of underground utilities for record documents.
 - 3. Inspecting, testing, and approving of underground utilities.
 - 4. Removing concrete formwork.
 - 5. Removing trash and debris from excavation.
 - 6. Removing temporary shoring and bracing, and sheeting.
 - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

3.12 PLACEMENT OF FILL

- A. Preparation: Remove vegetation, topsoil, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface before placing fills.
- B. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- C. When subgrade or existing ground surface to receive fill has a density less than that required for fill, break up ground surface to depth required, pulverize, moisture-condition or aerate soil and recompact to required density.
- D. Place and compact fill material in maximum 8” lifts. After placement, thoroughly knead all general fill with sheep’s foot rollers to break down any remaining chunks of soil prior to vibratory compaction.
- E. Do not deposit fill in areas of standing water. Any pockets of sediment and foreign material are to be removed before filling continues.
- F. Compaction: Each lift shall be compacted. Maintain optimum and proper moisture content to achieve required compaction. Coordinate with Owner on testing schedule throughout earthwork operations.

- G. Fill under lawn areas shall be compacted between 92% and 96% modified AASHTO laboratory density (ASTM D-1557, Method C).
- H. Fill under structures, pavements, and footings within 5' of grade shall be compacted to minimum 95% OF MODIFIED AASHTO laboratory density (ASTM D-1557, Method C). Fill under pavement 5 or more feet below grade shall be compacted minimum 92% of modified AASHTO laboratory density (ASTM D-1557, Method C). Under bituminous pavements, compact processed aggregate materials to minimum 98% modified AASHTO laboratory density.
- I. Special Requirements
 - 1. Remove all accumulated silts and organic material from temporary sedimentation, siltation, and detention basins prior to proceeding with earthwork.
 - 2. Phase all earthwork operations in all key identified slopes so that each slope and bench/terrace is completed, including compaction and stabilization prior to proceeding with next higher slope/bench. Notify Architect, Engineer, and Geotechnical Consultant for inspection of each slope/bench as it is formed and stabilized. Do not proceed with additional embankment/earthwork operation until approved by Owner's Representative and Engineer.
 - 3. The natural soils and the existing fills will be susceptible to remolding under equipment when wet. It is the Contractor's responsibility to execute work in a manner that will protect these soils from moisture infiltration. The Contractor will be responsible for the removal and replacement of all soils that have been exposed to moisture infiltration and cannot be worked or compacted therefore deemed unsuitable.

3.13 MOISTURE CONTROL (All Soils)

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within 2 percent of optimum moisture content.
- B. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
- C. Remove and replace, or scarify and air-dry, all soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.
 - 1. Stockpile or spread and dry removed wet satisfactory soil material.

3.14 FILL AND COMPACTION OF BORROW MATERIALS

- A. Place materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment (minimum 10 tons static weight, 20 tons dynamic force) and not more than 4 inches in loose depth for material compacted by hand-operated tampers. Otherwise, conform to requirements of paragraph 3.12.

- B. Place backfill and fill materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

3.15 GRADING

- A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated. Shape pavement base course with required cross sections and elevations.
 - 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.
 - 3. In all cases, maintain positive drainage.
- B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
 - 1. Lawn 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.
- D. Pavement Shoulders: Place shoulders along edges of subbase and base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of acceptable soil materials and compact simultaneously with each subbase and base layer.

3.16 FIELD QUALITY CONTROL

- A. Testing Agency: Allow the Owner's testing agency to inspect and test each subgrade and each fill or backfill layer. Do not proceed until test results for previously completed work verify compliance with requirements.
 - 1. Perform field in-place density tests according to ASTM D 1556 (sand cone method), ASTM D 2167 (rubber balloon method), or ASTM D 2937 (drive cylinder method), as applicable.
 - a. Field in-place density tests may also be performed by the nuclear method according to ASTM D 2922, provided that calibration curves are periodically checked and adjusted to correlate to tests performed using ASTM C 1556. With each density calibration check, check the calibration curves furnished with the moisture gages according to ASTM D 3017.

- b. When field in-place density tests are performed using nuclear methods, make calibration checks of both density and moisture gages at beginning of work, on each different type of material encountered, and at intervals as directed by the Engineer.
- 2. Trench Backfill: In each compacted initial and final backfill layer, perform at least one field in-place density test for each 150 feet or less of trench, but no fewer than two tests.
- B. When testing agency reports that subgrades, fills, or backfills are below specified density, scarify and moisten or aerate, or remove and replace soil to the depth required, re-compact and retest until required density is obtained.

3.17 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 the Architect; reshape and re-compact at optimum moisture content to the required density.
- C. Settling: Where settling occurs during the Project correction period, remove finished surfacing, backfill with additional approved material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

3.18 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.
- B. Refer to Division 32 Section "Topsoil" for disposal of topsoil.

END OF SECTION 31 20 00

SECTION 31 21 13 – RADON MITIGATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SCOPE

Installation of passive radon mitigation systems at Anna Reynolds School.

1.3 DESCRIPTION OF WORK

- A. The Contractor shall supply all labor, materials, equipment, services, insurance, and incidentals which are necessary or required to perform the work in accordance with applicable governmental regulations and these specifications.
- B. Contractor shall supply and install passive radon mitigation systems at 11 locations at Anna Reynolds School in accordance with this specification and Drawing H1.13.

1.4 DEFINITIONS

PVC: Polyvinyl chloride plastic.

1.5 REFERENCES

- A. The current issue of each document shall govern. Where conflict among requirements or with these specifications exists, the more stringent requirements shall apply.

Radon Mitigation Standards for Schools and Large Buildings (RMS-LB 2018).

1.6 QUALITY ASSURANCE

- A. Training – Radon system installer shall hold current certification as a radon mitigator by the National Radon Proficiency Program (NRPP).

PART 2 - MATERIALS

2.1 PIPING MATERIALS

- A. Schedule 40 PVC 4” dia riser piping, perforated piping, and fittings.

2.1 ACCESSORY MATERIALS

- A. Stainless steel pipe supports.

B. Sill seal foam gasket.

C. Polyurethane sealant.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Coordinate installation with waste plumbing trade and roofing trade.

3.2 TRENCHING

A. Trenching in support of running pipe under chase slab by others.

3.3 PIPING INSTALLATION

A. Following trenching of bathroom chase, place $\frac{3}{4}$ " crushed stone in bathroom chase trench under perforated 4" dia sub-slab radon piping.

B. Install sub-slab piping perpendicular to chase as shown on Drawing H1.13. Hand-dig as required to insert piping under adjacent intact slab.

C. Place $\frac{3}{4}$ " crushed stone on top of sub-slab piping.

D. Run 4" PVC piping up wall of chase to roof deck. Secure piping to wall of chase with stainless steel clamps at 6' intervals.

E. Wrap base of pipe with sill seal foam gasket to protect it from the pouring of concrete for the base of the chase.

F. Glue PVC pipe and fittings together with PVC cement and primer.

G. After concrete is poured to patch trenching in chase, and before chase walls are completed, trim the foam gasket at the radon vent pipe penetrations in the floor and seal with polyurethane sealant.

3.4 ROOF PENETRATION

A. Install vent pipe through roof and flash vent pipe as per Drawing A3.03 Detail 14 and Drawing A3.04 Detail 23.

B. Coordinate vent pipe blocking and flashing with the roofing trade.

C. Install rain guard PVC diverter cap on top of rooftop radon vent.

D. Label rooftop radon vent as a radon system.

END OF SECTION 31 21 13

SECTION 31 23 10 - STRUCTURAL EXCAVATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SCOPE OF WORK

- A. The work under this Section includes all labor, supervision, materials and equipment necessary for the completion of all building structure excavation within the building and excavation five (5') feet outside the building for structures and utility lines, as shown on the Drawings and as specified.
- B. Work shall include, but not be limited to, the following:
 - 1. Building excavation, including pits and trenches for utilities within the building
 - 2. Protection of utilities
 - 3. Stockpiling of reusable materials
 - 4. Removal of unsuitable materials
 - 5. Rock excavation

1.3 RELATED WORK

- A. Section 31 50 04 - Earthwork Protection
- B. Section 31 23 20 - Structural Fill

PART 2 - PRODUCTS - Not applicable

PART 3 - EXECUTION

3.1 EXCAVATION

- A. Excavate all areas as required to perform work shown on Drawings and to conform to new finish grades. Excavations shall be to proper depth and width to allow for slabs, gravel bases and other subsequent construction.
- B. Excavate to depth and lineal dimensions required to permit subsequent formwork and concrete operations to proceed without hindrance. Excavation for footings, walls, piers, grade beams, etc., must be sufficiently wide to compact all fill by mechanical means. In general, excavation shall be cut to a line eighteen (18") inches outside of the face of footings, with no undercutting permitted.

- C. Surfaces of excavations shall be suitably dressed to grade noted to receive subsequent construction. Bottoms shall be substantially level, with no large projections, and free of loose material. Material at bottoms of excavation shall be undisturbed. The Engineer shall be immediately notified if material unsatisfactory for foundation bearing is encountered, for further instructions, before proceeding with work.
- D. Trenches and excavations shall be of sufficient width and depth at all points to allow all pipes to be laid, joints to be formed, and structures and appurtenant construction to be built in most thorough and workmanlike manner, and to allow for sheeting and shoring, pumping and draining. Trenches and excavations shall be at least eighteen (18") inches wider than outside dimension of structures they are to contain. Trenches for pipes must not be unnecessarily wide so as to materially increase load on pipe resulting from backfill. Bottoms of trenches and other excavations shall be carried to lines and shapes satisfactory to Engineer.
- E. Completely remove all abandoned subsurface utilities, structures and existing foundations within the lines of the new building construction. Plug abandoned utility lines at least five (5') feet outside of new construction.
- F. If footing bottoms are disturbed, allowed to freeze, or if excavations for footings are carried below indicated elevations shown on the Protect structures, utilities, sidewalks, pavements, and other facilities immediately adjacent to structure excavation from damage caused by settlement, lateral movement, undermining, washout and other hazards.

3.2 PROTECTION OF UTILITIES

- A. Protect existing utilities and relocate only as shown on Plans or in Specifications.
- B. Notify utility companies to shut off services when required.
- C. Any damage to existing drainage and utility structures to be retained shall be repaired at the Contractor's expense.
- D. Maintain drainage of site and adjacent areas to prevent damage and erosion. When necessary to interrupt drainage of existing facilities, provide temporary facilities until permanent installations have been completed.

3.3 REMOVAL OF UNSUITABLE MATERIALS

- A. Remove all debris subject to termite attack, rot or corrosion and all other deleterious materials from areas to be filled.
- B. Remove from the interior of the building all unsuitable materials such as topsoil, loam or other organic materials.
- C. Remove from site, all excavated materials not required for fill.

3.4 STOCKPILES

- A. Approved excavated material suitable for fill or structural fill (i.e., clean granular material) shall be stockpiled.

3.5 ROCK EXCAVATION

- A. Definition: Rock is defined as ledge, stone or hard shale, concrete, or masonry structures which require drilling or blasting for removal, and boulders larger than one (1 cy) cubic yard in volume within the building excavation and one-half (1/2 cy) cubic yard in volume encountered in trench excavations.
- B. Measurement: Rock shall be stripped for measurement before proceeding, and no rock excavated or loosened before measurement will be allowed or paid for as rock. Measurement and payment therefore shall be by the number of cubic yards required to bring the excavation to the required surface or grade shown on the Drawings. In making rock excavation, eighteen (18") inches will be allowed outside the footing lines, in vertical planes; twenty-four (24") inches will be allowed outside walls without footings and outside footings where drains are required. Submit cross-sections and certification of quantities by a Connecticut Registered Land Surveyor or Professional Engineer.
- C. Blasting: Blasting will be allowed under this Contract.
 - 1. Contractor shall retain a geotechnical engineer (or blasting seismologist) licensed in the State of Connecticut to monitor all blasting procedures.
 - 2. Controlled Blasting: When explosives are used, work shall be executed by experienced powdermen or persons who are licensed or otherwise authorized to use explosives. Explosives shall be stored, handled and used in accordance with local regulations and the "Manual of Accident Prevention in Construction" of the Associated General Contractors of America, Incorporated. Structural Engineer shall be notified of scheduled blasting. Any damage to existing or new construction caused by the use of explosives shall be corrected at the Contractor's expense.
- D. Blasting Limit Criteria
 - 1. The Contractor shall conduct all blasting activity in such a manner that the peak particle velocity does not exceed 1.9 (one and nine-tenths) inches per second at the ground line adjacent to any existing structure in the vicinity of the blasting operations.
 - 2. No blasting shall occur near recently placed concrete with an age of 3 days or less.
 - 3. The Contractor shall conduct all blasting activity in such a manner that the peak particle velocity does not exceed 4.5 inches per second adjacent to recently placed concrete.
 - 4. The Contractor shall conduct all blasting activity in such a manner that the peak airblast overpressure measured at the location of the nearest structure (considering wind direction) does not exceed 0.018 psi.
- E. Blast Monitoring
 - 1. The Contractor shall monitor ground vibrations and airblast overpressures resulting from the blasting operations.

- F. The Contractor shall be completely responsible for all damages resulting from the blasting operations and shall take whatever measures are necessary to maintain peak airblast overpressure and vibrations within the specified limits, and to minimize damage to rock left in place. Modifications to blasting and excavation methods required to meet these requirements shall be undertaken at no additional cost to the Owner.
- G. Shelving: If rock surfaces supporting footings should be encountered, such surfaces shall be leveled off to a slope not exceeding one (1) inch per foot unless otherwise indicated on the plans.

END OF SECTION 31 23 10

SECTION 31 23 19 – DEWATERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. This Section includes construction dewatering.
- B. Related Sections include the following:
 - 1. Division 01 Section "Temporary Facilities and Controls".
 - 2. Division 31 Section "Earth Moving"
 - 3. Division 31 Section "Erosion and Sedimentation Control"

1.3 PERFORMANCE REQUIREMENTS

- A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control ground-water flow into excavations and permit construction to proceed on dry, stable subgrades.
 - 1. Work includes removing dewatering system when no longer needed.
 - 2. Maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
 - 3. Prevent surface water from entering excavations by grading, dikes, or other means.
 - 4. Accomplish dewatering without damaging existing buildings adjacent to excavation.

1.4 SUBMITTALS

- A. Shop Drawings: For dewatering system. Show arrangement, locations, and details of wells and well points; locations of headers and discharge lines; and means of discharge and disposal of water.
 - 1. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
 - 2. Include a written report outlining control procedures to be adopted if dewatering problems arise.
 - 3. Include Shop Drawings signed and sealed by the qualified professional engineer responsible for their preparation.

- B. Qualification Data: For firms and persons specified in “Quality Assurance” Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
- C. Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by dewatering operations.
- D. Record drawings at Project closeout identifying and locating capped utilities and other subsurface structural, electrical, or mechanical conditions performed during dewatering.
- E. Field Test Reports: Before starting excavation, submit test results and computations demonstrating that dewatering system is capable of meeting performance requirements.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer to assume engineering responsibility and perform dewatering who has specialized in installing dewatering systems similar to those required for this Project and with a record of successful in-service performance.
- B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the jurisdiction where the Project is located and who is experienced in providing engineering services for designing dewatering systems that are similar to those indicated for this Project in material, design, and extent.
 - 1. Engineering Responsibility: Engage a qualified professional engineer to prepare or supervise the preparation of data for the dewatering system including drawings, testing program, test result interpretation, and comprehensive engineering analysis that shows the system’s compliance with specified requirements.
- C. Regulatory Requirements: Comply with water disposal requirements of authorities having jurisdiction.

1.6 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Architect and then only after arranging to provide temporary utility services according to requirements indicated.
- B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner will not be responsible for interpretations or conclusions drawn from this data.
 - 1. Make additional test borings and conduct other exploratory operations necessary for dewatering.

- C. Survey adjacent structures and improvements, employing a qualified professional engineer or land surveyor, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
 - 1. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Architect if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
 - 1. Prevent surface water and subsurface or groundwater from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
 - 2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

3.2 DEWATERING

- A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls. Maintain site drainage at all times.
- B. Before excavation below ground-water level, place system into operation to lower water to specified levels and then operate it continuously until drains, sewers, and structures have been constructed and fill materials have been placed, or until dewatering is no longer required.
- C. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
- D. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
 1. Maintain piezometric water level a minimum of 24 inches below surface of excavation.
- E. Dispose of water, removed from excavations, in a manner to avoid endangering public health, property, and other portions of work under construction or completed. Dispose of water in a manner to avoid inconvenience to others. Provide sumps, sedimentation tanks, temporary siltation basins or any other measures requested by authorities having jurisdiction. Prevent erosion or siltation of adjacent areas.
- F. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on a continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense.
 1. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.
- G. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.

3.3 OBSERVATION WELLS

- A. Provide, take measurements, and maintain at least the minimum number of observation wells or piezometers as required to maintain dry excavations and as may be required by authorities having jurisdiction.
- B. Observe and record daily elevation of ground water and piezometric water levels in observation wells.
- C. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. Suspend construction activities in areas where observation wells are not functioning properly until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.
 1. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.

END OF SECTION 31 23 19

SECTION 31 23 20 - STRUCTURAL FILL AND FOUNDATION DRAINAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SCOPE OF WORK

- A. The work under this Section consists of furnishing all labor, materials and equipment required to complete the structural steel as shown on the Drawings and/or as herein specified.
- B. Work shall include, but not be limited to, the following:
 - 1. Structural Fill
 - 2. Compaction
 - 3. Testing
 - 4. Footing Drains
 - 5. Drainage Filter

1.3 RELATED WORK

- A. Section 31 23 10 - Structural Excavation
- B. Section 31 50 00 - Earthwork Protection

1.4 SUBMITTALS

- A. The Contractor shall submit for approval to the Engineer prior to commencing operations a sieve analysis, a modified proctor density test of proposed structural fill material, and drainage filter material. The tests shall be prepared by an approved testing laboratory at the Contractor's expense.
- B. A sample of each approved material shall be kept at the Construction Site Field Office for comparison purposes during this phase of work.
- C. Any material, which does not reasonably conform to the approved sieve analysis, shall be subject to removal.

1.5 FIELD INSPECTION AND TESTING

- A. The Owner shall retain and pay for an independent soils laboratory to perform inspection and/or testing of structural backfill. The laboratory will have an inspector on the site during backfilling operations and will make tests required for fill and backfill placed.

- B. The following field tests shall be performed:
1. One modified Proctor Density Test for each source of fill material performed in accordance with ASTM D1557.
 2. Standard field density tests, each of an accuracy of plus or minus one (1%) percent.
- C. Field density tests shall be at the rate of one (1) per two hundred (200 cy) cubic yards of fill, or at the discretion of the inspector. The tests shall be made at a maximum height differential of sixteen (16") inches throughout the fill.
- D. It shall be the Contractor's responsibility to notify the Engineer and Testing Laboratory when each layer of fill is to be in place and ready for testing. The Contractor shall allow ample time for testing. If any fill is placed in excess of sixteen (16") inches without testing, it shall be subject to removal.
- E. All required compaction and retesting due to unsatisfactory compaction shall be at the Contractor's expense.

1.6 COORDINATION AND MEASUREMENTS

- A. Prior to submitting Shop Drawings, the Contractor shall field verify all dimensions and elevations to assure proper fabrication and erection.
- B. The work of this Section shall be closely coordinated with work of other trades by the General Contractor.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Structural fill shall be clean gravel, free from foreign substances, lumps of clay, silt, loam or vegetable matter. The gravel shall be sound, tough, durable and free from thin elongated pieces. The material shall meet the following gradation requirements:

1. Sieve Size	3"	1 1/2"	1/4"	No. 10	No. 40	No. 100	No. 200
2. Percent Passing	100	55-100	25-60	15-45	5-25	0-10	0-5

- B. Three-quarter (3/4") inch crushed stone fill shall be clean uniform material free from foreign substances, lumps of clay, silt, loam or vegetable matter. The gravel shall be sound, tough, durable and free from thin elongated pieces. The material shall meet the following gradation requirements:

1. Sieve Size	1"	3/4"	3/8"
2. Percent Passing	100	90-100	0-10

- C. Three-eighths (3/8") inch stone subbase shall be clean uniform material free from foreign substances, lumps of clay, silt, loam or vegetable matter. The gravel shall be sound, tough, durable and free from thin elongated pieces. The material shall meet the following gradation requirements:
- | | | | |
|--------------------|------|--------|-------|
| 1. Sieve Size | 1/2" | 3/8" | No. 4 |
| 2. Percent Passing | 100 | 85-100 | 0-10 |
- D. Filter Fabric: Manufacturer's standard non-woven geotextile fabric of polypropylene or polyester fibers or a combination thereof.
- E. Drain filter material shall be clean, sound aggregate meeting the following gradation requirements:
- | | | | |
|--------------------|------|------|--------|
| 1. Sieve Size | 3/4" | 3/8" | No. 40 |
| 2. Percent Passing | 100 | 85 | 0 |
- F. Polyvinyl Chloride Pipe: ASTM D2729. Furnish drainage pipe complete with bends, reducers, adapters, couplings, collars and joint materials.
- G. Perforated Polyvinyl Chloride Pipe: ASTM D2729. Furnish drainage pipe complete with bends, reducers, adapters, couplings, collars and joint materials.
- H. Filter Fabric: Nonwoven needle punched, 8 ounce/SY, geotextile fabric. Minimum tensile strength of 205 pounds (ASTM D-4632). Apparent opening size of 80 US sieve.

2.2 LOCATION OF MATERIALS

- A. Structural fill shall be used for all backfill under all slabs on grade, under all footings required to achieve footing base elevations for all backfill against exterior basement and retaining walls, to extend a distance of five (5') feet beyond the face, including that backfill required for structural or utility excavation and trenches within the limits of the outermost foundation walls of the building.
- B. See Drawings for location and placement of footing drain materials.

PART 3 - EXECUTION

3.1 CONSTRUCTION METHODS

- A. Structural fill shall be deposited in eight (8") inch layers and compacted to the following percent optimum density ASTM D1557:
1. Ninety-five (95%) percent under footings and under all slabs on grade, trenches, sidewalks, driveways and paved areas, against interior face of foundation walls and retaining walls.
 2. Ninety (90%) percent against exterior face of foundation walls and retaining walls.
- B. No material shall be compacted when its moisture content is greater than optimum.

- C. The excavation must be sufficiently dry to permit complete inspection of the excavation and to permit use of compaction machinery for placement of fill and compaction as specified.
- D. It shall be the responsibility of the General Contractor to notify the laboratory when excavation is complete so that inspection of conditions before filling may be made.
- E. Compacting equipment shall not be of a nature so as to cause unstable conditions in the underlying natural soil.
- F. No backfilling will be permitted against foundation walls until floor slabs at both top and bottom of walls have been placed and cured, or unless walls have been adequately braced. Where backfill occurs on both sides of a wall, levels of backfill on each side shall be kept approximately equal at all times.
- G. Do not place structural fill or backfill on frozen material. Do not place frozen fill material.
- H. If grade freezes or excavation bottom freezes, remove frozen material to extent of freezing prior to placing new structural fill or backfill material.

3.2 FOUNDATION DRAIN INSTALLATION

- A. Lay drain pipe with tight joints to grade shown at a uniform rate.
- B. Drain pipe shall be bedded in six (6") inches minimum of specified filter material with full bearing of each pipe section. Place filter fabric beneath bedding material.
- C. Drains on the fill side of foundation walls and/or retaining wall shall have six (6") inches minimum of filter material on each side and above the pipe. Filter fabric shall wrap the outside perimeter of the filter material to provide an encapsulated assembly.
- D. Underfloor drainage piping shall also be bedded in six (6") inches of filter material. The width of piping trenches shall be wide enough to permit six (6") inches of filter material on each side and four (4") inches above the pipe. See Plans for location.
- E. Drainage piping shall be installed only after all formwork has been removed.
- F. Once draining piping installation has begun, install required filter material in a timely manner to prevent clogging of piping.
- G. Water test foundation drain piping system to assure free flow. Remove any obstructions, replace any damaged components as required, and retest prior to installing any additional compacted structural backfill.

END OF SECTION 31 23 20

SECTION 31 23 33 — TRENCHING AND BACKFILLING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.02 DESCRIPTION

- A. Work Included: Excavate trenches for utilities; compacted bedding under and compacted fill over utilities to subgrade elevations; backfilling and compaction. Work under this item also include the complete replacement of all items disturbed by trenching activities, including sidewalks, curbs, signs, pavement, etc.
- B. Related Sections:
 - 1. Section 31 20 00 – Earth Moving;
 - 2. Section 31 25 00 – Erosion and Sedimentation Controls;
 - 3. Section 33 40 00 – Storm Drainage Utilities;
 - 4. Section 33 30 00 – Sanitary Sewerage Utilities;
 - 5. Section 33 10 00 – Water Utilities.

1.03 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.
- B. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction, Form 818 (2020), as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

1.04 REGULATORY REQUIREMENTS

- A. Notify utility companies in accordance with Public Act 77-350 'CALL BEFORE YOU DIG', (1-800-922-4455).
- B. Comply with United States Department of Labor, Occupational Safety and Health Administration.

- C. Construction Standards for Excavations, 29 CFR part 1926, subpart P.
- D. Obtain required permits from authorities.
- E. Do not close or obstruct roadways, sidewalks, or hydrants without permits.
- F. Comply with all applicable requirements of State and local authorities for trenching, backfilling and maintenance and protection of traffic within city streets.

1.05 SUBMITTALS

- A. Samples of filter cloth and warning tape shall be submitted for approval. Other samples and certificates of compliance may be requested.
- B. Where sheeting and shoring is used, complete sheeting and shoring sketches and calculations shall be prepared by a Connecticut registered Professional Engineer and shall meet OSHA regulations.

PART 2 – PRODUCTS

2.01 CRUSHED STONE

- A. Crushed stone of the size specified shall conform to the requirements of Section M.01.01 of the DOT specifications.

2.02 SAND

- A. Conform to Section M.03.01-2 of the DOT Specifications.

2.03 GRANULAR FILL

- A. Conform to Section M.02.01 of the DOT Specifications.

2.04 BACKFILL MATERIAL

- A. Wherever reference is made on the Drawings or in the Specifications to suitable material, suitable backfill material, and suitable fill material, the material shall be mineral soil substantially free from organic materials, topsoil, wood, trash, and other objectionable materials which may be compressible or which cannot be properly compacted. It shall not contain rocks or lumps larger than six (6) inches in largest dimension, and not more than 15 percent of the rocks or lumps shall be larger than 2 1/2 inches in largest dimension. Further, it shall not contain granite blocks, broken concrete, masonry rubble, or other similar materials. It shall have physical properties such that it can be readily spread and compacted during filling. Snow, ice, and frozen soil will not be permitted.

2.05 GEOTEXTILE FILTER CLOTH

- A. Geotextile filter cloth shall conform to the requirements of Section M.08.01-26 of the D.O.T. Specifications. Geotextile shall be approved for subsurface drainage use, Class A.

2.06 WARNING TAPE

- A. Warning tape shall be 3-inch wide, detectable, color to suit utility being identified.

2.07 SHEETING AND SHORING

- A. Lumber used for sheeting, rangers, bracing, and other construction purposed shall be sound, straight grained, free from shakes, loose knots and other defects liable to impair its strength or durability. Lumber and sheeting may be reused if not ordered left in place and if in good condition. Lumber shall be spruce and/or fir.

PART 3 – EXECUTION

3.01 GENERAL

- A. Verify that backfill materials to be used are acceptable.

3.02 PREPARATION

- A. Identify required lines, grades, levels, contours, and datum.
- B. Maintain and protect existing above and below grade utilities to remain. The contractor shall contact “Call Before You Dig” utility locating service at 1-800-922-4455 at least 48 hours prior to the start of any site construction to have existing underground utilities located.
- C. Protect trees, plant life, lawns, rock outcropping, and other features remaining as a portion of final landscaping.
- D. Protect benchmarks, existing structures, fences, sidewalks, paving, and curbs from excavation equipment and vehicular traffic.
- E. Cut out soft areas of subgrade not capable of insitu compaction. Backfill with granular fill and compact to density equal to or greater than requirements for subsequent backfill material.

3.03 EXCAVATION

- A. Excavate subsoil required for utility installation.
- B. Excavate rock and unsuitable material as specified in Section 31 20 00 – Earth Moving.

- C. Make all trenches open vertical construction with sufficient width to provide free working space at both sides of the trench and around the installed item as required for caulking, jointing, backfilling, and compacting.
 - 1. Depth: Excavate to the elevations shown on the Drawings.
 - 2. Excavation shall not interfere with normal 45 degree bearing splay of foundations.
 - 3. Hand trim excavation. Hand trim for bell and spigot pipe joints. Remove loose matter.
 - 4. Remove lumped subsoil and boulders.
- D. Correct unauthorized excavation.
- E. Correct areas over-excavated by error. Where trench excavation is inadvertently carried below proper elevations, fill with granular fill and compact to provide a firm and unyielding subgrade or foundation at no additional cost to the Owner.
- F. Stockpile excavated material in area designated on site and remove excess material not being used, from site.
- G. Keep excavations dry; Construction work to be installed "in the dry". Do not use pipe being constructed for trench drainage.
- H. Grade top perimeter of excavation to prevent surface water from draining into trench. Do not obstruct surface drainage, but provide means whereby storm water is diverted into existing gutters, other surface drains, or temporary drains.

3.04 SHEETING AND SHORING

- A. Trench Bracing:
 - 1. Properly support all trenches in strict accordance with all pertinent rules and regulations.
 - 2. Brace, sheet, and support trench walls in such a manner that they will be safe and that the ground alongside the excavation will not slide or settle, and that all existing improvements of every kind, whether on public or private property, will be fully protected from damage.
 - 3. In the event of damage to such improvements, immediately make all repairs and replacements necessary at no additional cost to the Owner.
- B. The Contractor shall leave in place all sheeting and bracing which the Engineer may direct him in writing to leave in place at any time during the progress of the work for the purpose of preventing injury to structures, utilities, or property, whether public or private. All sheeting to be left in place shall be cut off at least 3' below paved surfaces and 2' below non-paved surfaces.

- C. All sheeting and bracing not left in place shall be carefully removed in such manner as not to endanger the construction of other structures, utilities, or property. All voids left or caused by withdrawal of sheeting shall be immediately refilled with sand by ramming with tools especially adapted to that purpose.
- D. Sheeting and bracing ordered to be left in place shall not be construed as creating any obligation on his part to issue such order, and his failure to exercise his right to do so shall not relieve the Contractor from liability for damages to persons or property occurring from or upon the work occasioned by negligence or otherwise growing out of a failure on the part of the Contractor to install or leave in place sufficient sheeting and bracing to prevent any caving or moving of the ground.

3.05 PIPE AND STRUCTURE BEDDING

- A. Grade trench bottoms for pipes, manholes, catch basins, utility services, and other items to provide a smooth, firm, and stable foundation free from rock points.
- B. Support pipe conduit during placement and compaction of bedding fill. Provide continuous bedding layer. Use of blocking not acceptable.
- C. Pipes and structures shall be bedded and backfilled as detailed in the drawings.

3.06 PIPE BACKFILLING

- A. Backfill trenches to contours and elevations with unfrozen materials.
- B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen or spongy subgrade surfaces.
- C. Backfill in accordance with trench details.
- D. Place and compact backfill materials in continuous layers not exceeding 8 inches compacted depth, compacted as shown on the drawings.
- E. Employ placement and compaction methods that do not disturb or damage pipes, conduits or structures.
- F. Maintain optimum moisture content of backfill materials to attain required compaction density.
- G. Remove surplus backfill materials from site.
- H. Leave fill material stockpile areas completely free of excess fill materials.

3.07 TOLERANCES

- A. Top Surface of Backfilling: Plus or minus one inch from required elevations.

END OF SECTION 31 23 33

SECTION 31 25 00 — EROSION AND SEDIMENTATION CONTROLS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.02 DESCRIPTION

- A. Work Included: Controlling sedimentation and erosion as shown on the Drawings and as specified.
- B. Related Sections:
 - 1. Section 31 20 00 – Earth Moving;
 - 2. Section 31 23 33 – Trenching and Backfilling.

1.03 REFERENCES

- A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges, and Incidental Construction Form 818 (2016) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

PART 2 – PRODUCTS

2.01 STRAW BALES AND STAKES

- A. Straw Bales: Forty pounds minimum weight and 120 pounds maximum weight.
- B. Wood Stakes:
 - 1. Two (2) per bale for securing bales.
 - 2. Sizes: As shown on the Drawings.

2.02 MATERIALS FOR SILT FENCE

- A. Filter Fabric; Filter Cloth:

1. Subarticle M.08.01-26, DOT Specifications.
 2. Obtain manufacturer's certification that filter fabric conforms to the requirements of these Specifications.
 3. Obtain the filter fabric from a manufacturer who produces the material for use in silt fences and who has a design for that use.
 4. Do not use fabric susceptible to deterioration in sunlight.
 5. Submit 2-foot square sample and technical data sheet for acceptance by the Owner.
 6. Submit manufacturer's installation instructions for acceptance by the Owner.
- B. Posts or Other Suitable Mounting:
1. Lengths of wood posts: As shown on the Drawings. Cross-section dimensions: As recommended by filter fabric manufacturer.
 2. Other Suitable Mounting: As recommended by the manufacturer.
- C. Provide materials as required by the manufacturer for attaching fabric to posts.

2.03 MATERIALS FOR ANTI-TRACKING PAD

- A. Crushed Stone: Sound, tough and durable; free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. Grading: Article M.01.01, DOT Specifications No. 4.
- B. Filter Cloth: Subarticle M.08.01-26, DOT Specifications.

2.04 EROSION-CONTROL BLANKETS

- A. Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.

PART 3 – EXECUTION

3.01 PLACING STRAW BALES

- A. Place straw bales at slopes, at catch basins and at other locations as shown on the Drawings.
- B. Embed straw bales to a depth of 6 inches.
- C. Drive stakes through hay bales into ground to secure hay bales.

- D. Place and stake straw bales at all locations as necessary to intercept and to filter overland stormwater flows before these flows enter streams or ponds.
- E. Whenever pumping water from excavations, discharge the water such that it passes through straw bales before entering a storm drain or water body.
- F. Remove accumulated sediment and replace bales when system becomes clogged or when directed by the Owner.
- G. Remove straw bales at completion of project unless the Owner directs otherwise.

3.02 CONSTRUCTION AND MAINTENANCE OF SILT FENCES

- A. Construct silt fences as shown on the Drawings.
- B. Construct silt fences in accordance with manufacturer's instructions as accepted by the Owner.
- C. Maintain or replace silt fences until they are no longer necessary or as ordered by the Owner.
- D. Remove silt fences at completion of project unless the Owner directs otherwise.

3.03 CONSTRUCTION AND MAINTENANCE OF ANTI-TRACKING PAD

- A. Construct anti-tracking pad at location shown on the Drawings.
- B. Excavate to length, width and depth dimensions as shown on the Drawings.
- C. Place filter cloth on excavated subgrade.
- D. Place crushed stone on filter cloth to depth as shown on the Drawings.
- E. Maintain the entrance in a condition that will prevent tracking or flowing of sediment onto the public right-of-way. When necessary, increase thickness by adding additional crushed stone; or increase length by excavating to subgrade and placing additional filter cloth and crushed stone; or do both in order to prevent tracking or flowing of sediment. Immediately remove all sediment spilled, dropped, washed or tracked onto the public right-of-way.
- F. Remove anti-tracking pad at completion of project unless the Architect directs otherwise or at a time when permanent access can be constructed.

3.04 CONSTRUCTION OF EROSION CONTROL BLANKETS

- A. Protect seeded areas with slopes exceeding 1V:3H or as indicated on the plans with erosion-control blankets installed and stapled according to manufacturer's written instructions.

3.05 COMPLIANCE WITH GUIDELINES AND PERMITS

- A. The Contractor shall review the CTDEEP guidelines (Connecticut Guidelines for Soil Erosion and Sediment Control), and the requirements of the General Permit for the Discharge of Stormwater and Dewatering Wastewaters Associated with Construction Activities prior to any site disturbance.
- B. Inspection shall be performed in accordance with the General Permit as directly cited below:
 - 1. “Qualified personnel (provided by the permittee) shall inspect disturbed areas of the construction activity that have not been finally stabilized, structural control measures, and locations where vehicles enter or exit the site at least once every seven calendar days and within 24 hours of the end of a storm that is 0.1 inches or greater. Where sites have been temporarily or finally stabilized, such inspection shall be conducted at least once every month for three months.”
 - 2. “Disturbed areas used for storage of materials that are exposed to precipitation shall be inspected for evidence of, or the potential for, pollutants entering the drainage system. Erosion and sediment control measures shall be observed to ensure that they are operating correctly. Where discharge locations or points are assessable, they shall be inspected to ascertain whether erosion control measures are effective in preventing significant impacts to receiving waters. Locations where vehicles enter or exit the site shall be inspected for evidence of off-site sediment tracking.”
 - 3. “Based on the results of the inspection, the description of the potential sources and pollution prevention measures identified in the Plan shall be revised as appropriate as soon as practicable after such inspection. Such modification shall provide for timely implementation of any changes to the site within 24 hours and implementation of any changes to the Plan within three calendar days following the inspection. The plan shall be revised and the site controls updated in accordance with the General Permit.”
- C. Stormwater runoff shall be directed away from disturbed areas whenever possible by the use of temporary berms, swales hay bales or silt fence.
- D. In areas where more than 2 acres will be disturbed, sediment traps or other controls will be constructed in accordance with the guidelines.
- E. For discharge points that serve an area with more than 5 disturbed acres at one time, a sediment basin, designed in accordance with the guidelines, shall be installed and shall provide a minimum of 134 cubic yards of water storage per acre drained. The sediment basin shall be maintained until final stabilization of the contributing area. This requirement shall not apply to flows from off-site areas and flows from the site that are either undisturbed or have undergone final stabilization where such flows are diverted around the sediment basin. Outlet structures from sedimentation basins shall not encroach upon a wetland.
- F. The Owner or its representative may require additional controls, as they are deemed necessary due to construction phasing, weather conditions, or other unforeseen conditions that cause excessive soil erosion or sedimentation.

END OF SECTION 31 25 00

SECTION 31 25 01 – ENVIRONMENTAL CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. Environmental controls shall include all labor, materials, equipment and performance of all operations in connection with environmental protection.

1.3 DEFINITIONS

- A. Resource Areas: Those areas, conditions or features which, when disturbed by construction activities, create an adverse environmental impact. Such areas include, but are not necessarily limited to densely wooded areas, wetland areas, streams, brooks, rivers, and other water crossings and steep slopes.
- B. Form 816 refers to State of Connecticut, Department of Transportation, “Standard Specifications for Roads, Bridges and Incidental Construction, Form 816”, 2004 addition, with 2005 Supplement.

1.4 SUBMITTALS

- A. Submit under provisions of Division 01.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 SEDIMENTATION AND EROSION CONTROL

- A. The Contractor shall follow the requirements of Section, “Sedimentation and Erosion Control” and the “Connecticut Guidelines for Soil Erosion and Sedimentation Control”, as amended.

3.2 PROTECTION OF AIR AND WATER RESOURCES

- A. During the progress of the work, the Contractor shall conduct his operations and maintain the area of his activities, including sweeping and sprinkling of water as necessary, so as to minimize the creation and dispersion of dust. If the Engineer decides that it is necessary to use

calcium chloride for more effective dust control, then the Contractor shall furnish and apply the material as directed.

- B. Fuels, lubricants or other hazardous materials shall not be stored in any resource areas.
- C. Fuel, lubricants and other hazardous material shall be stockpiled within an area of positive containment. The area shall have no open communication with surface water bodies or other resource areas, shall have a base of relatively impermeable material and shall have an adequate supply of materials required for spill clean up.

In the event that any such waste is spilled onto the ground, the Contractor shall immediately notify the Engineer, promptly clean up the spillage and all contaminated soil, and dispose of the cleanings as hazardous waste material. If a spill occurs, the clean-up activities shall take precedence over normal construction activities in order that damage to the environment is minimized.

- D. All hazardous materials containers shall be properly marked, and their contents identified. All fuel oil, lubricant, gasoline, and hydraulic fluid containers shall be fixed in place on the transport vehicle when the vehicle is in motion.
- E. The construction project shall be in compliance with all Federal, State, and local laws with respect to hazardous materials.
- F. All clean up and disposal operations shall comply with all applicable Federal, State, and local statutes, regulations and ordinances and anti-pollution laws.

3.3 NOISE ABATEMENT

- A. Construction equipment including generator and compressors shall be enclosed or equipped with mufflers, silencers or miscellaneous to minimize noise.
- B. The Contractor shall limit construction noise in accordance with EPA latest standard criteria.
- C. The Contractor shall comply with all applicable Federal, State and Local regulations.

3.4 UTILITIES

- A. The Contractor shall comply with all requirements of all applicable Federal, State, and local regulations and all permits issued for the Contract.

END OF SECTION 31 25 01

SECTION 31 50 00 - EARTHWORK PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SCOPE OF WORK

- A. The work under this Section includes all labor, supervision, materials and equipment necessary for the completion of earthwork protection as specified.
- B. Work shall include, but not be limited to, the following:
 - 1. Protection of work and property
 - 2. Stability of sides
 - 3. Shoring and bracing
 - 4. Drainage and pumping

1.3 RELATED WORK

- A. Section 31 23 00 - Structural Excavation
- B. Section 31 23 20 - Structural Fill

PART 2 - PRODUCTS - Not applicable

PART 3 - EXECUTION

3.1 PROTECTION OF WORK AND PROPERTY

- A. Protect structures, utilities, sidewalks, pavements, and other facilities immediately adjacent to structure excavation from damage caused by settlement, lateral movement, undermining, washout and other hazards.
- B. Take precautions and provide necessary bracing and shoring to guard against movement or settlement of existing improvements or new construction. The Contractor is solely responsible for the strength and adequacy of bracing and shoring; and for the safety and support of construction from damage or injury caused by the lack thereof, of movement and/or settlement.
- C. Protect excavation, trenches, and all items of subsurface construction from damage by rain, water from melted snow, surface water and subsurface water. Provide all pumps, equipment, and enclosures necessary to ensure such protection.
- D. Protect exposed earth and foundations in excavation areas when the atmospheric temperature is less than 35 degrees F by covering with dry insulating materials of sufficient depth to prevent frost penetration of soil.

3.2 STABILITY OF SLOPES

- A. Slope the sides of excavations over five (5') feet to the angle of repose of the material excavated; otherwise, shore and brace where sloping is not possible either because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in a safe condition until completion of backfilling by benching, shelving, or bracing.
- B. Take precautions to prevent slides or cave-ins when excavations are made in locations adjacent to backfilled excavations, and when sides of excavations are subjected to vibrations from vehicular traffic or the operation of machinery or any other source.

3.3 SHORING, SHEETING AND BRACING

- A. Contractor shall furnish, install in place, and maintain such sheeting, shoring, and bracing as may be required to support sides of excavations and to prevent any movement which could in anyway injure work, diminish necessary width of trench or other excavations, or otherwise delay work or endanger adjacent structures. Sheeting shall be driven and excavation work conducted in such a manner as to prevent material in back of sheeting from running under sheeting and into trench.
- B. Provide steel or timber materials for sheeting, shoring, and bracing, such as sheet piling, uprights, stringers, rangers and cross-braces, in good serviceable condition. Use timbers that are sound and free of large or loose knots. Maintain shoring and bracing in excavations, regardless of the time period excavations will be open. Carry down shoring and bracing as the excavation progresses.
- C. Provide trench shoring and bracing to comply with the provisions of ANSI A10.2 "Safety Code for Building Construction", and with requirements of the local codes and authorities having jurisdiction.
- D. The Contractor shall, prior to driving sheeting, determine the presence and extent of underground structures as may affect the driving of sheeting.
- E. Care shall be taken to prevent voids outside of sheeting; but if voids are formed, they shall be immediately filled and well rammed. Sheeting shall not be carried to such depth at manholes that it will bear upon pipe. Special precautions, by using sheeting, shoring, and bracing shall be taken to guard against any damage to or settlement of buildings, walls or other structures which are adjacent to work.
- F. Sheeting shall not unnecessarily be driven below structures and thereby necessitate its being left permanently in place.
- G. Bracing, rangers and sheeting shall be securely fastened in place so that they cannot loosen up and fall from position. Sheeting, shoring, bracing, etc., or parts thereof, shall be removed after completion of work.

3.4 DRAINAGE AND PUMPING

- A. Perform excavation in a manner to prevent surface water from flowing into the excavations, and to prevent water from flooding the project site and surrounding area. Do not allow water to accumulate in excavations. Remove water from excavations using dewatering methods which will prevent softening of foundation bottoms, undercutting of footings, and soil changes detrimental to the stability of subgrades and foundations.
- B. Provide and maintain pumps, sumps, suction and discharge lines and other dewatering system components necessary to convey the water away from excavations. Convey water removed from excavations and rain water to runoff areas. Provide and maintain temporary drainage ditches and other diversions outside the excavation limits for each structure. Do not use trench excavations for site utilities as temporary drainage ditches.

END OF SECTION 31 50 00

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SECTION 32 00 00 – EXTERIOR IMPROVEMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. This Section includes the following:
1. Project Signage and Posts
 2. Standard Metal Bollards and Sleeves
 3. Granite Bollards
 4. Flagpole
 5. Installation of Light Pole Bases
 6. Bicycle Rack
 7. Concrete Footing and Post Sleeves for Hoop Game, Tables and Benches
 8. Dining Tables and Chairs w/ Sunshade **(For Reference Only, N.I.C)**
 9. Metal Landscape Edging
 10. Stone Mulch Surfacing
 11. Bonded Rubber Mulch Surfacing
 12. Installation of Salvaged Items
 13. Stone Veneer Seat Wall
 14. School Message Board
 15. Pencil Bollards
 16. Honorary Stone Monument
 17. School Medallion
 18. Metal Benches
- B. Related Sections: The following Sections contain requirements that relate to this Section:
1. Division 32 Section “Concrete Paving”.
 2. Division 32 Section “Poured Play Area Surfacing”
 3. Division 32 Section “Turf and Grasses”.
 4. Division 32 Section “Plants”.
 5. Division 32 Section “Topsoil”.
 6. Division 26 Section “Electrical”.
 7. Division 03 Section “Cast-In-Place Concrete”.

1.3 DEFINITIONS

- A. Form 816: “Standard Specifications for Roads, Bridges and Incidental Construction”, State of Connecticut, Department of Transportation, Form 816, 2004 edition, with 2005 supplement.

1.4 SUBMITTALS

- A. Shop Drawings: Contractor shall provide fully dimensioned shop drawings and manufacturer's technical literature for all improvements noted within this section and confirm fabrication, reinforcing, and anchoring systems for review and approval by Architect. Shop drawings shall conform with product manufacturer's installation requirements unless otherwise noted. Contractor shall note that all components required for a complete installation of each item specified in this section shall be included in the shop drawings and shall be included in this cost of this bid and shall not be an additional expense to the contract.

PART 2 - PRODUCTS

2.1 PROJECT SIGNAGE

- A. 3/32" thick sign face – sheet aluminum signs in conformance with Form 816, Article M.18.13.
- B. Graphic image, text, and sign to conform to Connecticut State Statute and project requirements (see Drawings for schedule of graphics).
- C. Posts set in bollards: 2" tubular steel, galvanized, with domed cap. Fastening hardware for all signs shall be galvanized, and compatible with pole materials. Sample submittal required.
- D. All site ground mounted signposts shall be CTDOT approved/ City of New Britain standard "U" channel break away signposts. Posts shall be powder coated black.

2.2 STANDARD METAL BOLLARDS & SLEEVES

- A. Schedule 40 galvanized seamless pipe including concrete core and dome.
- B. 4,000 psi concrete footings.
- C. Bollard sleeves shall be similar to:

"Post Guard", as manufactured by Encore Commercial Products, Inc., Southfield, MI, or approved equal.
- D. Provide plastic bollard sleeve with retro reflective tape banding; color to be approved. Product shall have a minimum of two grey colors as an option for bollards. Provide plastic bollard sleeve with retro reflective tape banding; bollard sleeve color to be custom color or standard color. Submit manufacturer's full standard color range for review. Color shall be integral with the plastic and not be surface applied. Custom color range shall include all Pantone/Sherwin Williams colors and shall be selected by Architect at time of submittal.
- E. Provide 3M retro reflective tape as detailed. Install per manufacturers requirements. Color: Provide full selection of manufacturer's colors for approval. Color selection shall include black, grey/silver and white.

2.3 GRANITE BOLLARDS

- A. Granite Bollards shall be fabricated from Old Berkshire granite as supplied by Williams Stone Company in East Otis MA (as distributed by O&G industries) or approved equal.
- B. Polished top and thermal finish sides. ¼" Bevel edge, ease all edges. Each bollard shall be solid and a single unit fabricated from a single stone block.
- C. Dimension as detailed.
- D. Cleanly and neatly seal joint in pavement around the bollard base w/ color match sealant. Sika flex or equal. Submit manufacturer's full range of colors to match.

2.4 FLAGPOLES

- A. Flagpole shall be 6063-T6 aluminum, tapered seamless tubing, with an exposed height of 50 feet. The pole shall be ground-set in a 16 gauge, corrugated galvanized steel foundation sleeve. Finish shall be satin brush.
- B. Pole shall contain an internal halyard system, with cast aluminum hood and internal revolving truck, 7x19 construction stainless steel aircraft cable, neoprene ball (block), stainless steel snap hooks, solid neoprene ball retaining loop with aircraft cable core, internal winch and removable handle.
- C. Accessories shall include: A gold anodized 14-gauge aluminum ball finial on top and a spun aluminum collar, with finish to match pole.
- D. Flagpole shall be similar to Model #PT5010D as manufactured by Pole-Tech Co., East Setauket, NY, or approved equal.
- E. Other acceptable manufacturer's include American Flagpole, Abingdon, VA and Ewing, Buffalo, NY. Product shall be equal to specified Pole-Tech product.
- F. Flag shall be United States national flag, size 8 feet by 12 feet for 50' pole. It shall be made of 100% nylon, color fast, with strong ultra-white heavy duck heading, and stars that are dense-filled embroidered. The flag shall have hand-fitted, double needle seams with back-stitch reinforcement. There shall be two rows of stitching on top and bottom hems and four rows of locking stitching with back-stitch reinforcements on the fly end. The flag shall be specifically manufactured for outdoor use. The flag shall have integral, brass grommets on the mounting end.
- G. Submit signed and sealed shop drawings by a CT licensed engineer indicating provided flagpole with flag is rated for local max. wind loading. Contractor shall install footing size and reinforcing as required by engineer at no additional cost to the Owner.
- H. Submit all product information and warranties.

2.5 LIGHT POLE BASES

- A. The site contractor shall be responsible to provide and install precast light pole bases. The electrical contractor shall furnish to the site contractor, anchor bolt templates and anchor bolts which the site contractor shall install. The electrical contractor shall furnish and install all light fixtures, conduit wire and/or cabling.

2.6 BICYCLE RACK

- A. Bicycle parking racks shall be a looped or wave rack with, fabricated from a 2-3/8" diameter, schedule 40 steel pipe. Rack shall be configured for direct embedment and finished in a baked-on powder coat finish, color to be selected by Architect from manufacturer's standard color range.
- B. Basis of Design: Heavy Duty Challenger model as manufactured by Madrax, a T.L. Graber Co., Middleton, WI, or approved equal. Contractor shall provide Two (2) H36-11 units with 11 bicycle capacity and One (1) H36-7 unit with a 7 bicycle capacity.
- C. Other acceptable bicycle rack manufacturers include:
 - 1. DuMor, Inc., Mifflintown, PA or approved equal.
 - 2. Enterprises, Inc., Lincoln, NE or approved equal.

2.7 CONCRETE FOOTING AND POST SLEEVES FOR HOOP GAME, TABLES & BENCHES

- A. Provide concrete footings 24" diameter by 48" deep. 4,000 psi. concrete in areas indicated on drawings. Dimension table and chair footings as indicated on details.
- B. PVC sleeves shall be schedule 40 with a minimum diameter of 6". The site contractor shall coordinate final sleeve diameter with playground phase contractor. Sleeve to receive post of hoop game and pedestal table which will be installed by playground phase contractor.

2.8 DINING TABLE & CHAIRS W/ SUNSHADE (For Reference Only, N.I.C)

- A. To be installed by a separate phase playground contractor. Site Contractor shall coordinate for required concrete footing sleeve sizes (Concrete footing shall be installed by Site Contractor).
- B. Steel "carousel" style tables and attached seats shall be six-seat units at dining height. One table in each dining area shall be five-seat, with seat opening for ADA accessibility. Tables shall be 42-inch, round, "Catena" style, made of powder-coated steel, and contain an umbrella hole at the center.
- C. Table top shall be steelhead, set in 1-1/2 inch O.D. tubular frame, reinforced with steel channels beneath the top. Supports shall be steel tubing, 2-inch O.D. by 0.120-inch wall thickness.
- D. Seats shall be back-and-seat combination, made from perforated metal, 14-gauge steel panels with 1/4-inch square holes on 7/16-inch straight centers. Seats shall be welded to 7/8-inch by 0.120-inch wall tubular steel frame.
- E. Each table shall have a coordinated umbrella installed in the center hole of each table. Umbrella shall be solid panels, constructed from 16-gauge aluminum. Frames shall be extruded recycled aluminum. Clearance under umbrellas shall be 6'-2".

- F. Table/seat combinations and umbrellas shall be surface mounted to concrete slabs, utilizing stainless steel bolts and anchors.
- G. Finishes shall be polyester powder coated, color to be selected by Architect.
- H. Entire assembly shall be similar to “Catena” style tables and seats, and “Solstice” style umbrellas as manufactured by Landscape Forms, Inc., Kalamazoo, MI, or approved equal.
- I. Provide and install ground anchor plugs set in flush in concrete to allow fastening tables in location and layout confirmed by Owner. Coordinate heavy duty stainless steel fastener lags and receiving plug size with anchor hole on table. Fasteners shall be easily removed for relocating table. Submit product for approval by Owner and Architect. Epoxy plugs in concrete as required.

2.9 METAL LANDSCAPE EDGING

- A. Steel edge restraints for plant beds, stone surfacing shall be black painted commercial steel edging with loops pressed from, or welded to, the face, in order to receive anchor stakes at 36 inches on center. Steel stakes shall be a minimum of 15 inches long. Fabricate, bend, trim and form accurately to the lines indicated and as detailed. Size of edging to be ¼ inch by 5 inches, by required length. Edging shall be similar to Ryerson Steel Edging or Sure-Loc Edging or approved equal. It is the Contractors option to substitute aluminum edging. An aluminum product substitution shall be similar to Permaloc Cleanline XL or approved equal.

2.10 STONE MULCH SURFACING

- A. Stone mulch shall be crushed native, minimum double washed stone produced for decorative landscape surfacing. The stone shall have general aesthetic quality for use as surface mulching in landscape applications. Product shall be 3/4” Crushed River Blend (size unless noted otherwise in details) by Dunning Sand and Gravel in Farmington CT, or Equal.
- B. Color: Earth tones. Provide colors for selection and approval by Landscape Architect & Owner.
- C. **Absolutely NO fines** shall be permitted. Placed material shall be free of soil or sediment. Presence of soil or sediment is just cause for rejection and replacement.
- D. Material shall be washed prior to installation to remove sediment.
- E. Weed fabric utilized under stone mulch surfacing shall be Dewitt Pro 5 or approved equal.

2.11 BONDED RUBBER MULCH SURFACING

- A. 100% virgin EPDM Rubber Mulch as manufactured by Melos/SYNLAWN and distributed by New England Turf Store in Canton, MA or approved equal. Installed product shall represent shredded bark mulch and shall include a layer of EPDM granules.

- B. 100% dyed through EPDM Rubber mulch. UV stable and Non-toxic. Designed for use in play areas. Manufacturer's compatible binding material specifically manufactured for binding rubber mulch in play area applications.
- C. Colors: 50%/50% Blend of beige and brown by Melos is basis of design (Code: 462196 RAL: 8024 + 1001). Submit manufacturer's full range of colors for selection by Architect.
- D. Product shall be flame retardant.
- E. Provide shop drawings for review and approval by Architect. Include edge detailing and example photos of previous work. Contractor shall be experienced in installation of resilient play surfacing and have completed a minimum of 6 similar surfacing projects within the last 2 years.

2.12 STONE VENEER SEAT WALL & RETAINING WALL

- A. Stone veneer seat wall shall be comprised of thin stone, ashlar cut, earthtone, similar to Old Spruce Ashlar as supplied by O&G Industries or equal.
- B. Granite coping shall be fabricated from Old Berkshire granite as supplied by Williams Stone Company in East Otis MA (as distributed by O&G industries) or approved equal.
- C. Aluminum flashing, drip edge
- D. Stainless steel pins for epoxy anchoring wall cap into top of concrete wall.
- E. Color Match Sealant,
- F. Colored grout for wall cap. Submit color for selection by Architect.
- G. Colored mortar for stone veneer.
- H. Ardex thin set mortar for adhering thin stone to concrete wall. Provide full manufacturer's lifetime warranty for product performance.
- I. Refer to structural drawings and specifications for additional information.

2.13 REINSTALLATION OF SALVAGED ITEMS

- A. Refer to Division 31 "Site Clearing" for salvage, cleaning and storage of existing site items.
- B. Contractor shall confirm and review all salvaged items with Owner prior to commencing demolition operations as noted in Division 31, Section 'site clearing' of the project specifications. Items for salvaging and reinstallation include but are not limited to a Memorial Plaque and post and Memorial Boulder.
- C. Contractor shall dispose of any unwanted items at no additional expense to the Owner.

2.14 SCHOOL MESSAGE BOARD

- A. School message board shall be fabricated from minimum 1/8" thick Aluminum tubing & sheet stock. Sign shall be fabricated by either Lauretano Sign Group, Terryville CT or Art FX, Bloomfield CT, or approved equal.
- B. Cabinet, posts and roof shall be made from aluminum tubing and extend the full depth of the footing.
- C. Raised school lettering shall be aluminum welded to aluminum gable panel. Lettering shall be painted black.
- D. Footings shall be 4,000 psi concrete formed with sono tubes.
- E. The entire fabricated message board shall receive a powder coat finish. Individual operating parts shall powder coated separately.
- F. Heavy-duty stainless-steel piano hinges on cabinet doors. Piano hinge shall run continuous along one side of the cabinet door. Secure hinge to cabinet and door.
- G. A keyed lock shall be integrated into the aluminum cabinet door. Provide a minimum of 2 key sets.
- H. Fabricate a viewing window for the message board cabinet door made from clear 1/4" thick plexi glass. Window shall be made from a single sheet and be free of scratches, cracks and seams. Secure and seal the window in the cabinet door frame to withstand frequent use and prevent water infiltration.
- I. Commercial dry erase panel set in cabinet fastened to aluminum backing with w. Dry erase panel shall.
- J. Aluminum message board cabinet shall be weather-proof and be enclosed on all sides. Cabinet shall have a tray at the bottom of cabinet for storing markers.
- K. Powder coating finish colors shall be selected by Architect from the manufacturer's full range. The unit will have two powder coat colors: roof shall be black and the message board & posts shall be red.
- L. Provide complete shop drawings for review and approval, including attachment to concrete footings.

2.15 PENCIL BOLLARDS

- A. Pencil bollards shall be fabricated from Aluminum fabricated by either Lauretano Sign Group, Terryville CT or Art FX, Bloomfield CT, or approved equal.
- B. Bollards shall have concealed mounting bracket at bottom capable of securing the unit to the concrete foundation with galvanized anchor bolts. Bracket shall allow for adjusting each bollard to be plumb.

- C. Powder coating finish colors shall be selected by Architect from the manufacturer's full range. Each individual pencil bollard will receive individual base colors as detailed and consistently colored detailing.
- D. Provide complete shop drawings for review and approval, including attachment to concrete footings.

2.16 HONORARY STONE MONUMENT

- B. Honorary stone monument shall be fabricated from Old Berkshire granite as supplied by Williams Stone Company in East Otis MA (as distributed by O&G industries) or approved equal.
- C. Refer to details for medallion dimensioning. Thickness of the stone shall be consistent.
- D. The honorary stone monument surface shall have a smooth polished finish on top and a standard smooth cut finish on sides and bottom. Top edge shall be eased. The engraving shall be as represented in the detail. Lettering shall be formed by approximately 1/8" deep sandblasted engraving or as required to produce a highly detailed relief. The depth of engraving shall not compromise the integrity of the stone piece. All engraved areas shall be infilled with shadow or highlight to enhance the legibility of the engraving.
- E. The engraver shall provide a minimum of three similar completed samples of engraving (1 physical sample and min. 2 photographs) and produce project specific shop drawings for review and approval by Architect and owner prior to fabrication. Engraver shall be Ciarlo Monumental Works, Waterbury CT or approved equal. The engraver shall make adjustments to the text and graphic per Architects comments on shop drawings at no additional expense to the contract.

2.17 SCHOOL STONE MEDALLION

- A. Stone medallion shall be fabricated from Old Berkshire granite as supplied by Williams Stone Company in East Otis MA (as distributed by O&G industries) or approved equal.
- B. Refer to details for medallion dimensioning. Thickness of the stone shall be consistent.
- C. The medallion surface shall have a thermal finish on top and a standard smooth cut finish on sides and bottom. Top edge shall be eased. The Newington Public Schools graphic as represented in the detail shall be formed by approximately 1/8" deep sandblasted engraving or as required to produce a highly detailed relief. The depth of engraving shall not compromise the integrity of the stone piece. All engraved areas shall be infilled with shadow or highlight to artistically enhance the visibility of the engraved School Logo.
- D. The Owner will provide the Logo graphic as detailed to the Contractor's engraver prior to commencing work. The engraver shall enhance the graphic detail as required to produce a highly detailed medallion. The engraver shall provide a minimum of three similar completed samples of engraving (1 physical sample and min. 2 photographs) and produce project specific shop drawings for review and approval by architect and owner prior to fabrication. Engraver shall be Ciarlo Monumental Works, Waterbury CT or approved equal. The engraver shall

make adjustments to the graphic per Architects comments on shop drawings at no additional expense to the contract.

2.18 METAL BENCHES

- A. Furnish four (2) 6' long long benches in the honorary garden patio area. Benches shall be model 495-60 Series by DuMor, Inc. ,Mifflintown, PA or approved equal. Units shall be powder coated. Legs shall be cast aluminum with backless steel seats. Submit manufacturer's full range of colors for selection by Landscape Architect.
- B. All steel members shall be coated with zinc rich epoxy and finished with polyester powder coating.
- C. Furnish manufacturer's expansion anchor bolts for anchoring unit to anchor in footings.
- D. Concrete footings shall be installed at each bench support.

PART 3 - EXECUTION

3.1 JOB CONDITIONS

- A. Confirm completion of pavements and other improvements are properly sequenced prior to installation of specified improvements.

3.2 PROJECT SIGNAGE

- A. Install signs and posts at each designated location general locations indicated on plans. Conform with MUTCD guidelines for signage layout.
- B. Install signage plates and fabricated steel post/bollard assembly where and as detailed at handicap parking areas.
- C. Signs to be installed level and plumb, at a constant vertical alignment.
- D. Contractor shall review and coordinate final locations in field with Owner and Landscape Architect.
- E. All signs shall be plumb and arranged for visibility.
- F. Install salvaged signs in locations as indicated on plans. Install on new posts.
- G. Install signage bollards at each designated handicapped parking space, van accessible space and passenger loading space. Install as per detail.

3.3 STANDARD METAL BOLLARDS & SLEEVES

- A. Install bollards and sleeves where and as detailed. Hold bollards at a constant alignment.
- B. Install as detailed in locations indicated on plans.

- C. Install shims and fasteners to secure bollard covers.
- D. Cleanly cut vinyl sleeves around signposts.
- E. Install bollards centered on handicapped parking spaces for accessible sign bollards unless otherwise directed.
- F. Accessible sign bollards shall be located at back of curb line unless otherwise directed.
- G. Cleanly cut tactile warning surfaces around bases of bollards as occurs.

3.4 GRANITE BOLLARDS

- A. Install bollards and sleeves where and as detailed. Hold bollards at a constant alignment and offset from curb line. Maintain a consistent height.
- B. Install as detailed and per manufacturer's requirements.
- C. Set granite bollards plumb and in alignment with walks and adjacent features.
- D. Seal all joints with color matching sealant.
- E. Dowel & epoxy granite into concrete base. Coordinate & align reinforcing bar/dowels with fabricated bollards.
- F. Submit complete shop drawings for review and approval.

3.5 FLAGPOLES

- A. Install flagpole in location as indicated on Drawings. Foundation to be a minimum 5'-0' below finish grade. Final shop drawing design shall conform to manufacturer recommendations and engineered requirements.
- B. Clean entire flagpole per manufacturer recommendations at completion of installation.
- C. Deliver flag in original container, to Owner.

3.6 LIGHT POLE BASES

- A. The site contractor shall be responsible for all excavation, backfill and concrete work required for the installation of the lighting system as shown on the Drawings. Install light pole bases in accordance with manufacturer's instructions. Bases shall be installed plumb, in excavated hole, with tops 36" above finish grade in parking areas (in designated locations shown on drawings) and 6 inches above finished grade, in lawn areas, along walkways or where they are respectively indicated on plans. Refer to Electrical drawings for additional information. The electrical contractor shall furnish and install all required grounding cable and grounding rods as typically shown on the Drawings. Backfill and compact around bases, in accordance with

“Earth Moving” section of this Specification. Face of Light pole bases shall be set a minimum of 4’ back from face of curb where possible or as indicated on drawings.

- B. Maintain a consistent height and offset from the curb line throughout the site.
- C. Light pole bases shall be laid out in coordination and aligned with parking stripes to occur between parked vehicles.
- D. Broken, chipped or cracked light pole bases shall not be acceptable and grounds for rejection. Replace as directed by Owner and Architect.
- E. Clean, rub, fill voids on light pole bases as directed or approved by Architect.
- F. Lifting lugs shall be located below finished grade and shall not be visible at completion of light pole installation.

3.7 BICYCLE RACKS

- A. Install where shown on drawings and in accordance with manufacturer’s recommendations.
- B. Review layout and clearances in field according to manufacturer’s recommendations for bicycle parking standards.
- C. Install each unit plumb and level.

3.8 CONCRETE FOOTING AND POST SLEEVES FOR HOOP GAME, TABLES & BENCHES

- A. Install concrete footings with sleeves centered.
- B. PVC sleeves shall be plumb and flush with the top of the footing. Sleeve shall be full depth of footing.

3.9 DINING TABLE & CHAIRS W/ SUNSHADE (**For Reference Only, N.I.C**)

- A. Anchor tables w/ chairs in into concrete pavement in location as directed by the owner. Approximate location shown on drawings. Coordinate layout/table arrangement with owner prior to installing anchors in concrete.
- B. Fastener shall be easily removed for relocating table. Epoxy ground anchor plugs in concrete as required.
- C. Fasten umbrellas to tables, in accordance with manufacturer’s instructions.
- D. Site contractor shall install footings and coordinate with the table and chair manufacturer’s recommended anchoring system.

3.10 METAL LANDSCAPE EDGING

- A. Install metal landscape edging along stone mulch beds, stone dust mow strips, stone drainage areas (along drive) and mulched planting beds as specified or indicated on drawings. Maintain straight lines and smooth curves as indicated on the layout plans. Remove and install new edging along existing beds that are adjacent to and contiguous with new planting beds to form a continuous landscape edging.
- B. Maintain a consistent height above grade. Adjust grade and mulch beds elevations as required to achieve this.
- C. Lock metal edging units together and secure with manufacturer's anchoring stakes at edging loops to hold edge firmly in place. Set stakes below top of edging and grade per manufacturer.
- D. Remove and replace any broken, bent or kinked edging pieces. Ease any sharp ends or corners as directed by Architect or Owner.
- E. Continue separation and weed fabric to edging and return a minimum of 2" up the sides to ensure there is no exposed soil to prevent for weed growth. Hold edge of fabric below top of mulch and metal edging so that it is not visible.

3.11 STONE MULCH SURFACING

- A. Spread crushed stone in locations indicated on plans over separation or weed fabric to depths indicated. Provide complete coverage so that fabric is not visible.
- B. Notify Landscape Architect to review stockpiles on site prior to placing stone mulch to verify material is free of fines.
- C. Remove any soil or sediment prior to placement. **Absolutely No fines** are permitted over the weed fabric.
- D. Wash material on site if silt and soil is present in material if necessary as directed by Landscape Architect at no additional expense to Owner.
- E. Cover all separation and weed fabric with stone mulch to specified depths.
- F. Smooth, level and blend flush to adjacent grades.
- G. Review placement of stones around base of plants with Architect in field.

3.12 BONDED RUBBER MULCH SURFACING

- A. Install separation fabric over structural soil and top finish stone layer prior to installing EPDM base layer.
- B. Install EPDM granular base layer per manufacturers requirements. Install EPDM shredded mulch surfacing over granular layer. Place and spread mulch evenly. Level and smooth surface around the base of the tree to the edge of the planter. Install per manufacturer's requirements to achieve an aesthetic and consistent surface. Hold surfacing approx. 3" back from tree trunk/root flare and taper down to soil.

- C. Fully coat base course and shredded mulch surfacing material with manufacturer's recommended binding agent prior to placement to ensure the finished product is fully bound together and will maintain integrity within a high use play area environment. No loose or weakly bound material is permitted.
- D. Installed material shall be permeable and acceptable for installation around tree base and designed for use in street tree planters.
- E. Provide manufacturer's standard product warranty.
- F. Provide a surface for adhering synthetic landscape grass around the perimeter of the bonded mulch ring as detailed. Utilize a compatible adhesive. The turf shall be adhered to the base rubber layer. Form a smooth tapered transition between the rubber mulch topping and the adjacent synthetic grass.

3.13 STONE VENEER SEAT WALL & RETAINING WALL

- A. Provide a mock-up on site for review and approval by Architect.
- B. Maintain consistent quality of craftsmanship throughout stone veneer wall construction.
- C. Prepare concrete wall with anchors and moisture barrier per product specifications.
- D. Mortar all joints. Tool all mortared joints to establish a clean and consistent appearance.
- E. Maintain a cavity/ air gap between back of stone and wall to permit flow of moisture and air. Install weeps at bottom of wall. Drain to grade. Anchor stone with wall ties at consistent intervals to maintain wall stability.
- F. Refer to structural drawings for additional concrete wall information.
- G. Install flashing and drip edges below caps. Solder all corners of flashing, drip edges, joints and drip edges to prevent sharp edges and points. Turn down corners if requested. Review installation and edge treatment in field with Architect.
- H. Epoxy and dowel caps to reinforced concrete retaining walls and seat walls. provide a minimum of 2 per cap hold a minimum of 4" from edges of unit. Cap fabricator shall drill holes. Hole depth and location shall not compromise integrity of unit.
- I. Seal all cap joints with color match sealant. Sika Flex or equal. Maintain consistently spaced joints for all caps. Install backer rod to prevent sagging sealant.

3.14 REINSTALLATION OF SALVAGED ITEMS

- A. Clean and restore all items prior to reinstallation.

- B. Install all items salvaged from site to match existing unless otherwise noted. Ensure that items have been cleaned and are free from damage. Restore as required. Install as previously installed, or as detailed on the Drawings.
- C. Provide processed aggregate setting bed material for memorial boulder.
- D. Review re location of salvaged items in field with Owner and Architect. Field adjust if requested.

3.15 SCHOOL MESSAGE BOARD

- A. Install school message board in concrete footings.
- B. Hold sign plumb and level.
- C. Prevent sign from any damage during installation.
- D. Seal any joints as necessary to prevent water infiltration. Utilize a heavy duty color match sealant.
- E. Refer to detail for additional information.
- F. Install sign per approved shop drawings.
- G. Provide keys to Owner.

3.16 PENCIL BOLLARDS

- A. Install school message board in concrete footings.
- B. Hold sign plumb and level.
- C. Prevent sign from any damage during installation.
- D. Refer to detail for additional information.
- E. Install sign per approved shop drawings.

3.10 HONORARY STONE MONUMENT

- A. Install stone monument on a level base as detailed.
- B. Align monument with edge of walk.\
- C. Seal joint between the walk and monument.

3.11 SCHOOL STONE MEDALLION

- A. Install school medallion flush with adjacent pavement as detailed.
- B. Seal perimeter with color match caulking (Sika or equal). Color to be selected by Architect.

3.12 METAL BENCHES

- A. Assemble and install benches per manufacturer's instructions.
- B. Anchor benches to concrete footings as detailed using manufacturer's anchoring hardware. Level with galvanized washers. Cut excess thread off anchor bolts.
- C. Configure benches as directed by Landscape Architect in same location as granite benches are indicated.
- D. Pitch mounting pads to drain.

3.13 PROTECTION/CLEAN UP

- A. Protect all newly installed equipment until acceptance of the project.
- B. Replace or refinish the surfaces if damaged prior to acceptance.
- C. Clean up all debris from installation procedures.

END OF SECTION 32 00 00

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SECTION 32 12 16 — ASPHALT PAVING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.02 DESCRIPTION

- A. Work Included: Bituminous concrete drives, parking, and patching, complete in place, as shown on the Drawings and as specified herein including:
 - 1. Saw cut existing pavement as required.
 - 2. Painted pavement markings and legends.
 - 3. Maintenance and protection of pedestrian traffic as required.
- B. Related Sections:
 - 1. Section 31 20 00 – Earth Moving;
 - 2. Section 31 25 00 – Erosion and Sedimentation Controls;
 - 3. Section 33 10 00 – Water Utilities;
 - 4. Section 33 30 00 – Sanitary Sewerage Utilities;
 - 5. Section 33 40 00 – Storm Drainage Utilities.

1.03 QUALITY ASSURANCE

- A. Qualifications of Workmen
 - 1. Provide at least one person who shall be thoroughly trained and experienced in the skills required, who shall be completely familiar with the design and application of work described for this Section, and who shall be present at all times during progress of the work of this Section and shall direct all work performed under this Section.
 - 2. For actual finishing of bituminous concrete surfaces and operation of the required equipment, use only personnel who are thoroughly trained and experienced in the skills required.

1.04 REFERENCES

- A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction Form 818 (2020) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Subbase crusher-run stone conforming to the requirements of Article M.01.01, for No. 6 stone (3/8" crushed stone), DOT Specifications or to the following:
- B. Base: Processed aggregate for the base shall conform to the requirements of Article M.05.01, DOT Specifications. Coarse Aggregate shall be broken stone conforming to the requirements of Article M.05.01-2 (b).
- C. Pavement Materials:
 - 1. Bituminous concrete mixtures conforming to the requirements of Section M.04 of the DOT Specifications. Reclaimed Asphalt Pavement (RAP) will be allowed for use per the requirements of Section M.04.01-6.
 - 2. In Section M.04, reference is made to the Chief, Materials Testing Section, to the Materials Testing Section, and to the Laboratory; none will be involved in this work. Do the work of the Chief, the Section, and the Laboratory; or arrange for the producer of the bituminous concrete to do this work. Make the determinations, verifications, rejections, approvals, tests, and inspections as specified by Section M.04 and as necessary to produce satisfactory bituminous mixtures.
- D. Tack Coat: Section M.04 of the DOT Specifications.
- E. Joint Sealer: A rubber compound of the hot-poured type conforming to the requirements of Article M.04.02 of the DOT Specifications.
- F. Paint: Shall conform to Section M.07.22 of the DOT Specifications for Epoxy Resin Pavement Markings.

PART 3 - EXECUTION

3.01 INSPECTION

- A. Examine the areas and conditions under which work of this Section will be installed. Correct conditions detrimental to proper and timely completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.02 FINAL PREPARATION OF SUBGRADE

- A. After preparation of subgrade as specified in Section 31 20 00 – Earth Moving of these Specifications, thoroughly scarify and sprinkle the entire area to be paved, and then compact by rolling to a smooth, hard, even surface of 95 percent of modified optimum density to receive subbase. Finish to the required grades, with due allowance for the thickness of bituminous concrete courses to be placed thereon.
- B. Equipment: Compact by rolling with a 15-Ton vibratory roller.

3.03 CONSTRUCTION OF SUBBASE AND BASE COURSE

- A. After subgrade has been completed and accepted by the Architect, construct the subbase and base over all areas to be paved.
- B. Construct subbase in accordance with the requirements of Article 2.12.03 of the DOT Specifications, however compact with four passes of a 15-Ton (static weight) roller.
- C. Construct base in accordance with the applicable requirements of Article 3.04.03 of the DOT Specifications. Compact to at least 98 percent of modified optimum density.

3.04 CONSTRUCTION OF BITUMINOUS CONCRETE PAVEMENT

- A. Construct pavement in courses as called for on the Drawings. Use a class of bituminous concrete for each course as indicated on the Drawings. Thickness of each course: As shown on the Drawings.
- B. Construct the bituminous concrete pavement in accordance with Article 4.06.03 of the DOT Specifications, except as modified below:
 - 1. Article 4.06.03-1 Samples: Samples will not be taken by Materials Testing Section. Arrange for the producing plant to take its own samples to ascertain that mixtures are proper. Provide certifications. The Contractor will have the ultimate responsibility.
 - 2. Article 4.06.03-2 Mixing Plant Inspection:
 - a. Inspections, verifications, determinations, and approvals at the mixing plants will not be made by the Chief, Materials Testing Section. The Contractor will be responsible for mixtures and shall take whatever steps are required to ensure production of satisfactory mixtures. He shall certify that mixtures do meet specifications.
 - b. Weights of completed mixtures will not be required.
 - 3. Article 4.06.03-3 Mixing Plant Inspection - Field Laboratory: Delete in its entirety.
 - 4. Article 4.06.03-4: Delete "Assistant Manager of Materials Testing" and substitute "Contractor."

5. Article 4.06.03-5: Delete "Assistant Manager of Materials Testing" wherever it appears and substitute "Contractor."
- C. Certifications: Furnish certified test reports, material certificates, and certificates of compliance in accordance with the requirements of Article 1.06.07 of the DOT Specifications.

3.05 APPLICATION OF PAINTED PAVEMENT MARKINGS AND LEGENDS

- A. The contractor shall furnish a technical advisor, who shall be fully knowledgeable of all equipment operations and application techniques, to oversee the project operation.
- B. Pavement markings shall be applied in accordance with the details shown on the Drawings, in accordance with Section 12.09 of the DOT Specifications and as directed by the Architect.
- C. The road surface shall be cleaned to the satisfaction of the Architect just prior to application. Pavement cleaning shall consist of at least brushing with a rotary broom (non-metallic), and additionally as recommended by the material manufacturer and acceptable to the Architect.
- D. The painted pavement markings application shall immediately follow the pavement cleaning. Operations shall be conducted only when the pavement surface temperatures are 50°F or greater.
- E. After application the paint shall be protected from crossing vehicles and pedestrians for a time at least equivalent to the drying time of the paint.
- F. The contractor shall place necessary "spotting" at appropriate points to provide horizontal control for striping and to determine necessary starting and cutoff points. Longitudinal joints, pavement edge and existing markings shall serve as horizontal control when so directed.

3.06 PROTECTION

- A. Protect from traffic during all operations.

3.07 FINISH TOLERANCES

- A. Finish surfaces to the following tolerances.
 1. Subbase and Base: Plus 0.00 feet to minus 0.10 feet from line and grade shown on the Drawings.
 2. Bituminous Concrete Surface Course: Plus or minus 0.05 feet at any point from line and grade shown on the Drawings. No variations in surface more than 1/8 inch in a 10-foot plane.

END OF SECTION 32 12 16

SECTION 32 13 13 — CONCRETE PAVING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.02 DESCRIPTION

- A. Work Included: Portland cement concrete sidewalks, utility pads and dumpster pads, complete in place, as shown on the Drawings and as specified.
- B. Related Work Specified Elsewhere
 - 1. Section 31 20 00 – Earth Moving;
 - 2. Section 32 12 16 – Asphalt Paving.

1.03 QUALITY ASSURANCE

A. Qualifications of Workmen

- 1. Provide at least one person who shall be thoroughly trained and experienced in the skills required, who shall be completely familiar with the design and application of work described for this Section, and who shall be present at all times during progress of the work of this Section and shall direct all work performed under this Section.
- 2. For actual finishing of concrete surfaces and operation of the required equipment, use only personnel who are thoroughly trained and experienced in the skills required.

1.04 APPLICABLE SPECIFICATIONS

- A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction Form 818 (2020) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Concrete: Article M.03.01, DOT Specifications. Class: As indicated on the Drawings.
- B. Air-Entraining Portland Cement and Air-Entraining Admixture: Article M.03.01, DOT Specifications.

C. Reinforcement:

1. Welded Wire Mesh: WWM shall be used in all concrete sidewalk ramps and concrete sidewalk locations. The WWM shall be W1.4xW1.4 and conform to the latest AASHTO M55M/M55-94 "Standard Specifications for Welded Steel Wire Fabric for Concrete Reinforcement."
2. Written request may be made to substitute synthetic:
100% virgin polypropylene fibers, minimum 1.5lbs per cubic yard or as approved by the manufacturer. Acceptable manufacturers of polypropylene fibers are W.R. Grace, Fibermesh, and Forta Corp.

D. Sealant to be Saltguard® WB as manufactured by Prosoco, Inc. or approved equal.

E. Curing Materials:

1. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.
2. Moisture-Retaining Cover: Wet curing utilizing white polyethylene film or white burlap polyethylene sheet, ASTM C171; Similar to Hydracure or equal, or resin-based, clear emulsion liquid dissipating cure which will not discolor the concrete, conforming to ASTM C309 Type I of ID, Class A & B and AASHTO M-148.
3. Water: Potable. Water shall not have mineral content that may discolor concrete.
4. Curing compounds may be utilized by the contractor at their option. The curing compound shall be suitable and compatible with the specified salt guard. The Contractor shall submit a letter from the compound manufacturer verifying the compatibility in this specific application. Contractor shall describe and outline the procedures and process for preparing the concrete to receive salt guard. Owner and Architect will review submittal in consideration of acceptance. Contractor shall provide other projects where this product has been used for review.
5. Absorptive Covers and Moisture retaining Covers: The Contractor shall utilize coverings that are clean of residue and debris. Follow the manufacturer's requirements for reuse limitations. The coverings shall be non-marking. Dispose of soiled and material coated covers and utilize new coverings as necessary to ensure the finished concrete surface is consistent in color and texture.

F. Granular for Base: Article M.02.01, DOT Specifications.

G. Expansion and Isolation Joint Filler Strips: ASTM D 1751, asphalt saturated, cellular fibers, as manufactured by Sealtight, W.R. Meadows, or approved equal.

1. Thickness – one-half inch.
2. Depth – to match full section of concrete pavement/curb.

H. Removable Vinyl Joint Cap Strips: Compatible with filler strips width, as manufactured by Vynlex Corp. or approved equal. Provide in lengths equal to lengths of filler strips.

I. Joint Sealer: Compatible with filler strips, two component polyurethane elastomeric type complying with FS-TT-S-00227, self-leveling designed for pedestrian and vehicular traffic, as manufactured by Sika, Percora, or approved equal. Include primer and backing rods as required.

1. Type: Class II, non-load bearing, for bonding freshly mixed to hardened concrete.
2. Type: Class I and II, non-load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.
3. Type: Class IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

Expansion Joint Filler: For installation at expansion joints: Bituminous cellular type, AASHTO M213.

J. Detectable warning surfaces shall be vitrified polymer composite, cast-in-place replaceable tiles fabricated from an epoxy polymer composition with an ultraviolet stabilized coating employing aluminum oxide particles in the truncated domes. Color shall be selected from manufacturers full selection of colors. Tiles shall be similar to “Armor-Tile” as manufactured by Engineered Plastics or approved equal. Units shall be removeable/ replaceable type and anchored with manufacturers stainless hardware.

PART 3 – EXECUTION

3.01 INSPECTION

- A. Examine the areas and conditions under which work of this Section will be installed. Correct conditions detrimental to proper and timely completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.02 CONSTRUCTION METHODS

- A. Conform to the requirements of Article 9.21.03 of the DOT Specifications.
- B. Install expansion joint filler at expansion joints located as shown on the Drawings.
- C. Curing and Protection
 1. Protect interior and exterior concrete from moisture loss and premature drying for a minimum of 7 days. Follow applicable provisions of ACI 301.
 2. Apply silane / siloxane type water repellent on all exposed concrete surfaces using manufacturer’s recommendations.

END OF SECTION

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SECTION 32 14 00 - UNIT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Concrete pavers
 - 2. Concrete base and sand setting beds
 - 3. Aluminum edge restraints.
 - 4. Cast-in-place concrete edge restraints.
- B. Related Sections include the following:
 - 1. Division 31 Section "Earth Moving".
 - 2. Division 32 Section "Asphalt Paving".
 - 3. Division 32 Section "Concrete Paving".

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Pavers.
 - 2. Edge restraints.
- B. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C 136.
- C. Samples for Initial Selection: Manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available for each type of unit paver indicated.
 - 1. Include similar samples of material for joints and accessories involving color selection.
- D. Samples for Verification: Full-size units of each type of unit paver indicated; in sets for each color, texture, and pattern specified, showing the full range of variations expected in these characteristics.
 - 1. Provide samples with joints grouted and cured, showing the full range of colors to be expected in the completed Work.
 - 2. Include samples of exposed edge restraints.

- E. Qualification Data: for firms and persons specified in “Quality Assurance” Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has completed unit paver installations similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in –service performance.
- B. Source Limitations: Obtain each type of unit paver, joint material, and setting material from one source with resources to provide materials and products of consistent quality in appearance and physical properties.
- C. Mockups: Before installing unit pavers, build mockups for each form and pattern of unit pavers required to verify selections made under sample Submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for the completed Work, including same base construction, special features for expansion joints, and contiguous work as indicated:
 - 1. Build mockups in the location and of the size indicated or, if not indicated, minimum 8’ x 8’.
 - 2. Demonstrate the proposed range of aesthetic effects and workmanship.
 - 3. Obtain Architect’s approval of mockups before starting unit paver installation.
 - 4. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 5. Demolish and remove mockups when directed.
 - 6. Approved mockups may be part of the completed work.
- D. Comply with material standards as defined in [State of Connecticut] Department of Transportation Standard Specification Form 816.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.
- B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.
- C. Store aggregates where grading and other required characteristics can be maintained, and contamination avoided.
- D. Store liquids in tightly closed containers protected from freezing.
- E. Store asphalt cement and other asphalt materials in tightly closed containers.

1.6 PROJECT CONDITIONS

- A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.
- B. Weather Limitations for Asphalt Setting Bed:
 - 1. Install asphalt setting bed only when ambient temperature is above 40 deg F and when base is dry.
 - 2. Apply asphalt adhesive only when ambient temperature is above 50 deg F and when temperature has not been below 35 deg F for 12 hours immediately before application. Do not apply when setting bed is wet or contains excess moisture.

PART 2 - PRODUCTS

2.1 CONCRETE PAVERS

- A. Concrete Pavers: Solid paving units, made from normal-weight concrete with a compressive strength not less than 8000, with an average water absorption of 5 percent not more than 7 percent according to ASTM C 140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C 67, Section 8, Method A, 50 cycles.
 - 1. Basis-of-Design Product: The design for concrete pavers is based on a Unilock, Artline Paver. Subject to compliance with requirements, provide the named product or a comparable product by one of the following:
 - a. Belgard Hardscape Product by Newcastle.
 - b. Hanover Architectural Products, Inc.
 - 2. Thickness: 2-3/4"
 - 3. Face Size and Shape: Random sizes to form linear banding appearance of similar widths in each row. Pavers shall be set in a staggered running bond pattern.
 - 4. Color: Unilock Fossil or as selected by Architect from manufacturer's full range. Contractor shall submit full range of standard and custom colors for final selection.
 - 5. Finish: Unilock Smooth finish. Paver shall have a refined surface appearance resembling natural stone. Enduracolor Face mix technology or approved equal.

2.2 ACCESSORIES

- A. Paver Edge Restraints: Permaloc GeoEdge, 3 inch x 3.25 inch high x 8 feet long, extruded aluminum, alloy 6063, T-52 hardness, solid sidewalls as manufactured by Permaloc Corporation, Holland MI or approved equal.
- B. Connection Method: Section ends shall splice together with horizontal 0.060 inch thick x 1 inch wide x 2-3/4 inches long aluminum sliding connector on wall and base.

- C. Galvanized fasteners designed for anchoring into concrete in exterior applications. Hilti or approved equal.
- D. Base flanges shall have holes to receive anchors.
- E. Color: Standard mill finish.
- F. Other acceptable paver restraint manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Sur-loc Edging Corporation.
 - b. BRICKSTOP Corporation
 - c. Curv-Rite, Inc.

2.3 SAND SETTING-BED AND PAVER JOINTING SAND

- A. Sand for Leveling Course: Sound, sharp, washed, natural sand complying with gradation requirements of ASTM C 33 for fine aggregate, maximum 03% silt and shall be free of deleterious or foreign matter and soluble salts.

- 1. Gradations; as per ASTM G 136:

<u>Sieve Size</u>	<u>Percentage Passing</u>
3/8"	100
No. 4	95-100
8	80-100
18	50-85
30	25-60
50	10-30
100	2-10

- B. Polymeric sand for Joints: Infill joint sand shall be Commercial grade G2 Gator Maxx Super Sand, polymeric sand by Alliance Gator or approved equal.

- 1. Provide the polymeric sand manufacturer's full range of colors for review and selection.

- C. Concrete base shall conform with concrete pavement per Concrete Paving specifications. Infill drainage holes with 3/8" crushed stone, or sand.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas indicated to receive paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.
- B. Clean concrete substrates to remove dirt, dust, debris, and loose particles.
- C. Proof-roll prepared subgrade according to requirements in Division 2 Section "Earthwork" to identify soft pockets and areas of excess yielding. Proceed with unit paver installation only after deficient subgrades have been corrected and are ready to receive subbase and base course for unit pavers.

3.3 INSTALLATION, GENERAL

- A. Do not use unit pavers with chips, cracks, voids, discolorations, and other defects that might be visible in finished work.
- B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
- C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.
 - 1. For concrete pavers, a block splitter may be used.
- D. Exercise care in handling coated brick pavers to prevent coated surfaces from contacting backs or edges of other units. Remove coating from bonding surfaces before setting brick.
- E. Joint Pattern: Running bond
- F. Tolerances: Do not exceed 1/32-inch unit-to-unit offset from flush lippage nor 1/8 inch in 10 feet from level, or indicated slope, for finished surface of paving.
- G. Tolerances: Do not exceed 1/16-inch unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches and 1/4 inch in 10 feet from level, or indicated slope, for finished surface of paving.
- H. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
 - 1. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after unit paver installation.
- I. Concrete setting base shall be finished uniformly and pitched to mirror finished grade with installed pavers. Screed a minimum amount of sand as specified to shim or create a leveling base for the pavers. Coordinate depth of concrete base and sand setting bed with paver thickness and adjacent finished surface elevations.
- J. Drill 1-1/2" drainage holes in concrete 3' o.c across the paving field and at any low points as directed by the Architect. Contractor shall conduct a flood test to determine low points and effective drainage locations. Contractor shall provide additional holes as required for drainage

as directed by Architect. Repeat flood test as necessary to confirm all areas drain. Contractor may set pvc sleeves in concrete as an alternative to drilling holes. Sleeves shall be free of any debris to promote positive drainage. Infill drainage holes with specified free draining materials.

- K. Concrete bases for pavers shall be doweled into adjacent concrete pavement or foundations to prevent movement. Thicken adjacent concrete pavements to depth of concrete paver base to receive slip dowels as detailed for concrete pavement joints.

3.4 SAND SETTING-BED & JOINT FILLING

- A. Place leveling course and screed to a thickness of $\frac{3}{4}$ " to 1 inch, taking care that moisture content remains constant and density is loose and constant until pavers are set and compacted.
- B. Set pavers with a minimum joint width of $\frac{1}{16}$ inch and a maximum of $\frac{1}{8}$ inch, being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines. Fill gaps between units that exceed $\frac{3}{8}$ inch with pieces cut to fit from full-size unit pavers.
 - 1. When installation is performed with mechanical equipment, use only unit pavers with spacer bars on sides of each unit.
- C. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf compaction force at 80 to 90 Hz. Perform at least three passes across paving with vibrator. Vibrate under the following conditions:
 - 1. After edge pavers are installed and there is a completed surface or before surface is exposed to rain.
 - 2. Before ending each day's work, fully compact installed concrete pavers to within 36 inches of the laying face. Cover pavers that have not been compacted, and leveling course on which pavers have not been placed, with nonstaining plastic sheets to protect them from rain.
- D. Spread dry polymeric sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling. Remove excess material once thoroughly vibrated and joints are filled. Follow polymeric sand manufacturer's instructions fully.
- E. Activate polymeric sand with potable water by following the manufacturer's instructions.
- F. Do not allow traffic on installed pavers until sand has been vibrated into joints.

3.5 REPAIRING

- A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

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END OF SECTION 31 14 00

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SECTION 32 16 13 — CONCRETE CURBS AND GUTTERS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.02 DESCRIPTION

- 1. Work Included: Precast and cast-in-place concrete curbing, complete in place, as shown on the Drawings and as specified.
- 2. Related Work Specified Elsewhere
 - a. Section 31 20 00 – Earth Moving;
 - b. Section 32 12 16 – Asphalt Paving.

1.03 QUALITY ASSURANCE

- 1. Qualifications of Installers: Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

1.04 APPLICABLE SPECIFICATIONS

- 1. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction Form 818 (2020) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

PART 2 – PRODUCTS

2.01 MATERIALS

- 1. Cast-in-Place Concrete: Article M.03.01, DOT Specifications. Class: As shown on the Drawings.
- 2. Precast Concrete
 - a. Materials: Article M.03.01, DOT Specifications, except that coarse aggregate gradation may be varied subject to acceptance by the Architect.
 - b. Minimum 28-day compressive strength: 4000 psi

- c. Entrained air: 5 to 7 percent
- d. Cement: Type I or II
- 3. Joint Filler: Bituminous cellular type, AASHTO M213.
- 4. Mortar: Article M.11.04, DOT Specifications.
- 5. Granular Base: Article M.02.03, DOT Specifications.

PART 3 – EXECUTION

3.01 CONSTRUCTION METHODS

- 1. General: Construct concrete curbing on the prepared base to the lines and grades indicated on the Drawings. Use either cast-in-place or precast concrete curbing unless otherwise indicated on the Drawings. Cast-in-place and precast concrete curbing may be mixed. Make color of each type to match the other as closely as possible, subject to acceptance by the Architect.
- 2. Excavation: Excavate the trench to the bottom of the 6-inch granular base below the curbing. Make trench to a width that will permit thorough tamping. Obtain Architect's acceptance of conditions at bottom of trench.
- 3. Placing Base: Place and compact granular base to a firm, even surface. Obtain Architect's acceptance of the surface.
- 4. Installation of Cast-in-Place Concrete Curbing
 - a. Refer to DOT Specifications: Conform to the requirements of Article 6.01.03 for concrete for structures, as supplemented by Article 8.11.03.
- 5. Installation of Precast Concrete Curbing
 - a. Set curbing on prepared base and settle into place to the line and grade required, straight and true for the full depth of curbing. Use a heavy wood hand-rammer to settle curbing into place.
 - b. Place mortar and point joints for full depth of curbing. At approximately 50-foot intervals, leave a ½-inch wide joint free of mortar for expansion.
 - c. At driveways and intersections, form ends of the curbing so that they are beveled or rounded as directed by the Architect.
 - d. Where indicated on the Drawings or as directed by the Architect, make drainage openings through the curbing at the elevations and of the size required.

6. Backfilling: Backfill the trench with the specified granular base material. Make the first layer 4 inches in depth, thoroughly rammed. Make successive layers 6 inches in depth, thoroughly rammed. Fill the trench to elevations as indicated on the drawings.

END OF SECTION 32 16 13

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SECTION 32 18 13 – SYNTHETIC GRASS SURFACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. Section includes:
 - 1. Procurement and installation of synthetic grass surfacing.
 - 2. Procurement and installation of infill.
 - 3. Procurement, assembly, and training of synthetic grass system grooming equipment.
 - 4. Pre and post manufacturing testing of synthetic grass system.
 - 5. Dynamic Stone drainage base.
 - 6. Warranty and maintenance requirements for the synthetic grass system.
 - 7. All incidental work items required to complete the work as shown on the Drawings and as called-for in the Specifications.
- B. Contractor shall coordinate work between all Contractors, sections, and trades required for the proper completion of the work. Carefully examine all of the Contract Documents for requirements which affect the work of this Section. The exact scope of work of this section cannot be determined without a thorough review of all Specification Sections and other Contract Documents.
- C. In all cases when conflicts exist between information contained in this Section and in other parts of the Contract Documents, Contractor shall assume that the more stringent and highest-performing solution is required.
- D. Contractor is responsible for all health and safety .
- E. Related Sections include the following:
 - 1. Division 31 Section “Earth Moving”
 - 2. Division 32 Section “Topsoil” (CU Soil)
 - 3. Division 32 Section “Poured Play Area Surfacing”

1.3 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. American Society for Testing and Materials (ASTM)
 - 1. ASTM D 789 - Yarn Melting Point
 - 2. ASTM D 1335 - Standard Test Method for Tuft Bind of Pile Yarn Floor Coverings
 - 3. ASTM D 1577 - Standard Test Methods for Linear Density of Textile Fibers (Fiber Denier)
 - 4. ASTM D5034 – Standard Testing Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)
 - 5. ASTM D5035 – Standard Testing Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
 - 6. ASTM D 2256 - Standard Test Method for Tensile Properties of Yarns by the Single-Strand Method (Breaking Strength and Elongation)
 - 7. ASTM D 2859 - Standard Test Method for Ignition Characteristics of Finished Textile Floor Covering Materials (Flammability)
 - 8. ASTM D 3218 – Standard Test for Fiber Thickness (Microns)
 - 9. ASTM D 4491 - Water Permeability of Geotextiles by Permittivity.
 - 10. ASTM F 1632 - Particle Size Analysis and Sand Shape Grading of Golf Course Putting Green and Sports Field Rootzone Mixes
 - 11. ASTM F2157 - Standard Test Method for Base Material Evenness
 - 12. ASTM F 2765 - Standard Specification for Total Lead Content in Synthetic Grass Fibers.
- C. Synthetic Turf Council Guidelines (STC)

1.4 DEFINITIONS

- A. Most terms used within the documents are industry standard. Certain words or phrases shall be understood to have specific meanings as follows:
 - 1. Provide: Furnish and install completely connected up and in operable condition.
 - 2. Furnish: Purchase and deliver to a specific location within the building or site.
 - 3. Install: With respect to equipment furnished by others, install means to receive, unpack, move into position, mount and connect, including removal of packaging materials.

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1.5 SUBMITTALS

A. Pre-Manufacturing Submittals

1. The following letters, on the synthetic grass surfacing manufacturer/vendor's letterhead and signed by an officer of the company, shall be submitted prior to manufacturing.
 - a. Manufacturer's Review of Synthetic Grass Surfacing Requirements: A letter shall confirm their intent to conform to all requirements set forth in the Bid Documents for the Synthetic Grass Surfacing System and qualified installation crew. Including, but not limited to, the Bid Drawings, Specifications, Addendum, and RFI Clarifications.
 - b. Manufacturer's Review of Synthetic Grass Surfacing: A letter confirming that the Bid Documents for the Synthetic Grass Surfacing System have been completely reviewed by qualified representatives of the materials manufacturer and that they are in agreement that the materials and system to be used for the synthetic grass surfacing are proper and adequate for the applications shown and in no way impact the system warranty.
2. Product Data: Submit manufacturer's general specifications and installation instructions for all products in the Synthetic Grass Surfacing System, including certifications and other data as may be required, to show compliance with the Contract Documents.
 - a. Material Safety Data Sheets (MSDS) sheets for all products and product components, as necessary. This shall include solvents and other products required as part of clean-up.
 - b. Certified Statement of the presences of toxic and or hazardous materials. Any toxic and/or hazardous material exceeding 100 parts per million (ppm) shall be identified in list form. The list shall reference the standard in name and threshold if applicable, and the test results. This requirement is above and beyond the requirements for MSDS.
3. Material Testing: Submit for approval test results for all material testing performed under "Quality Control Testing, Pre-Manufacturing" herein. Provide copies of all Testing Agency reports. Testing shall be no more than 12 months old from date of submittal.
4. Material Samples: Submit three (3) samples, with required testing data, for approval for all materials under 2.1 Materials including, but not limited to, the following:
 - a. Synthetic Grass Surfacing Fiber Samples for each color used.
 - b. Synthetic Grass Sample: Twelve-inch (12") square samples of un-filled synthetic grass for each color used. The samples shall be reviewed as the general product intended for use in play areas, please not any discrepancies between the product sample submitted and the product to be manufactured for this project.
 - c. Seaming: Twelve-inch (12") long samples of all materials to be used for seaming or sewing of the synthetic grass turf system including, but not limited to, thread and seaming tape.

- d. Synthetic Grass Surfacing infill: One-pound samples of sand.
 5. Shop Drawings: Submit for approval the following:
 - a. Seaming plan; Seams of the play area shall not coincide with the subsurface drain system nor seams of pad (if applicable).
 - b. Details on play area construction, making special note of any details that may deviate from the Drawings or Specifications. Include: edge detail, covers for access to subsurface structures, other inserts, etc.
 6. Warranties: Submit copies of warranties in Owner's name for all products furnished under this section for review and approval.
 7. Testing Agency: Submit qualification of testing agency(s) for review and approval.
 8. Synthetic grass surfacing manufacturer/vendor and installer qualifications:
 - a. Installer Qualifications: Synthetic Grass Installation Sub-Contractor shall certify in writing the designated supervisory personnel on the project are competent in the installation of the synthetic grass material, including gluing or sewing seams and proper installation of the infill mixture. The synthetic grass surfacing installer shall have a representative on-site to certify the installation and warranty compliance. Provide experience to show that installation crew is competent to complete the level of work outlined in this project. Synthetic Grass Installation superintendent shall have experience to demonstrate that the superintendent is competent to oversee and complete the level of work outlined in this project. Installer shall be STC Certified and provide documentation to represent.
 - b. At a minimum, provide the following documentation: Fifteen (15) reference projects consisting of synthetic grass from the submitted manufacturer of 5,000 square-feet or larger within the past five (5) years.
 - c. Project Information: At a minimum, provide the following information for each reference project:
 - 1) Project Name
 - 2) Project Location
 - 3) Project scope
 - 4) Construction timeline
 - 5) Construction cost
 - 6) Reference name, title, affiliation, and contact information.
- B. Post Manufacturing/Pre-Installation Submittals
1. Material Testing: Submit for approval test results for all material testing performed under "Quality Control Testing, Post-Manufacturing/Pre-Installation" herein. Provide copies of all testing agency reports.
 2. Material Samples: Submit three (3) samples, with required testing data, for approval for all materials under 2.1 Materials including, but not limited to, the following:

- a. Synthetic Grass Carpet Sample: Twelve-inch (12") square samples of un-filled synthetic grass for each color manufactured for the project.
 - b. Synthetic Grass System Sample: Sample box of synthetic grass system, including infill material.
3. Acceptance of Prior Work: Refer to section 3.2 Examination.
- C. Post-Installation Submittals
 1. Material Testing: Submit for approval test results for all material testing performed under "Quality Control Testing, Post-Installation" herein. Provide copies of all testing agency reports.
- D. Warranty Quality Control Submittals
 1. Material Testing: Submit for approval test results for all material testing performed under "Quality Control Testing, Warranty" herein. Provide copies of all testing agency reports to the Owner and Landscape Architect for review and approval for the entire warranty period.

1.6 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.
- B. The Owner, or Landscape Architect on the Owners behalf, reserves the right to submit any material, either before or after installation, for testing it deems necessary to satisfy the conditions of this contract.
 1. Any material tested and found not in compliance with the contract will be rejected and replaced with material conforming to the specifications. This will be done at the sole expense of the Contractor.
 2. Any testing performed by the Owner will be at the Owner's expense. The Contractor is responsible for the cost of all testing that fails. Contractor will bear the cost of all retesting as required by the Owner.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Schedule delivery to minimize on-site storage. Segregate differing materials and prevent from contamination with other materials.
- B. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturers' identification. All materials shall be stored in a dry place out of the direct sunlight.
- C. Prior to the installation of any materials and immediately upon delivery of the synthetic grass system and components to the project site, the Contractor shall inspect materials as follows:
 1. For damaged or defective items.

2. Measure synthetic grass roll lengths, perforations, and uniformity.
 3. Adhesives and seaming tape shall arrive in sealed dry containers and be kept in adequate temperature per manufacturer's requirements.
 4. Sand in-fill shall arrive in large sacks or bags without tears and loose material.
 - a. If bulk sand is to utilize, approval shall be requested by Owner and Landscape Architect. Location of delivery and storage shall also be reviewed for approval.
 5. Sand in-fill shall arrive dry and loose.
 6. Sand in-fill shall be free from contamination of site materials.
- D. Bulk Materials: Deliver materials in clean, washed and covered trucks to eliminate contamination during transportation. On site stockpiling locations to be coordinated with the Owner. Stockpile only in areas free of debris and away from drainage routes. Cover all materials with plastic or geotextile if materials are to be stockpiled more than 48 hours.

1.8 QUALITY CONTROL TESTING

- A. All sampling/testing shall be the responsibility of Contractor. Contractor shall retain and pay for the services of a third-party Testing Agency to perform all sampling/testing in accordance with applicable standards.
- B. All testing shall be completed by an independent (third-party) Testing Agency as approved by Landscape Architect. Testing must be for current materials with current date from independent testing laboratory as described herein.
- C. Certified copies of laboratory reports shall be submitted for all testing.
- D. Pre-Manufacturing Testing
 1. Timing: Contractor shall submit to Landscape Architect a copy of all test results certified by the independent Testing Agency prior to manufacturing of the Synthetic Grass Surfacing for the Project. Provide testing data for the following:

TESTING METHOD	CHARACTERISTIC	DECLARATION
SYNTHETIC GRASS YARN (include results for each yarn color separately)		
ASTM D 789	Melting Point	> 235 degrees F
ASTM D 1907	Denier	> 9,900/9
ASTM D 2859	Pill Burn Test	8 Passed/0 Failed
ASTM D 3218	Microns (mono)	> 300 microns

ASTM D 3218	Microns (slit-film)	> 120 microns
ASTM D 5034	Breaking Strength (length)	> 283 lbs./ ft.
ASTM D 5034	Breaking Strength (width)	> 200 lbs./ft
ASTM F 1015	Fiber Abrasiveness Index	< 35
ASTM F 2765-09	Lead Content	< 50 ppm
EN ISO 20105-A02	Artificial Weathering (3,000 hours UVA) Turf Color Change	> Gray Scale 3
EN 13864	Artificial Weathering (3,000 hours UVA) Pile Yarn Tensile Strength	<50% reduction
SYNTHETIC GRASS BACKING MATERIALS		
ASTM D 5848	Primary Backing Weight	> 6 oz./yd ²
ASTM D 5848	Secondary Backing Weight	> 22 oz./yd ²

SYNTHETIC GRASS INFILL MATERIALS		
ASTM F 1632	Particle Size Analysis	Pass

2. Any material tested and found not in compliance with the contract may be rejected and Contractor shall submit a material found to be acceptable.
3. The Owner, or Landscape Architect on the Owner behalf, reserves the right to independently test any material. Any testing performed by the Owner will be at the Owner's expense. The Contractor is responsible for the cost of all testing that fails. Contractor will bear the cost of all retesting as required by the Owner.

E. Post Manufacturing/Pre-Installation Testing

1. Drainage Testing, Frequency
 - a. Perform infiltration tests, double-ring infiltrometer, ASTM F1551/EN 12616 - Standard Test Method for Comprehensive Characterization of Synthetic Turf Playing Surfaces and Materials, after base is completed. Alternative infiltration testing will not be considered valid. > 30 in./hr.

- b. Testing Frequency: Perform one test for each 5,000 square feet (5,000 sf) of completed area.
 - c. Testing criteria: Each test will be considered acceptable when an infiltration rate meets requirements. Do not proceed with installation of subsequent layers until all tests are considered acceptable.
2. Any material tested and found not in compliance with the contract may be rejected and Contractor shall rectify the issue to be acceptable. Any area/item not within conformance shall be retested at the Contractors expense after remedy is implemented until satisfactory results are achieved.
3. The Owner, or Landscape Architect on the Owner behalf, reserves the right to independently test any material. Any testing performed by the Owner will be at the Owner's expense. The Contractor is responsible for the cost of all testing that fails. Contractor will bear the cost of all retesting as required by the Owner.

SYNTHETIC GRASS SURFACING CARPET		
ASTM D 1335	Tuft Bind (w/out infill)	> 8 lbs. or 30N
ASTM D 5793	Stitch Gauge	< 3/8"
ASTM D 5823	Pile Height	> 1 7/8"
ASTM D 5848	Pile Weight	> 75 oz./yd ²
ASTM D 5848	Total Weight	103 oz./yd ² of specification
Visual	Perforations	> 3/8" dia. holes, spaced 4" on center
ASTM F1551/EN 12616	Water Infiltration Rate Installed/Post Installation	>400 in./hr./sy

1.9 PATENT RIGHTS AND INFRINGEMENT

- A. The Drawings and Specifications are not indented to be proprietary or in violation of any current or pending patents. The Contractor and subcontractors are responsible to provide the Owner and Landscape Architect with any violations contained here in prior to bidding. By bidding on the project, the Contractor and subcontractors shall hold the Owner, Construction Manager, and Design Consultants harmless from infringement of any current or future patent issued for the synthetic grass surfacing system.

- B. Contractor and subcontractors shall hold the Owner, Construction Manager, and Design Consultants harmless from infringement of any current or future patent issued for the synthetic grass surfacing system, fibers, backings, including impact attenuation pad, installation methods and vertical draining characteristics. The successful bidder will be required to submit a letter for consent from their surety. The Surety shall indemnify the requirements.
- C. There are various established performance criteria throughout this request for products and services. There may exist patent coverage for some means and methods of achieving those performance criteria. Bidders are responsible for ascertaining that means and methods of the products and services which they are providing are not being provided in violation of any such patent rights. Bidder's responsibilities are as follows:
 - 1. To hold harmless, the Owner, Construction Manager, and Design Consultants, as to any violation to include dollar amounts that could be owed as a result of damages for infringement including potential treble damages as provided for under U.S. Patent Law.
 - 2. Any and all costs that the Owner, Construction Manager, and Design Consultants, would incur in replacing materials and services which are determined to infringe patent rights.
 - 3. All administrative, legal and other costs that would be incurred as a result of an infringement.

1.10 WARRANTY AND MAINTENANCE OBLIGATIONS

- 1. The Synthetic Grass Manufacturer/Supplier shall be required to provide testing, as described under G. Warranty Testing, and maintenance plan for the lifespan of the warranty as part of this Contract and shall submit a schedule of visits at the time of completion.
- 2. The Synthetic Grass Manufacture/Supplier to return to the site once (1) per year for the duration of the warranty, no less than 8 visits.
- 3. The Synthetic Grass Manufacture/Supplier shall inspect any areas of concern and make repairs as necessary under warranty during each visit including, but not limited to, the following:
 - a. Nailer Board/Concrete Anchor Curb Repairs
 - b. Conditions
 - c. Fiber Conditions
 - d. Fiber Height
 - e. Testing per paragraph G, Warranty Testing.
- 4. Additional infill may be required by contractor to maintain the G-Max levels and required infill depths.
- 5. Test results, field repairs, and field concerns shall be submitted to the Owner and the Landscape Architect in a Field Inspection Report and Testing Results for review annually.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Synthetic Grass Surfacing System

1. All components and their installation method shall be designed and manufactured for use in outdoor areas. The finished synthetic grass surface shall appear as mowed grass with no irregularities. The finished surface shall resist abrasion and cutting from normal use.
2. The materials as hereinafter specified should be able to withstand full climatic exposure in all climates, be resistant to insect infestation, rot, fungus, mildew, ultraviolet light, heat degradation, and be non-allergenic and non-toxic. The entire system shall be constructed to maximize dimensional stability, to resist damage and normal wear and tear from its designated uses and to minimize the ultra-violet degradation.
3. The system shall have the basic characteristics of flow-through drainage, allowing free movement of surface runoff through the synthetic grass system where such water may flow to the existing base and into the drainage system.
4. The synthetic grass system shall be a proven caliber yarn designed specifically for outdoor use and stabilized to resist the effect of ultraviolet degradation, heat, foot traffic, water, and airborne pollutants.
5. All adhesives used in bonding the system together shall be resistant to moisture, bacterial and fungus attacks, and resistant to ultra-violet rays at any location upon installation.
6. The Secondary Backing shall be not less than 22 ounces per square yard. The coating for the Secondary backing shall be uniform and monolithic when cured.
7. All glued seams shall have a 12" wide seaming tape, fully coated with adhesive. All inlays shall not have any adhesive applied to any exposed fibers.
8. All synthetic grass surfacing seams shall lay flat after in-fill.
9. Fabric surface shall be constructed and installed in minimum widths of 15 feet with no longitudinal or transverse seams.
10. The seams shall be 15'-0" apart. No fitted pieces shall be allowed to true alignment.
11. The Synthetic Grass System shall remain free draining at all times before, during, and after the infill materials are installed.

B. Synthetic Grass

1. Synthetic grass landscape surfacing material be a multi-color combination of polyethylene fibers and textured polypropylene thatch constructed to the following:

- a. Warranty: Lifetime
 - b. Pile weight: >75 ounces
 - c. Total weight: >103 ounces
 - d. Fiber height: 1 7/8"
 - e. Thatch height: .75"
 - f. Permeability: >45 inches per hour
 - g. Infill: Envirofill
2. Acceptable synthetic grass yarn manufactures include:
 - a. SYN Lawn/SYN Augustine 347 as distributed by New England Turf Store and installed by Atlantic Sports Group, Canton MA or approved equal.
- C. Perforations
1. Synthetic grass carpeting shall be perforated to provide vertical drainage as specified herein.
 2. Size and spacing of perforations shall be as specified herein. Spacing of perforations shall be uniform in both directions.
 3. Perforations shall be complete and full diameter for a minimum of 95% of each roll.
 4. Perforations shall be tested by passing a 3/8" drill bit through the holes with no more than 7 lbs. pressure.
- D. Adhesive Materials and Seaming Tape
1. Adhesive material to fix the synthetic grass carpet to the seaming tape shall be a polyurethane adhesive:
 - a. NORDOT Adhesive by Synthetic Surfaces Inc.
 - b. Turfbond Synthetic Turf Adhesive
 - c. SYNBind Adhesive
 2. If a hot melt welding method is used, the glue shall have an application temperature of 325 degrees F. with a melting point of 180 degrees F. Material shall be National Adhesive #34-5372 or equal. Submission of all hot melts shall be 10 calendar days prior to installation.
 3. Bonding surfaces shall be clean, dry, and free from grease, oil, wax, weak oxide films, mold release agents, and other surface contaminants.
 4. The adhesive shall be applied at the rate not to exceed 60 square feet per gallon.

5. The adhesive shall have the same warranty period as the synthetic grass system.
6. Seaming tape shall be a 12" wide polypropylene or polyethylene fabric acceptable for use with the synthetic turf carpet system and the adhesive material.
7. Seaming tape shall meet FIFA Joint Strength >25N/100mm

E. Synthetic Grass Infill

1. Infill shall be Envirofill by USGreentech or approved equal.
 - a. Non-toxic acrylic coated round sand with Microban antimicrobial protection infused into the coating to prevent growth of bacteria, mold and mildew.
 - b. Material shall remain free draining.
 - c. Minimum 16-year warranty.
2. Infill Materials shall be uniformly filled to a depth.

F. Impact Attenuation Pad

1. Impact attenuation pad system shall be installed prior to installing the synthetic grass landscape surfacing. A minimum 20 mm thick pad shall be as manufactured by Brock or approved equal. Pads shall be interlocking expanded polypropylene manufactured specifically for shock absorption and impact attenuation for playgrounds and athletic fields. Product shall be resistant to heat, chemicals, moisture, micro-organisms and retain shape memory. The pad shall be free draining in all weather conditions. **Shock pad thickness shall be no less than above mentioned however it shall meet or exceed the critical fall height requirements of any surrounding structure directly on top of proposed area.**

G. Synthetic Grass Nailer

1. Nailer board: 2"x4"x12' composite lumber manufactured for use in synthetic turf tack board applications. Composite lumber shall be as manufactured by Best Plus Plastic Lumber. Composite lumber shall be fabricated in the USA from recycled HDPE plastic with a non-porous surface, waterproof, non-rotting with flexible characteristics.
2. Min. 3" long Hilti Nails for fastening composite nailer board to face of concrete curbing and walkway edges around perimeter of synthetic landscape grass area. Fasten 16" O.C. Tapcon screws are also an acceptable fastener. Pre-drill holes if screws are utilized.
3. PL Construction adhesive or equal for fastening nailer board to face of concrete curbing and walkway edges around the perimeter of the synthetic landscape grass area.

H. Dynamic Stone Base shall be constructed of base stone and finishing stone as specified.

1. Base stone shall be crushed angular stone processed from a stone quarry, washed, graded, free draining crushed basalt stone. Processed stone shall be clean and free of deleterious materials. Base stone shall have a gradation as follows:

<u>U.S SIEVE NO.</u>	<u>% PASSING BY WEIGHT</u>
1"	100
¾ "	85-100
½ "	55-85
3/8 "	40-75
¼"	25-65
#4	5-35
#8	0-20
#16	0-10
#200	0-2

2. Finishing Stone shall be crushed angular stone processed from a stone quarry, washed, graded, free draining crushed basalt stone. Processed stone shall be clean and free of deleterious materials.

<u>U.S. SIEVE NO.</u>	<u>% PASSING BY WEIGHT</u>
¾ "	
½ "	100
3/8 "	85-100
¼"	75-100
#4	60-90
#8	35-75
#16	10-55
#30	0-40
#50/60	0-15
#100	0-8
#200	0-2

3. Fragmentation of Base and Finish stone shall be 100%. No rounded stone or sand shall be accepted.

PART 3 - EXECUTION

3.1 GENERAL

- A. Verify site conditions before proceeding with demolition work. Field check the accuracy of the Drawings and inspect structures, utilities, and other site features prior to start of work and notify Engineer in writing, of any hazardous conditions and/or discrepancies.
- B. Weather Permitted Conditions: The Contractor shall not perform any work if the conditions for working are:
 1. Ambient air temperatures are below 45 degrees F.

2. Material temperature falls below 45 degrees F.
 3. Rain is forecast or falling.
 4. Conditions exist or are pending that will be unsuitable to the installation of the system.
- C. Drawings / Specifications: The Contractor shall perform all work in strict accordance to the Contract Drawings / Plans, Shop Drawings and manufacturer's specifications and instructions.
- D. Verification: The Contractor shall be responsible for the inspecting, verifying and completing all installed work of this section.

3.2 EXAMINATION

- A. Acceptance of Prior Work-Stone Base: Upon completion of the base work, the Turf Installation Contractor shall submit a letter, addressed to the Owner, signed by the Site General Contractor and the Turf Installer/Manufacturer. The letter shall confirm Stone Base has been reviewed, including all testing data, and is acceptable for installation of the new synthetic grass surfacing. Any discrepancies, problems, and/or conflicts shall be addressed prior to issuance of the letter. Continuing with the installation of the synthetic grass surfacing over the play area base stone without issuance of such letter shall be considered as an approval of the base by the Turf Manufacturer Installer/Manufacturer.
1. Drainage Testing:
 - a. Perform infiltration tests, double-ring infiltrometer, ASTM F1551/EN 12616 - Standard Test Method for Comprehensive Characterization of Synthetic Turf Playing Surfaces and Materials, after the play area base is completed. Alternative infiltration testing will not be considered valid.
 - b. Testing Frequency: Perform one test for each 5,000 square feet (5,000 sf) of completed area.
 - c. Testing criteria: Each test will be considered acceptable when an infiltration rate meets requirements. Do not proceed with installation of subsequent layers until all tests are considered acceptable

3.3 PREPARATION

- A. The Contractor shall take special care to protect curbing, base stone and drainage. Any damage shall be repaired or replaced at the cost of the Contractor.
- B. Layout: The Contractor shall be responsible for field measurements and coordination with turf manufacturer prior to fabrication and delivery to site.
- C. Maintain clean base stone. Contractor shall prevent tracking soils or debris into base stone of turf areas. Fine grade stone base to establish grades and compact stone base to produce a consistent planarity.

3.4 INSTALLATION

A. Synthetic Grass Surfacing Installation

1. The synthetic grass carpet shall be staged and unrolled as necessary for a daily installation. No material will be allowed to be unrolled 24 hours prior to installation.

B. Seams

1. All panel seams shall be securely glued and lay flat.
2. All panel seams spacing is to be held to a minimum of 15 feet unless prior approval of seaming diagram indicates a lesser panel.
3. All seams shall be brushed thoroughly before infill materials are installed.

C. Synthetic Grass System Edges and Termination

1. All edges and ends of the synthetic grass system shall be secured to the termination nailer/curb.

D. Synthetic Grass Surfacing Infill

1. No in-fill materials shall be installed until the synthetic grass surfacing is fully, except for the edge attachment.
2. The synthetic grass surfacing shall be thoroughly brushed prior to any in-fill materials to remove any wrinkles and defibrillate the slit film.
3. The in-fill materials shall be installed in layers not to exceed 0.30 lbs. per sq. ft per layer.
4. The synthetic grass surfacing shall be attached to the edge anchor after sufficient infill has been installed.

E. Fastening Synthetic Grass Surfacing System

1. Prior to fastening the nailer board apply PL Construction Adhesive to the face of the board and vertical concrete face to provide consistent and even coverage for maximum adhesion to each surface. Apply per manufacturer's instructions. Prevent adhesive from being transferred onto finished and visible surfaces.
2. Attach 2"x4" composite nailer board to concrete containment edge with min 3" long Hilti Nails or Tapcon screws. Pre-drill holes if screws are utilized. Ensure method of fastening does not compromise integrity of concrete curbing or walkway edges. Fastening should occur along center line of board at approximately 16" O.C. drive nails flush with surface of nailer board.
3. Locate board at a consistent elevation to provide an even reveal from finished sidewalk and curb finished grade. Coordinate top of nailer elevation with final shop drawings to coordinate final infill depth and turf fiber height.

4. Cut synthetic grass surfacing backing to fully cover the composite nailer and conform to the perimeter containment edge. Cut a clean and consistent edge in the grass surfacing backing without tears. Fasten turf to nailer with galvanized staples 1" O.C.. Turf shall lay flat on nailer. Synthetic grass edge shall not be permitted to curl up face of vertical concrete edges. Top surface of composite nailer shall be smooth and free from excess adhesive.
5. Edge shall not create a tripping hazard. Round exposed concrete edges abutting the turf surface as detailed.
6. Cut bottom edge of nailer board at 45-degree angle, facing outward to ensure base aggregate infills under the nailer board, preventing voids which could cause differential future settlement along the turf and concrete edges.

F. Impact Attenuation Pad

1. Impact attenuation pads shall be set on fine graded top finishing stone to form a stable base with consistent planarity. No voids will be permitted under the pad. Interlock or secure pads together per manufacturer requirements prior to installing synthetic grass surfacing over pads. Ensure edges of base and finished stone are compacted to prevent future settlement. Top of pad shall be set flush with the top of the perimeter composite nailer board or concrete lip.

3.5 PROTECTION

- A. The Contractor shall take special care to protect all site improvements. Any damage shall be repaired or replaced at the cost of the Contractor.

3.6 TRAINING INSTRUCTION AND OWNER'S MANUALS

- A. Provide an on-site training instructional program for the Owner. The training shall include review and demonstration generally of the following, but not be limited to:
 1. Daily/Weekly fiber, infill, and seam inspections.
 2. Low infill hand grooming and infill placement.
 3. Seam repair.
 4. Sweeping and grooming.
 5. Procedure for Warranty claims.

3.7 CLEAN UP

- A. The site shall be kept clean and free of debris throughout the installation. Empty barrels, sacks, bags, and remnant materials shall be stored or disposed daily in a proper container or legal manner.

- B. After completion of the entire Project, the site shall have a general cleanup removing all debris remaining on the site that is not a part of the final Project.
- C. The equipment supply requirements for this Project shall be part of the total price and shall be the sole expense of the Contractor.
- D. All-natural grass areas disturbed during this construction shall be restored to the satisfaction of the Owner at no additional cost to the Owner.
- E. All attic stock materials shall be placed in it's appropriate location as determined by the Owner.

3.8 Acceptance

- A. Should any imperfections develop in the surface areas prior to the final acceptance of the work, they shall be removed and replaced with new materials. All such repair work shall be done at no additional cost to the Owner.
- B. Acceptance will be issued to the Contractor as described under "Substantial Completion" when all work under this section is found to be completed. The Owner or Landscape Architect will not be responsible for any additional acceptance requirements by the Contractor or subcontractor.

END OF SECTION 32 18 13

SECTION 32 18 16.01 – POURED PLAY AREA SURFACING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Installation of a geotextile fabric over a prepared processed aggregate base.
 - 2. Installation of a porous, synthetic safety surface system.
- B. Related Sections include the following:
 - 1. Division 31 Section “Earth Moving”.
 - 2. Division 32 Section “Synthetic Grass Surfacing”

1.3 PERFORMANCE REQUIREMENTS

- A. All material specified and installed under this Section must comply with:
 - 1. Handbook for Public Playground safety (Publication No. 325, April, 2008) of the U.S. Consumer Product Safety Commission as referenced by the Connecticut Department of Consumer Protection.
 - 2. The Americans with Disabilities Act Accessibility Guidelines For Play Areas – October 15, 2000, Final Rule.
 - 3. ASTM F 1951, Provisional Standard Specification for Determination of Accessibility of Surface Systems Under and Around Playground Equipment.
 - 4. ASTM F 1292, Standard Specification for Impact Attenuation of Accessible Surfacing Systems Under and Around Playground Equipment.

1.4 SUBMITTALS

- A. Manufacturer literature and sample indicating conformance with project requirements.
- B. Written warranties for safety surfacing, including manufacturer’s certification of compliance with ASTM F-1292 and mandated shock absorbance for specified equipment.
- C. Written certification from the manufacturer and/or installation contractor, stating that the material, volume and configuration of the surface system installed at this specific location, (specific project must be mentioned in the letter) complies with the ASTM sections referenced in the Performance Requirements above.

1.5 QUALITY ASSURANCE

- A. Installer of surfacing systems to be approved by surfacing manufacturer and Owner.

1.6 WARRANTY

- A. Furnish manufacturer's standard written limited warranty covering compliance with HPPS guidelines per ASTM F355-86 for a period of 8 years.

PART 2 – PRODUCTS

2.1 RESILIENT SAFETY SURFACE

- A. The impact-attenuating, resilient safety surface shall be resilient water permeable, synthetic rubber playground safety system comprised of polyurethane binders, processed rubber particles, and EPDM rubber granules installed over a suitable base at compacted thickness of 3-7/8 inches to comply with the latest Consumer Products Safety Commission guidelines. The product shall be similar to GT Impax Poured as distributed by Marturano Recreation Company, Spring Lake, NJ or approved equal.
- B. The rubber granules for the cushion base mat shall be processed SBR rubber buffings 6-16 mesh size, containing less than 4% dust and have a density of 1.13 – 0.05. The rubber shall be packed in suitable bags to protect the rubber from moisture during transportation and handling.
- C. The colored rubber granules for the top layer shall be EPDM peroxide cured, man made rubber containing a minimum 20 percent EPDM and having a density of 1.50 – 0.05 and chopped to a 1-3 mm size. The EPDM rubber granules shall be protected from moisture as described above.
- D. Binder for the Surface System shall be an MDI based one component, polyurethane binding agent. The binding agent shall not have a free TDI monomer level above 0.8 percent, must be clear in color, not milky, and must be solvent free. The binding agent shall be specially formulated for compatibility with SBR and EPDM rubber granules. Specific gravity for the binder shall be 1.07 – 0.03.
- E. Mixture Compositions:
 - 1. Job Mix Formulas shall be as follows:
 - a. Black SBR Cushion Base

SBR Rubber particles	84 percent by weight
Polyurethane Binder	16 percent by weight

- b. Colored EPDM Top Layer
 - EPDM Rubber Granules 1-3 mm 80 percent by weight
 - Polyurethane Binder 20 percent by weight
- F. Sub-base shall be a processed aggregate as specified under Section “Earth Moving” of these Specifications, installation by others.
- G. Separation Fabric: Woven geotextile, specifically manufactured for use as a separation geotextile; made from polyolefins, polyesters, or polyamides; and with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
 - 1. Grab Tensile Strength: 200 lbf; ASTM D 4632.
 - 2. Tear Strength: 75 lbf; ASTM D 4533.
 - 3. Puncture Resistance: 90 lbf; ASTM D 4833.
 - 4. Water Flow Rate: 4 gpm per sq. ft.; ASTM D 4491.
 - 5. Apparent Opening Size: No. 30; ASTM D 4751.

PART 3 – EXECUTION

3.1 GENERAL

- A. Coordinate the installation of the geotextile fabric and synthetic safety surface system with Site Contractor’s installation of the edging system, underdrains and processed aggregate base. Verify that base system meets with required grades for installation of improvements under this section of the Specifications. Should a conflict exist, notify the Architect immediately for remediation of any discrepancies prior to proceeding with improvements.
- B. Insure that at a minimum, play equipment support posts have been installed, cured, and that base material has been backfilled, graded and compacted, prior to installation of improvements.

3.2 RESILIENT SAFETY SURFACE

- A. For products manufactured for the purpose of safety surfacing, a statement signed by an official authorized to certify on behalf of the manufacturer, attesting that the installed surfacing meets the requirements of ASTM F 1292 for a head-first fall from the highest accessible portion of specified playground equipment. The statement shall be dated after the award of the Contract, shall state the Contractor’s name, address and telephone number of the testing company, the date of the test, and the test results. Regardless of the

installer, the statement shall also attest that the installation complies with manufacturer's instructions and specifications.

- B. Resilient surface shall be installed over the geotextile fabric and a processed aggregate base as detailed on the Drawings.
- C. Process Aggregate base shall be covered with the geotextile fabric by the surface installation contractor. All seams shall overlap a minimum of six inches and be adhered per manufacturer's instructions.
- D. The shredded SRB rubber and polyurethane binder shall be blended together at a ratio of 84/16 in a mechanical mortar mixer until all particles of the rubber are coated with binder. The blended materials shall then be spread onto the prepared base and leveled to the proper elevation using gauge bars equal to the required thickness. After the material has been leveled it shall be finished to a smooth surface and compacted using steel trowels. Curing time is dependent on temperature and humidity and can vary from 2 hours to 2 days. On occasions of low humidity it is advised to fog the complete surface with water to aid the curing process. When the surface can be walked on without leaving depressions, it has cured enough to proceed with the installation of the top layer.
- E. The shredded EPDM rubber and polyurethane binder shall be blended together at a ratio of 80/20 in a mechanical mortar mixer until an EPDM rubber granules are coated with binder. The blended materials shall then be spread onto the cured cushion base and leveled to the proper elevation using gauge bars equal to the required thickness. After the material has been leveled it shall be finished to a smooth surface using steel trowels. Curing time is dependent on temperature and humidity and can vary from one hour to one day. On occasions of low humidity it is advised to fog the completed surface with water to aid the curing process. Color selection shall be by the Architect/Engineer. Access to finished surface shall be restricted until approved and accepted by the Architect/Engineer. This acceptance will not occur prior to 24 hours after top surface has set up.
- F. A manufacturer's representative experienced in installation of the specified playground safety surface shall be provided. The representative shall supervise the installation to ensure that the safety surfacing meets the specified impact attenuation safety performance requirement.
- G. Owner shall make arrangements to have an inspection by an independent Certified Playground Inspector to certify that play equipment and safety surface installation are in compliance with ASTM F-1487 and PPSH No. 325 regulations. Any discrepancies found by the inspection report shall be corrected by the Contractor at no cost to the Owner.
- H. Prohibit use of play equipment until final acceptance of project by Owner.

3.3 CLEAN UP/PROTECTION

- A. Protect until acceptance of the project. Replace or refinish the surfaces if damaged prior to acceptance.
- B. Clean up all debris from installation procedures.

ANNA REYNOLDS ELEMENTARY SCHOOL
NEWINGTON, CT

RENOVATIONS
STATE PROJECT #094-0109 RNV
KBA #21011.00

END OF SECTION 321816.01

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SECTION 32 18 23.26 — NATURAL FIELD PLAY SURFACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Construction of natural turf playing fields.
 - 2. Maintenance of natural turf playing fields until acceptance.
- B. Related Sections include the following:
 - 1. Division 31 Section “Earth Moving”.
 - 2. Division 32 Section “Topsoil”.
 - 3. Division 32 Section “Turf and Grasses”

1.3 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for the following:
 - 1. Fertilizers.
 - 2. Limestone.
 - 3. Chemical preservatives and controls – also confirm that each of the materials proposed to be applied are permitted for use by the State of Connecticut.
- C. Certification of grass seed from seed vendor for each grass seed mixture stating the botanical and common name and percentage by weight of each species and variety and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
- D. Submit list of machinery to be used during subgrade preparation and topsoiling operations. No rubber-tired machinery will be permitted except for lightweight, farm tractor grade machinery with wide tires designed for turf use. All heavy machinery must be track driven.
- E. Qualification data for firms and persons specified in the “Quality Assurance” Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and address of Architects and Owners, and other information specified.

- F. Material test reports from qualified independent testing agency indicating and interpreting test results relative to compliance of the following materials with requirements indicated.
 - 1. Analysis of existing surface soil.
 - 2. Analysis of imported topsoil.
 - 3. Sieve analysis of stockpiled subsoil.
- G. Planting schedule indicating anticipated dates and locations for each type of seeding.
- H. Field survey of playing field finished grades, for approval, prior to lawn installation.
- I. Maintenance instructions recommending procedures to be established by Owner for maintenance of lawns during an entire year. Submit before expiration of required maintenance periods.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who has completed lawn development work similar in material, design, and extent to that indicated for this Project and with a record of successful grass establishment.
 - 1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on the Project site during times that grass planting is in progress.
 - 2. Natural turf playing field contractors must have successfully completed 5 natural turf fields in the past three years, similar to the design and materials specified herein.
- B. Examine work to receive natural turf field development and notify the architect of any defects. Specifically review the subgrade preparation. Commencement of this work implies acceptance by Contractor of preparatory work by others.
- C. Pre-installation Conference: Conduct conference at Project site to comply with requirements of Division 1 Section "Project Meetings".

1.5 DELIVERY, STORAGE AND HANDLING

- A. Seed, Fertilizer and Lime: Deliver in original sealed, labeled, and undamaged containers, showing weight, analysis, and name of manufacturer.
- B. Protect materials from deterioration during delivery and while stored at site.

1.6 GUARANTEE

- A. Duration of guarantee shall be until the completion of the specified maintenance period and until Owner's final acceptance of all-natural turf playing fields.

PART 2 - PRODUCTS

2.1 SEED

- A. Grass Seed: Fresh, clean, dry, new crop seed complying with the Association of Official Seed Analysts' "Rules for Testing Seeds" for purity and germination tolerances.
 - 1. Seed Mixture: Provide seed of grass species and varieties, proportions by weight, and minimum percentages of purity, germination, and maximum percentage of weed seed as indicated on Schedules at the end of this Section.

2.2 LIME

- A. ASTM C 602, class T, agricultural ground limestone containing a minimum 50 percent total oxides (calcium oxide plus magnesium oxide), with a minimum 50 percent passing a 100-mesh sieve, and 98 percent passing a 20-mesh sieve, for powder form of lime.
 - 1. Provide lime in the form of dolomitic limestone.

2.3 FERTILIZER

- A. Phosphorus: Commercial, soluble; guaranteed analysis of 0-46-0.
- B. Starter Fertilizer: Commercial grade complete fertilizer of neutral character, consisting of fast release water soluble nitrogen, derived from natural organic sources of urea ammonium phosphate, or similar material.
 - 1. Composition: Nitrogen, phosphorus, and potassium in amounts recommended in soil reports from a qualified soil testing agency, 14.28.14 guaranteed analysis.
- C. Secondary Fertilizer: Granular fertilizer consisting of 50 percent water insoluble nitrogen, phosphorus, and potassium with guaranteed analysis of 15.15.15.
- D. Tertiary Fertilizer: guaranteed analysis of 46.0.0.

2.4 MULCHES

- A. Straw Mulch: Provide air dry, clean, mildew and seed free, salt hay or threshed straw of wheat, rye, oats or barley.
- B. Peat Mulch: Provide peat moss in natural, shredded, or granulated form, of fine texture, with a pH range of 4 to 6 and a water absorbing capacity of 1100 to 2000 percent.
- C. Fiber Mulch: Biodegradable dyed wood cellulose fiber mulch, nontoxic, free of plant growth or germination inhibitors, with maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.
- D. Non asphaltic Tackifier: Colloidal tackifier recommended by fiber mulch manufacturer for slurry application, nontoxic and free of plant growth or germination inhibitors.

2.5 SALT MARSH HAY

- A. Naturally harvested salt marsh hay, certified weed free.

2.6 CHEMICAL PREVENTATIVES AND CONTROLS

- A. The use of registered herbicides and pesticides for lawn care on k-8 school grounds are prohibited by the State of Connecticut General Statutes. Contractors shall utilize means and methods classified as acceptable by Local and the State regulations to establish weed free lawn areas. The contractor shall provide documentation confirming that all lawn care products used on this project comply with State and Local requirements.

2.7 GEOTEXTILE FABRIC

- A. Refer to Division 31 Section “Earth Moving” of this specification for separation fabric, type of geotextile fabric.

2.8 WATER

- A. Potable
- B. The Contractor is solely responsible for furnishing all water necessary to complete the establishment, maintenance and acceptance of natural turf playing fields, including temporary water, prior to installation/activation of any proposed irrigation system.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive natural turf playing fields for compliance with requirements and for conditions affecting performance of work of this Section. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 COORDINATION AND SCHEDULING

- A. Planting Season: Sow lawn seed during normal planting seasons for type of lawn work required. Correlate planting with specified maintenance periods to provide required maintenance from date of Substantial Completion.
- B. Weather Limitations: Proceed with planting only when existing and forecast weather conditions are suitable for work.
- C. Construct natural turf playing fields between April 1 and June 1, and between August 15 and October 1, unless otherwise approved.
- D. Examine areas to receive seeding and notify Architect of any problems prior to commencing work. Specifically review the topsoil placement (depths, grades and conditions). Commencement of this work implies acceptance by Contractor of preparatory work of others.

3.3 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements and other facilities, trees, shrubs, and plantings from damage caused by natural turf playing field development operations.
- B. Provide erosion control measures to prevent erosion or displacement of soils and discharge of soil bearing water runoff or airborne dust to adjacent properties and walkways.
- C. Ensure that natural turf playing field subgrade has been prepared in accordance with appropriate section of this specification to ensure it is free draining.

3.4 TOPSOIL PLACEMENT

- A. Apply approved, topsoil to depth indicated on Drawings.
- B. Install topsoil in accordance with Section “Topsoil” of this Specification.
- C. Loosen subgrade within all areas used for construction staging and activity. Contractor shall notify Architect to review loosened and prepared subgrade prior to topsoil installation.
- D. Spread topsoil using rubber tire loaders or graders which do not have a compaction capacity greater than a small farm tractor. Keep all heavy equipment and trucks off placed and graded topsoil.

3.5 TOPSOIL PREPARATION – GENERAL

- A. Apply lime, and phosphorus at the rates recommended by the topsoil tests in all areas where topsoil has been installed. Cultivate topsoil to its full depth by scarifying or other disking methods to thoroughly incorporate amendments into the topsoil. Maintain a loose friable seed bed. At no time will rubber tired loaders or graders having greater compaction than a small farm tractor be allowed on topsoil. Keep all heavy equipment and trucks off prepared topsoil: Do not prepare while ground is wet or frozen.
- B. Provide additional topsoil where and as required to properly meet all proposed finish grades.
- C. Remove: any weeds, debris, foreign matter and stones having any dimension greater than 1/2”. Remove from property.
- D. Fine grade to a smooth uniform surface. The entire area shall present an even grade with no depressions where water will stand. Any protective fencing around existing trees shall be removed and disposed of by the Contractor at this time. Topsoil shall be smoothly blended to existing finish grades around trees erosion control devices and adjacent existing conditions, maintain existing surface drainage patterns. Round off all top and toe of slopes. Reinstall erosion control devices and protective fencing as required.
- E. Approval of surface by architect shall be obtained before seeding operations begin. Where directed, perform bulk density and nuclear compaction readings to monitor degree of soil compaction/seed bed friability.

3.6 NATURAL TURF PLAYING FIELD GRADING

- A. Grade all-natural turf playing fields to a smooth, even surface with loose, uniformly fine texture using a grading tractor fitted with automatically controlled laser grading equipment (land plane or box plane). Laser guided system must be capable of generating a laser controlled, automatic system to within 1/4" tolerance the full length of the playing field.
- B. Conduct a field survey of all-natural turf playing field areas at 25' o.c. grid. Grades shall be checked using a dual plane laser operation survey instrument and shall be within 1/2" of required elevation, non-cumulative. Correct irregularities beyond this tolerance to eliminate all mounds and depressions, and produce a stable, firm seeding or sodding surface.

3.7 NATURAL TURF PLAYING FIELD SEEDING

- A. Install starter fertilizer on the finish grade.
- B. Hydro-seeding of natural turf playing fields is NOT permitted.
- C. Sow specified seed at the specified rates using a culti packer, silt type seeder. Apply the seed in two directions with the second application made at approximately 75-degree angle to the first application.

3.8 WATERING LAWN AREAS

- A. Maintain a moist seed bed at all times. Water seed bed daily with 1/4" water/day using minimum three spray sets, keeping the surface moist. Apply complete coverage to insure proper germination/root growth conditions. Maintain soil moisture at or near field capacity during the period of germination and seeding development.
- B. Protect all of the natural turf playing field areas with barricades, if necessary, to keep all traffic off the area. Repair all damage to lawn areas including topsoil replacement, at no additional cost to Owner. Protect turf and lawn areas until lawns are established and accepted.
- C. It is the contractor's responsibility to provide and maintain a temporary irrigation system as necessary to establish a full, acceptable stand of lawn in all areas. Adjust watering requirement as required at request of Owner and after a full ground cover has been achieved. Continue watering all lawn areas until acceptance by Architect and Owner.

3.9 MAINTENANCE

- A. Begin maintenance of natural turf immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:
 - 1. Seeded Areas: minimum 60 days after date of Substantial Completion, and after a minimum of 5 mowings.
 - 2. When full maintenance period has not elapsed before end of planting season, or if lawn is not fully established at that time, continue maintenance during next planting season.
- B. Maintain and establish all-natural turf playing field turf by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade and replant bare or eroded areas and mulch to produce a uniformly smooth lawn.
- C. Replant bare areas with same materials specified for natural turf playing fields.
- D. Add new mulch in areas where mulch has been disturbed by wind or maintenance operations sufficiently to nullify its purpose. Anchor as required to prevent displacement.
- E. Crabgrass and broadleaf weed control.
 - 1. General: Utilize products confirmed as acceptable by State of Connecticut and Local.
 - 2. Time: Conform to the manufacturer's recommendations.
 - 3. Rate: Conform to the manufacturer's recommendations.
- F. Disease Control
 - 1. General: Utilize products confirmed as acceptable by State of Connecticut and Local. Treat any diseased natural turf areas with disease control in conformance with the manufacturer's recommendations as required (after diagnosis of disease organisms).
 - 2. All materials shall conform with State of Connecticut Statutes.
 - 3. Time: Conform to the manufacturer's recommendations.
 - 4. Rate: Conform to the manufacturer's recommendations.
- G. Mow natural turf as soon as there is enough top growth to cut with reel mower set at mowing height of 1-1/2" (bench height). Repeat mowing as required to maintain specified height without cutting more than 30 percent of the grass height on maximum 5-day interval. Remove no more than 30 percent of grass leaf growth in initial or subsequent mowings. Do not mow when grass is wet. Schedule mowing when grass attains a 2" height. Subsequent mowings to maintain following grass height.
 - 1. Mow grass from 1-1/2 to 2 inches high.
 - 2. Maintain reel blade and bed knife in sharp condition and evenly matched to provide a clean cut.
- H. Secondary Fertilization: Apply secondary fertilization to entire natural turf playing field areas two weeks after seeding, 4 weeks after sodding.
- I. Tertiary Fertilizations: Apply three (3) tertiary fertilizations at two-week interval (4, 6, and 8 weeks after seeding) to entire seeded natural turf playing field areas only.

3.10 SATISFACTORY LAWN

- A. Seeded natural turf playing field turf will be satisfactory and eligible for Owner's acceptance provided all requirements, including maintenance, have been met and a health, uniform, dense stand of grass is established, free of weeds and bare spots and surface irregularities, with coverage exceeding 90 percent over any 5 squares selected by the Architect. Architect shall be the sole judge. Lawns must be reasonably free of weeds, crabgrass, and other undesirable plants, with no diseases present. Acceptance will not be made until all damaged areas have been restored to original conditions.
- B. Prior to acceptance of natural turf playing fields, the Contractor shall perform 4 inch deep by 3/8" inch hollow-core aeration. Allow the cores to dry, drag the cores, and topdress with a one-quarter inch depth of sand to all-natural turf playing field areas. Contractor must request a meeting with the Architect to establish specific timing of this operation.
- C. Areas will not be accepted in "pieces" unless specifically agreed to by the Owner.
- D. Replant natural turf areas that do not meet requirements and continue maintenance until lawns are satisfactory. Upon stabilization of lawn areas, remove erosion control devices and protective fencing. Reseed bare areas as required.

3.11 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by natural turf field work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto surface of roads, walks, or other paved areas. Broom clean all walks and pavements.
- B. Erect barricades and warning signs as required to protect newly planted areas from traffic, vandalism, and unauthorized use. Maintain barricades throughout maintenance period until natural turf playing field turf is established and accepted by the Owner.

3.12 LAWN MATERIALS INSTALLATION

- A. Lawns: Provide materials in not less than the following quantities or per topsoil testing lab recommendations:
 - 1. Weight of lime per 100 sq. ft.: as per topsoil test report.
 - 2. Weight of phosphorous per 1000 sq. ft.: as per topsoil test report.
 - 3. Weight of commercial fertilizer per 1000 sq. ft.: as per topsoil test report.
 - 4. Cellulose Pulp Fiber: 32 lbs. /1,000 SF.
 - 5. Grass Seeding Rate: Minimum 220 lbs. /acre.
 - 6. Starter Fertilizer: 310 lbs. /acre.
 - 7. Secondary Fertilizer: 300 lbs. /acre.
 - 8. Tertiary Fertilizer 50 lbs. /acre, providing 22 of nitrogen/acre.
- B. Amend topsoil as per Lab testing recommendations.

3.13 SEED

- A. Provide: fresh, clean, new crop seed; blue tag certified complying with the tolerance for purity and germination established by the Office of Seed Analysis of North America. Provide seed of the grass species, proportions and maximum percentages of weed seed.
- B. Provide seed in cleaned, sealed, properly labeled containers. Seed that is wet, moldy, or otherwise damaged will not be accepted. Handle seed to manufacturer recommendations for exposure to extremes of heat, cold, or moisture.
- C. Lawn Seed Quality:
 - 1. Weed Seed: maximum of 0.50%, no noxious weed seed.
 - 2. Purity: minimum of 97% pure.
 - 3. Crop: maximum 0.50%.
 - 4. Germination Rate: minimum 85%.

D. Mixture for Natural Turf Playing Field Areas:

Seed shall be as distributed by Hart Seed or approved equal.

TYPE OF SEED	PERCENT BY WEIGHT
Ashland Kentucky Bluegrass	30%
Rockstar Kentucky Bluegrass	30%
Baron Kentucky Bluegrass	30%
Frontier Perennial Ryegrass	10%

END OF SECTION 32 18 23.26

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SECTION 32 18 23.53 – PAVEMENT COLOR SURFACING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. Section includes:
 - 1. Playground Pavement Preparation.
 - 2. Playground Pavement Color Surfacing
 - 3. Tack coat and Patch Binder.
 - 4. Acrylic Resurfacer.
 - 5. Acrylic Filler & Finish Coat.
- B. Related Sections include the following:
 - 1. Division 31 Section “Earth Moving”.
 - 2. Division 32 Section “Asphalt Paving”.

1.3 REFERENCES

- A. Reference herein to any technical society, organization, group or regulation are made in accordance with the following abbreviations and, unless otherwise noted or specified, all work under this Section shall conform to the latest edition as applicable.
- B. Code of Federal Regulations (CFR).
 - 1. 29 CFR 1926, Safety and Health Regulations for Construction.
- C. American Concrete Institute (ACI).
- D. State of Connecticut.
 - 1. Standard Specifications for Roads, Bridges and Incidental Construction, Form 816, 2004 and any supplements.
- E. American Society for Testing and Materials (ASTM)

1.4 DEFINITIONS

- A. Manufacturer specifications for components, color chart and installation instructions.

1.5 SUBMITTALS

- A. Manufacturer specifications for components, color chart and installation instructions.
- B. Authorized Applicator certificate from the surface system manufacturer.
- C. Reference list from the installer of at least 10 projects of similar scope done in the past 5 years.
- D. Current Material Safety Data Sheets (MSDS).
- E. The contractor shall record the batch number of each product used on the site and maintain it through the warranty period. Record shall be submitted for documentation by the Landscape Architect.
- F. Warranty documentation as described here in Section 1.8 Warranty.

1.6 COORDINATION

- A. Contractor shall coordinate with all other trades, especially Site Contractors to ensure approval of bituminous concrete base prior to playground surfacing application. Any rework shall be done at no cost to the Owner.
- B. Contractor shall conduct a field meeting with Owner and Architect prior to commencing surfacing operations. Surface texture shall be discussed to maintain a slip resistant finish.

1.7 QUALITY ASSURANCE

- A. Surfacing installation superintendent is to be on-site at all times while work is commencing.
- B. Curing compounds should not be used unless the curing compound manufacturer specifically states the surface may be coated with water based acrylic coatings.
- C. The contractor shall record the batch number of each product used on the site and maintain it through the warranty period.
- D. The installer shall be an authorized applicator of the specified system.
- E. The manufacturer's representative shall be available to help resolve material questions.
- F. Sands must be incorporated at the manufacturing location to insure quality and stability.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store materials in accordance with manufacturer specifications and MSDS.
- B. Deliver product to the site in original unopened containers with proper labels attached.

All surfacing materials shall be non-flammable.

1.9 WARRANTY

- A. The Contractor shall be required to guarantee all labor, materials, workmanship and services for the acrylic surfacing for a time period no less than (5) years.
- B. Provide the manufacturer's standard warranty.
- C. This Contractor shall be required to submit the following documents regarding the guarantee:
 - 1. Letter from the manufacturer(s) of all materials attesting to the guarantee length and limits.
 - a. Must be signed by an officer of the organization.
 - 2. Maintenance Instruction Guide for the Contract Surfaces, signed by an officer of the surface company and notarized.
 - 3. Letter of Guarantee from the Installation Contractor for the above time period, signed by an officer of the Company and notarized.
 - 4. These documents shall be submitted to the Landscape Architect prior to final payment..

1.10 INSTALLER QUALIFICATIONS

- A. Installer shall be regularly engaged in construction and surfacing of acrylic tennis courts, play courts, playgrounds or similar surfaces.
- B. Installer shall be an Authorized Applicator of the specified surface system.
- C. Have completed 15 projects of similar scope done in the past 3 years using the same materials. On-site superintend shall be the same as proposed for this project on all 15 projects.

1.11 MANUFACTURER QUALIFICATIONS

- A. System manufacturer shall provide documentation that the surface to be installed is correct for its intended product use.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Plexipave - California Products Corp., Andover, MA. 01810 / Plexipave System www.plexipave.com.
- B. World Class Courts, Richmond, VA. www.worldclasscourts.com.
- C. Action Pave, www.copelandcoating.com/products/action-pave-acrylic-coating-products
- D. NOVACRYLIC, Nova Sports, Framingham, MA, www.novasports.com

2.2 MATERIALS

- A. Patch Binder/Patching Mix - for use in patching cracks, holes, depressions and other surface imperfections.
- B. Crack Filler - for use in filling fine cracks.
- C. Acrylic Filler/ Resurfacer – for use as a filler for new or existing for use as a filler for new or existing asphalt surfaces.
- D. Acrylic Color Surface– for use as the finish color and texture. A two-part system blended to achieve the correct slip resistant surface texture.
- E. Water – for use in dilution/mixing shall be clean and potable.

2.3 MATERIAL SPECIFICATIONS

- A. Patch Binder/Patching Mix – 100% acrylic resin blended with Portland Cement and silica sand.
 - 1. Percent solids by weight (minimum) 46%
 - 2. Weight 8.7-8.9 lbs./gallon
- B. Crack Filler – 100% acrylic resin blended with Portland Cement and silica sand.
 - 1. Percent solids by weight (minimum) 46%
 - 2. Weight 15 lbs./gallon
- C. Acrylic Filler/Resurfacer – 100% acrylic resin (no vinyl copolymerization constituent). The product shall contain not less than 3.5% attapulgite.
 - 1. Percent solids by weight (minimum) 26.7%
 - 2. Weight 8.7-8.9 lbs./gallon
- D. 100% Acrylic Resin (no vinyl copolymerization constituent) with selected light fast pigments. Green shall contain not less than 8% chrome oxide.
 - 1. Percent solids by weight (minimum) 36.5%
 - 2. Weight 10.0-10.2 lbs./gallon
- E. Color Base – 100% acrylic resin containing no vinyl copolymerization constituent. Contains not more than 63% rounded silica sand.
 - 1. Percent solids by weight (minimum) 74%
 - 2. Weight 13.1-14.1 lbs./gallon

- F. All surfacing materials shall be non-flammable and have a VOC content of not less than 100g./ltr. Measured by EPA method 24.
- G. Sands must be incorporated at the manufacturing location to ensure quality and stability.
- H. Asphalt or tar in any form will not be permitted in any coating.
- I. The color shall be pure acrylic containing no asphalt or tar emulsions and no vinyls, alkyds or non-acrylic resins. The color system shall contain factory mixed compounds requiring only the addition of water at the job site.
- J. Submit a full range of approved manufacturer's colors for final selection and approval by Architect and Owner.
- K. Base Bid Color: A minimum of 2 colors shall be selected by the Architect and Owner for installation within the general courtyard play area and track as shown on the project drawings.
- L. All lines in the play area shall be painted white and compatible with the acrylic product. All dashed center lines on track shall be painted yellow. White and yellow paint colors for line striping are in addition to the two acrylic colors that will be selected for play area surfacing.
- M. All material shall be delivered to the site in sealed containers with manufacturers label affixed.
- N. Final surface shall utilize sand and existing asphalt texture to provide a slip resistant finish suitable for play areas.

PART 3 EXECUTION

3.1 GENERAL

- A. Verify site conditions before proceeding with demolition work. Field check the accuracy of the Drawings and inspect structures, utilities, and other site features prior to start of work and notify Engineer in writing, of any hazardous conditions and/or discrepancies.
- B. Ensure that the bituminous concrete pavement has been allowed to cure at least 14 days prior to commencing work under this section.
- C. Bituminous concrete paving work shall be accepted by the surfacing installer, in writing, prior to applying surfacing.
- D. Contractor shall conduct a site meeting to review progress and surface texture following first application of resurfacer to determine additional applications. Final finish shall achieve a consistent texture across the play areas. The finish shall be slip resistant and suitable for play areas.
- E. Form clean lines differentiating colors.
- F. Fill in depressions in asphalt pavement with approved product to prevent puddling.

3.2 WEATHER LIMITATIONS

- A. Do not install when rainfall is imminent or extremely high humidity prevents drying.

- B. Do not apply unless surface and air temperature are 50°F and rising.
- C. Do not apply if surface temperature is in excess of 140°F.

3.3 PREPARATION

- A. Clean surfaces of loose dirt, oil, grease, leaves, and other debris in strict accordance with manufacturer's directions. Pressure washing will be necessary to adequately clean areas to be coated. Any areas previously showing algae growth shall be treated with Clorox or approved product to kill the organisms and then be properly rinsed.
- B. Holes and cracks: Cracks and holes shall be cleaned and a suitable soil sterilant, as approved by the Landscape Architect, shall be applied to kill all vegetation 14 days prior to use of Court Patch Binder according to manufacturer's specifications.
- C. Depression: Depressions holding enough water to cover a five cent piece shall be filled with Patch Binder Patching Mix. 3 gallons of Patch Binder, 100 lbs. 60-80 silica sand, 1 gallon Dry Portland Cement (Type I). **This step shall be accomplished prior to the squeegee application of Acrylic Filler/Resurfacer.**
- D. The surface to be coated as specified shall be inspected and made sure to be free of grease, oil and other foreign matter before starting the work. The Contractor shall remove by broom, vacuum, blower or power washer all dust, dirt, imbedded soil, etc., as necessary to provide a clean surface to receive the color system.
- E. Care shall be taken to protect adjacent areas and structures (fences, posts, sidewalks, buildings, etc.) which are not to be coated. In the event that coatings are applied to above, remove immediately before drying occurs.
- F. Filler/Resurface Course. (Acrylic Resurfacer): On the properly applied primer the filler course shall be applied to the clean underlying surface in one application to obtain a total quantity of not less than .06 gallon per square yard based on the material prior to any dilution. Acrylic Resurfacer may be used to pre-coat depression and crack/hole repairs to achieve better planarity prior to filler course application. The in depth filler coat coloring shall match the color combination for the finished surface.
 - 1. Over a properly repaired surface of concrete on existing walks, apply two coats of the filler course according to the following mix:
 - a. Acrylic Resurfacer 55 gallons
 - b. Water 20-40 gallons
 - c. Sand 600-800 lbs./60-80 mesh
 - d. Liquid Yield 112-138 gallons
 - 2. On new pavement, **a minimum of two coats of Acrylic Resurfacer** may be used to properly fill all voids in the asphalt surface. Use clean, dry 50-60 mesh sand and clean, potable water to make mixes. The quantity of sand and water in the above mix may be adjusted within above limits to complement the roughness and temperature of the surface.

3. The quantity of water used in diluting these coatings may exceed the quantity specified by the manufacturer only by a small amount and only if too rapid drying is occurring because of weather conditions. Permission of the Landscape Architect shall be obtained before adding any additional water.
4. Mix the ingredients thoroughly using accepted mixing devices and use a 70 Durometer rubber bladed squeegee to apply each coat of Acrylic Resurfacer as required.
5. Allow the application of Acrylic Filler/Resurfacer to dry thoroughly. Scrape off all ridges and rough spots prior to any subsequent application of Acrylic Resurfacer or subsequent cushion or color surface system.

3.4 APPLICATION

- A. All areas to be color coated shall be clean, free from sand, clay, grease, dust, salt or other foreign matters. The Contractor shall obtain the Engineer's approval, prior to applying any surface treatment.
- B. Blend color base and acrylic resin with a mechanical mixer to achieve a uniform mixture. The mix shall be:
 1. Color Base: 30 Gallons
 2. Acrylic Resin: 20 Gallons
 3. Water: 20 Gallons
- C. Application shall be made by 50 durometer rubber faced squeegees. The uniform mixture should be poured on to the playground surface and spread to a uniform thickness in a regular pattern.
- D. A total of 3 applications of the uniform mixture shall be made to achieve a total application rate of not less than .15 gal./sy. No application should be made until the previous application is thoroughly dry.

3.5 CLEANING

- A. Remove all containers, surplus materials and debris. Dispose of materials in accordance with local, state and Federal regulations.

3.6 PROTECTION

- A. Erect temporary barriers to protect coatings during drying and curing.

3.7 CLEAN UP

- A. Contractor shall remove all debris, residuals, and used materials at the conclusion of each day.
- B. Contractor shall leave the site in a clean and orderly condition, acceptable to the Owner, at the completion of the work.

END OF SECTION 32 12 16

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SECTION 32 31 01 – WOOD GUIDE RAIL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Wood Posts
 - 2. Wood Guiderail
 - 3. Miscellaneous Galvanized Fastening Hardware
- B. Related Sections include the following:
 - 1. Division 31 Section “Earth Moving”.
 - 2. Division 32 Section “Topsoil”.
 - 3. Division 32 Section “Lawns”.

1.3 SUBMITTALS

- A. Shop Drawings: Contractor shall provide fully dimensioned shop drawings and manufacturer’s technical literature for all improvements and confirm fabrication, reinforcing, and anchoring systems for approval.

1.4 QUALITY ASSURANCE

- A. Wood Treatment: Comply with American Wood Preservers Association (AWPA) standards for wood preservative treatment scheduled.
- B. Provide each piece of lumber factory grade marked in conformance with AWPA quality mark.
- C. Allowable Tolerances: Guiderail shall not deviate more than ½” in to grade in each section.

PART 2 - PRODUCTS

2.1 WOOD (TIMBERS)

- A. Rough sawn, No. 2 or better Southern Yellow Pine timbers, with a 1” chamfer on all edges.
- B. Rails: AWPA use Category UC3B, with 0.25 PCF ACQ retention, size 5 inch by 8 inch by length indicated.

- C. Posts: AWP use Category UC4A, with 0.40 ACQ retention, 12" x 12".
- D. Kiln dried or air dried before and after treatment for 25% maximum moisture content.

2.2 ACCESSORIES

- A. Provide miscellaneous steel hardware, concrete and accessories as required. All hardware shall be hot dipped galvanized, for exterior, high humidity, and treated wood conditions.
- B. Wood Stain: A water-based exterior grade, translucent stain. Stain shall be manufactured by Sherwin-Williams or equal.

PART 3 - EXECUTION

3.1 PREPARATIONS

- A. Obtain measurements and verify dimensions and details before proceeding with work.

3.2 JOB CONDITIONS

- A. Confirm pavements, curbs and other improvements are completed prior to installation of specified improvements.

3.3 INSTALLATION

- A. Install: Timber guide rails where and as show on the Drawings.
 - 1. Posts shall be set at a constant vertical alignment above finish grade of each segment of guiderail.
 - 2. Posts shall be held at a consistent distance from the edge of curbing as noted and shall be firmly installed below grade to the dimensions indicated.
- B. Install: Rails as indicated.
- C. Smoothly: finish grade around posts to prepare for replacement conditions. Provide topsoil as per Division 32, Section "Topsoil" for all proposed lawn areas. Do not allow water to stand adjacent to post bases.
- D. At completion of installation, prep wood for staining keeping the surface free of dirt, oil and other debris. Stain according to manufacturer's recommendation. See Division 09.

3.4 FINISHING

- A. Exposed edges of all timbers shall be chamfered 1/2" and lightly sanded to produce eased edges.

3.5 CLEANING

- A. Clean up debris and cutting on a regular periodic basis.
- B. Perform cleaning during installation of the work and completion of the work. Remove from site all excess materials, debris, tools and equipment. Repair damage resulting from rough carpentry work.
- C. Dispose of all pressure treated lumber in a satisfactory legal manner.

3.6 PROTECTION

- A. Protect until acceptance of project. Replace or refinish the surfaces if damaged prior to acceptance. Clean up all debris from installation. Dispose of excess pressure treated lumber in a satisfactory legal manner off-site.

END SECTION 32 31 01

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SECTION 32 31 13 – CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. This Section includes the following:
 - 1. System “B” – Colored vinyl coated chain link fencing system including fabric and framework.
- B. Related Sections include the following:
 - 1. Division 31 Section “Earth Moving”.
 - 2. Division 32 Section “Topsoil”.
 - 3. Division 03 Section “Cast-In-Place Concrete”.

1.3 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data in the form of manufacturer’s technical data, specifications, and installation instructions for each type of fence system, including gate posts, fabric, gates, and accessories, including mill certificates.
- C. Shop drawings showing location of fence, gates, each post, and details of post installation, extension arms, gate swing, slide gate, hardware, and accessories.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who has completed fence systems similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

1.5 PROJECT CONDITIONS

- A. Field Measurements: Verify layout information for fences and gates shown on the Drawings in relation to the property survey and existing structures. Verify dimensions by field measurements.

PART 2 - PRODUCTS

2.1 FABRIC

- A. Selvage: Knuckled on both selvages for all fabrics.
- B. Steel Chain Link Fence Fabric: Fabricated in one piece widths for fencing 12 feet and less in height to comply with Chain Link Fence Manufacturers Institute (CLMI) "Product Manual" and with requirements indicated below.
 - 1. System "B":
 - a. Thermally fused Black PVC coating, type 2B, 0.006 inches minimum thickness.
 - b. Fabric: 2 inch mesh, 9 gage galvanized steel core wire size, ASTM F668.
 - c. Framework and Accessories/Components: finish per ASTM F1043, color to match fabric. Framework members gages and sizes to comply with Paragraph 2.2.
 - d. Locking fence privacy inserts in areas as noted on the plans. Color shall be black.

2.2 FRAMING

- A. Round member sizes are given in actual outside diameter (OD) to the nearest thousandth of inches. Round fence posts and rails are often referred to in ASTM standard specifications by nominal pipe sizes (NPS) or the equivalent trade sizes in inches. The following indicates these equivalents all measured in inches:

<u>Actual OD</u>	<u>NPS Sizes</u>	<u>Trade Size</u>
1.315	1	1-3/8
1.660	1-1/4	1-5/8
1.900	1-1/2	2
2.375	2	2-1/2
2.875	2-1/2	3
4.000	3-1/2	4
6.625	6	6-5/8
8.625	8	8-5/8

- B. All posts shall be of sufficient length to allow specified setting into concrete footings.
- C. Type II Round Posts: cold-formed, electric-welded steel pipe conforming to heavy industrial requirements of ASTM F 1043, Group IC, with minimum yield strength of 50,000 psi, either protective coating system below according to ASTM F 1043, and weights per foot as follows:
 - 1. Coatings System "B": Thermally fused PVC coating per ASTM F 1043. Color to match fabric.

<u>Actual OD</u>	<u>Weight (lb/ft)</u>	<u>NPS Size</u>
1.315	1.35	1
1.660	1.84	1-1/4
1.900	2.28	1-1/2
2.375	3.12	2
2.875	4.64	2-1/2
4.000	6.56	3-1/2

- D. Top Rail: Manufacturer's longest lengths (17 to 21 feet) with swedged-end or expansion-type coupling, approximately 6 inches long for joining. Provide rail ends or other means for attaching top rail securely to each gate corner, pull, and end post. Minimum length of any top rail section – 10' – 0".

1. Round Steel: 1.660 inch OD Type II steel pipe.

- E. Steel posts for fabric heights up to 6 feet:

1. Round Line or Intermediate Posts: 2.375 inch OD Type II steel pipe.
2. Round End, Corner, and Pull Posts: 3.00 inch OD Type II steel pipe.

- F. Steel posts for fabric heights over 6 feet:

1. Round Line or Intermediate Posts: 2.875 Type II steel pipe.
2. Round End, Corner, and Pull Posts: 4.00 inch OD Type II steel pipe.

- G. Swing Gate Posts: Furnish posts to support single gate leaf, or one leaf of a double-gate installation, according to ASTM F 900, sized as follows for steel and aluminum pipe posts:

1. Steel posts for fabric height over 6 feet and gate leaf width:
 - a. Up to and including 6 Feet wide: 4.0 inch OD pipe weighting at least 4.64 lb per ft.
 - b. Over 6 to 12 Feet: 4.000 inch OD pipe weighing at least 8.65 lb per ft.
 - c. Over 12 to 24 Feet: 6.625 inch OD pipe weighing at least 10.02 lb per ft.
 - d. Over 18 to 24 Feet: 8.625 OD pipe weighing at least 27.12 lb per ft.

2.3 FITTINGS AND ACCESSORIES

- A. Material: System "B" vinyl coated per ASTM F 1043.

1. Preformed Units: Sizes to fit applications indicated, selected from manufacturer's standard thicknesses, widths, and lengths.
2. Aluminum: Die cast conforming to ASTM B 26, aluminum alloy 360 or sand cast conforming to ASTM B 85, aluminum alloy 365, ZG61A, or Tenzalloy.

- B. Post and Line Caps: Provide weathertight closure cap for each post. Provide line post caps with loop to receive tension wire or top rail. Base of Post Cap to override post a minimum of 2".
- C. Post Brace Assembly: Manufacturer's standard adjustable brace. Use material specified below for brace, and truss to line posts with 3/8-inch diameter rod and prefabricated adjustable tightener. Field bent applications are not accepted. Provide manufacturer's standard galvanized-steel, cast iron or cast aluminum cap for each end.
 - 1. Round Steel: 1-5/8 inch OD Type I or II steel pipe.
- D. Bottom, Auxiliary and Center Rail: Same material as top rail. Provide manufacturer's standard galvanized steel, cast iron or cast aluminum cap for each end. Color match. Continuous bottom rails required on all fence systems. Continuous bottom and center rails required on all fences 8' – 0" or more in height. Continuous bottom and Center rails are required at dumpster enclosures.
- E. Tension or Stretcher Bars: Hot-dip galvanized steel with a minimum length 2 inches less than the full height of fabric, a minimum cross section of 3/16 inch by 3/4 inch, and a minimum of 1.2 oz. of zinc coating per sq. ft. Provide one bar for each gate and end post, and two for each corner and pull post, except where fabric is integrally woven into the post.
- F. Tension and Brace Bands: 3/4 inch wide minimum hot dip galvanized steel with a minimum of 1.2 oz. Of zinc coating per sq. ft.
 - 1. Tension Bands: 0.074 inch thick (14 gage) minimum.
 - 2. Brace Bands: 0.105 inch thick (12 gage) minimum.
- G. Tension Wire: 0.177 inch diameter metallic coated steel marcelled tension wire conforming to ASTM A 824 with finish to match fabric. Bottom tension wire is required on all fences less than 6 feet in height.
- H. Tie Wires: 0.106 inch diameter (12 gage) galvanized steel with a minimum of 0.80 oz. per sq. ft. of zinc coating according to ASTM A641, Class 3 or 0.148 inch diameter (9 gage) aluminum wire alloy 1350-H19 or equal, to match fabric wire. Finish to match fabric.
- I. Drive Anchors: As manufactured by Anchor Fencing or approved equal.

2.4 CONCRETE/FOOTINGS

- A. Concrete: Provide concrete consisting of portland cement per ASTM C 150, aggregates per ASTM C 33, and potable water. Mix materials to obtain concrete with a minimum 28 day compressive strength of 4,000 psi. Use at least four sacks of cement per cu. yd., 1-inch maximum size aggregate, 3 inch maximum slump.
- B. Provide standard cylindrical cardboard tube liners for full depth of footing, where required by Architect if excavations are not held vertical and smooth.

2.5 SWING GATES

- A. Fabricate perimeter frames of gates from same material and finish as fence framework. Assemble gate frames by mitering corners and welding, prior to galvanizing or finishing. Provide horizontal and vertical members to ensure proper gate operation and attachment of fabric, hardware, and accessories. Space frame members maximum of 8 feet apart unless otherwise indicated.
 - 1. Fabric: Same as for fence unless otherwise indicated. Secure fabric at vertical edges with tension bars and bands and to top and bottom of frame with tie wires.
 - 2. Bracing: Install diagonal cross-bracing consisting of 1.660 o.d. pipe on all gates to ensure frame rigidity without sag or twist.
- B. Swing Gates: Comply with ASTM F 900.
 - 1. Steel: Gates up to 8 feet wide:
 - a. Fabricate perimeter frames of 1.90 inch minimum OD Type II steel pipe, with mitered and welded corners. Fabricate prior to galvanizing.

[Note: Gates over 8 feet wide require custom design and specification.]
 - 2. Gate Hardware: Provide galvanized hardware and accessories for each gate according to the following:
 - a. Hinges: Heavy Industrial duty box style, properly sized to suit gate size, non lift off type, offset to permit 180 degree gate opening. Provide a minimum of 3 hinges for each leaf; gates over 6 foot nominal height, provide sufficient hinges to support weight of gate, without sag.
 - b. Single Leaf Pedestrian Gates: All pedestrian gates along the accessible route shown on the drawings shall be ADA compliant and accessible. Contractor shall refer to the door hardware schedule and specification for ADA compliant gate hardware, including but not limited panic bars and levers. Contractor shall fully coordinate and fabricate a heavy duty powder coated steel plate for mounting specified hardware. Steel mounting plate shall be integrated into the framework of the chain link gate system. Latches shall be installed that are coordinated and function with the specified gate hardware shown in the project door hardware schedule. Stainless steel ADA Gate hardware shall be exterior grade surface mounted panic bar exiting device and a compatible lever for entry side of the fence as manufactured by ASSA ABLOY or approved equal. (Model ED5200 N955ET M51 with weepholes) refer to hardware schedule. Contractor shall provide and install a complete system, including an adjustable strike latch receiver bracket. ADA compliant lever hardware and panic bar shall have locking cylinders with keys matching other site gates. All fasteners shall be stainless steel. All fencing, latch components, hardware and mounting plate shall be powder coated to match fencing color.
 - c. Double Leaf Vehicle Gate Latches & Gas Enclosure: Gates shall be a heavy-duty double drive powder coated fulcrum style fork latch capable of pad locking.
 - d. Keeper: Provide a keeper for vehicle gates that automatically engages gate leaf and holds it in the open position until manually released.

- e. Gate Stops: Provide gate stops for double gates consisting of mushroom type flush plate with anchors, set in concrete, and designed to engage a center drop rod or plunger bar. Include a locking device and padlock eyes as an integral part of the latch, permitting both gate leaves to be locked with a single padlock
- f. Ferrule for plunger bar type gate keeper. Provide 3" depth stainless steel ferrules of the correct diameter in both the open and closed positions for all plunger bar type gate keepers. Core and epoxy ferrule (3" depth) in place if finished surface is concrete or provide a concrete footing and support (min. 12"x12"x12") for ferrule if finished surface is either asphalt or earth. Top of ferrules shall be flush with finished surface.
- g. Contractor shall furnish all gates with heavy duty Master/pad locks. Provide keys and spares to owner. Single key for all gate access.

C. FIRE ACCESS STATION / KNOX BOX

- 1. (1) Knox box installed at each swing & lift arm gate shall be capable of securely storing several keys for access to gate and other site features. Furnish and install American Access Systems Inc. Model 15-014 or approved equal. Knox box shall be heavy duty powder coated steel. Supply pad lock with 3 sets of keys to owner. Provide and install steel mounting plates to securely fasten to fence framework with tamper resistant mounting hardware. 1/4" heavy duty steel mounting plate and hardware shall be powder coated to match fence. Size plate to accommodate mounting of knox box. Mounting plates may also be welded to post.
- 2.6 GROUT: exterior Portland-cement based non-shrinking grout with 8,000 psi compression strength at 7 days, similar to Super Por-rok, by Minwax Company and distributed by Lambert Corporation, or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install fence to comply with the project details and ASTM F 567. Do not begin installation and erection before final grading is completed, unless otherwise permitted.
 - 1. Apply fabric to outside of framework. Install fencing on boundary lines inside of property line established by survey as required by Division 1.
- B. Excavation: Drill or hand excavate (using post hole digger) holes for posts to diameters and spacing indicated, in firm, undisturbed or compacted soil. Excavation to be vertical – tapered excavations are not permitted. Install posts and foundations for fences in paved areas, prior to the installation of pavement material. Augering holes in pavement for fence post installation will NOT be permitted.
 - 1. Excavate holes for each post to minimum diameter recommended by fence manufacturer, but not less than four times the largest cross section of post.
 - 2. Unless otherwise indicated, excavate hole depths approximately 3 inches lower than post bottom, with bottom of posts set not less than 48 inches below finish grade surface.

3. Provide full-length tube form liners if directed by Architect, due to inconsistent faces of excavation.
- C. Setting Posts: Center and align posts in holes as detailed. Space a maximum of 10 feet o.c., unless otherwise indicated.
 1. Protect portion of posts above ground from concrete splatter. Moisten soil prior to placing concrete. Place concrete around posts in a continuous pour, and vibrate or tamp for consolidation. Check each post for vertical and top alignment, and hold in position during placement and finishing operations.
 - a. Unless otherwise indicated, hold concrete footings 2 inches below grade and trowel to a crown to shed water.
 2. Provide terminal/corner posts wherever fence changes direction more than 10 degrees, at abrupt changes in grade, and at 300' maximum intervals.
 3. If ledge rock is encountered, the posts shall be set in holes drilled into rock at least 18" in depth and grouted with an approved non-shrink and non metallic grout to hold post firmly in correct position.
 - a. Hole size – 1" larger than O.D. of post pipe.
 - b. Grout consistency shall be flowable and soupy to completely fill voids between post and ledge.
 4. Setting posts: Remove loose and foreign materials from sides and bottoms of holes, and moisten soil prior to placing concrete.
 - a. Keep: exposed concrete surfaces moist for at least three (3) days after placement, or cure with membrane curing materials or other acceptable curing method.
 - b. Concrete Strength: Allow concrete to attain at least 75% of its minimum 28 day compressive strength, but in no case sooner than 7 days after placement, before rails, tension wire, or fabric and wires are installed.
- D. Top Rails: Run rail continuously through line post caps, bending to radius for curved runs and at other posts terminating into rail end attached to posts or post caps fabricated to receive rail. Provide expansion couplings as recommended by fencing manufacturer.
- E. Center Rails: Install center rails in one piece between posts and flush with post on fabric side, using rail ends and special offset fittings where necessary. Install center rail at both sides of all corner and brace posts. Install continuous center rail on all fences over 8' feet in height.
- F. Bottom Rails: Similar to top rails. On fences 6 feet high, install one bottom rail, 3 inches above bottom of fabric. On fences higher than 8 feet high, install a second bottom rail, 21 inches above the lower one.
- G. Bracing Assemblies: Install braces at end and gate posts and at both sides of corner and pull posts, and every 150' OC on continuous line posts. Locate horizontal braces at midheight of fabric on fences with top rail and at two-thirds fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.

- H. Bottom Tension Wire: Install tension wire within 6 inches of bottom of fabric before stretching fabric and tie to each post with not less than same gage and type of wire. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120 inch diameter (11-gage) hog rings of same material and finish as fabric wire, spaced a maximum of 12 inches on center. Tension wire must pass by vertical posts, on the same side as the fabric.
- I. Top Tension Wire: Install tension wire within 6 inches of top of fabric before stretching fabric and tie to each post with not less than same gage and type of wire. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120 inch diameter (11-gage) hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches on center. Tension wire must pass by vertical posts, on the same side as the fabric.
- J. Fabric: Leave 1-1/2 inches between finish grade and bottom selvage at all installations. Pull fabric taut and tie to posts, rails, and tension wires. Install fabric on playing or security side of fence, and anchor to framework so that fabric remains under tension after pulling force is released.
- K. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not over 15 inches o.c.
- L. Tie Wires: Use wire of proper length to secure fabric firmly to posts and rails. Bend ends of wire to minimize hazard to persons or clothing.
 - 1. Maximum Spacing: Tie fabric to line posts 12 inches o.c. and to top rails and braces 18 inches o.c.
- M. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts for added security.
- N. Fire Access Knox Box: Install (1) Knox Box adjacent to each (4) sliding gate vehicle access locations. Field locate box in an accessible location and secure per manufacturers recommendations. Mounting panel and box shall be located within proximity to gate latch locking point (max. 10'). Review and coordinate the final location with owner and fire marshal prior to installation. Fasten/secure mounting plate to fence post with tamper proof fittings, fasteners or welding or as recommended by the Knox Box manufacturer. Provide mounting method in shop drawings with fencing submittal for review and approval.

3.2 GAS METER ENCLOSURE

- A. Install system 'B' fencing enclosure at the gas meter with sides, cantilever extensions, top and min. 4'0" wide gate to provide enclosure of all gas meters in accordance with utility company requirements. Abut building wall max. 4" to prevent passage. Gas enclosure shall match existing configuration, including angled cantilevered panels on front and sides to prevent access to building roof. Reinforce with galvanized steel pipe bracing as required for structural stability. Contractor to verify all dimension in the field.
- B. Field coordinate gate location and swing with adjacent bollards and gas piping to enable full 90 degree gate opening and unobstructed access into enclosure.

- C. Install locking privacy slats on sides and cantilever panels of enclosure. Do not install on top (roof) panel. Slats shall match fence color.
- D. Provide shop drawings signed and sealed by a Structural Engineer licensed in the State of Connecticut. Final design shall include necessary reinforcement and bracing to account for privacy slats installed on cantilever panels.

3.3 GATE INSTALLATION

- A. Install gates plumb, level, and secure for full opening without interference. Install ground set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary. Install gates according to manufacturer's instructions, plumb, level, and secure.

END OF SECTION 32 31 13

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SECTION 32 31 19 —METAL PICKET FENCES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Polyester coated square steel tube picket fence, posts, gates and hardware.
- B. Related Sections include the following:
 - 1. Division 31 Section “Earth Moving”.
 - 2. Division 32 Section “Chain Link Fences and Gates”.
 - 3. Division 32 Section “Topsoil”.
 - 4. Division 03 Section “Cast-In-Place Concrete”.

1.3 SUBMITTALS

- A. Product data in the form of manufacturer’s technical data, specifications, and installation instructions for fence and gate posts, fabric, gates, accessories, and color selection chart including mill certificates if so required.
- B. Shop drawings showing location of fence, gates, each post, and details of post installation, extension arms, gate swing, hardware and accessories.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who has at least three years’ experience and has completed at least five fence projects with same material and of similar scope to that indicated for this Project with a successful construction record of in-service performance.
- B. Single-Source Responsibility: Obtain all fences and gates, including accessories, fittings, and fastenings, from a single source.
- C. All work shall comply with all Codes, rules, regulations, laws and ordinances for the Department of Public Works, State of Connecticut and all other authorities having jurisdiction.

1.5 WARRANTY

- A. Provide manufacturer's standard limited warranty that its ornamental fence system is free from defects in material and workmanship including cracking, peeling, blistering and corroding for a period of 15 years from the date of purchase.

1.6 PROJECT CONDITIONS

- A. Field Measurements; Verify layout information for fences and gates shown on the Drawings in relation to the property survey and existing structures. Verify dimensions by field measurements.

PART 2 - PRODUCTS

2.1 FENCE

- A. Pickets: Galvanized square steel tubular members manufactured per ASTM A-787, having a 45,000 psi yield strength and G90 zinc coating, 0.90 oz/ft². Minimum size pickets 1 inch square, 14 gauge. Space pickets 3-15/16" maximum face to face. Attach each picket to each rail with 1/4" industrial drive rivets. Size #4.
- B. Rails: 1-1/2" x 1-3/8" 11 gauge thick galvanized steel "U" channel per ASTM A 653 or ASTM A 1008/A through A 1008M, and A 1011/A through A 1011M, having a 50,000 psi (344 Mpa) yield strength and G90 zinc coating, 0.90 oz/ft². Punch rails to receive pickets and attach rails to rail brackets with 2 each. 1/4" industrial drive rivets. Size #4. Steel for rail produced under ASTM A653.
- C. Posts: Galvanized square steel tubular members manufactured per ASTM A 787 having a psi (310 Mpa) yield strength and G90 zinc coating, 0.90 oz/ft². Zinc coating is outside. Minimum post size 3", 12 gauge.
- D. Accessories: Assembled panels with ornamental accessories attached using industrial drive rivets to prevent removal and vandalism.
- E. Finish: All pickets, channels, posts, fitting and accessories shall be polyester coated individually after drilling and layout, to ensure maximum corrosion protection. (Coating of assembled sections is unacceptable). All components must have a 4 stage "Power Wash" pre-treatment process to clean and prepare the galvanized surface to assure complete adhesion of the finish coat. All metal must then be given a polyester resin based power coating applied by the electrostatic spray process, to a thickness 2.5 mils. The finish must be baked in a 450 degree F oven for 20 minutes. Color; Black.
- F. Rail Attachment Brackets-die cast of zinc per ASTM B86-83A 33521. Ball and socket design capable of 30 degree swivel (up/down-left/right). Bracket to fully encapsulate rail and for complete security.
- G. Industrial Drive Rivets: Of sufficient length to attach items in a secure nonrattling position. Rivet to have a minimum of 1100 lbs. Holding power and a shear strength of 1500 lbs.

- H. Post Caps: Formed steel, cast of malleable iron or aluminum alloy, weathertight closure cap. Provide one flat style post cap for each post.
- I. Picket tops shall be flat top finish.
- J. Refer to drawings and specifications for fence heights and locations.

2.2 GATES

- A. Gate Frames: Fabricate ornamental picket swing gate using galvanized steel members, ASTM 78, structural quality steel, 45,000 psi (310 Mpa) tensile strength, with galvanized G90 coating. Frame members welded using stainless steel welded to form rigid one-piece unit. Minimum size vertical uprights, 2" square 13 gauge wall thickness.
- B. Ornamental Picket Infill; "U" channel rails, formed from hot rolled, structural steel, 1-3/8" wide x 1-1/2" deep, 11 gauge wall thickness. Punch rails to receive pickets, and weld inside gate frame, pickets, galvanized steel, square tube of gauge, spacing and with accessories to match fence. Attach pickets to "U" rails by 1/4" industrial drive rivets, size #4.
- C. Bracing: Provide diagonal adjustable length truss rods on gates to prevent sag.
- D. Hardware Materials: Galvanized steel or malleable iron shapes to suit gate size.
- E. Hinges: Structurally capable of supporting gate leaf and allow opening and closing without binding. Non lift off type hinge design shall permit gate to swing 180 degrees.
- F. Keeper: Provide keeper for each gate leaf over 5' wide. Gate keeper shall consist of mechanical device for securing free end of gate when in full open position.
 - a. Double Gates: Provide drop rod to hold inactive leaf. Provide gate stop pipe to engage center drop rod. Provide locking device and padlock eyes as an integral part of latch, requiring one padlock for locking both gate leaves.
 - b. Ferrule for plunger bar type gate keeper. Provide 3" depth stainless steel ferrules of the correct diameter in both the open and closed positions for all plunger bar type gate keepers whether installed on single or double gates. Core and epoxy ferrule (3" depth) in place if finished surface is concrete or provide a concrete footing and support (min. 12"x12"x12") for ferrule if finished surface is either asphalt or earth. Top of ferrules shall be flush with finished surface.
- G. Gate Posts: Square members, ASTM A787, structural quality steel, 45,000 psi tensile strength, with galvanized G90 coating; size as indicated below:

Gate Leaf Single Width	Post Size (Square)
3 ft. to 4 ft.	3"
4 ft. to 8 ft.	4"
Over 8ft.	6"
Weight	
4.286 lb./ft	
5.779 lb./ft	

- H. Polyester Powder Coat Finish (Black): After components have been galvanized to provide maximum corrosion resistance, pretreat, clean, and prepare galvanized surface to assure complete adhesion of finish coat. Apply 2.5 mil thickness of polyester resin based powder coating by electrostatic spray process. Bake finish for 20 minutes at 450 degrees F metal temperature. Color to match fence.
- I. Gates in fence line shall have straight top configuration, height to match fence sections.

2.3 SETTING MATERIAL

- A. Concrete: Minimum 28 day compressive strength of 3,500 psi.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify areas to receive fencing are completed to final grades and elevations.
- B. Ensure property lines and legal boundaries of work are clearly established.

3.2 INSTALLATION

- A. Install fence in accordance with manufacturer's instructions.
- B. Space posts uniformly at 7' 8-3/4" maximum face to face unless otherwise indicated.
- C. Footing Set Posts: Drill hole in firm, undisturbed or compacted soil. Footing hole shall have diameter 4 times greater than nominal outside dimension of post, and depths approximately 6" (152 mm) deeper than post bottom. Excavate deeper as required for adequate support in soft and loose soils, and for posts with heavy lateral loads. Set post bottom 42" below surface when in firm, undisturbed soil. Place concrete around post in a continuous pour. Trowel finish around posts and slope to direct water away from posts. Hold top of footing 4" below finished grade.
 - 1. Gate Posts and Hardware: Set keepers, stoops, sleeves and other accessories into concrete.
- D. Core Set Posts: Core into tops of walls and wall coping for fence installation along tops of walls. Coordinate coring operations with post locations in the field. Core depths and post embedment shall be a minimum required to withstand 50 lb/ft. applied horizontally and concurrently with 100 lbf/ ft. applied vertically downward. Fill core with an approved non-shrink grout to secure the fence posts and structurally stabilize.
- E. Grouted posts shall have cored holes filled flush with adjacent surface to enable positive drainage away from post and prevent water from standing at post base.
- F. Non shrink grout around posts shall not be mounded above the adjacent surfacing.

- G. Fencing shall be aligned with the edges of concrete walkways with a consistent inset from the edge of the concrete as the condition occurs. The minimum fence inset shall be 3" from the edge of walk to the face of the post.
- H. Wall mount fence sections between masonry piers with mounting plates where indicated. Fasten with lag bolts and shields.
- I. Check each post for vertical and top alignment and maintain in position during placement and finishing operation.
- J. Align fence panels between posts. Firmly attach rail brackets to posts with ¼" bolt and lock nut, ensuring panels and posts remain plumb.
- K. Ensure that tops of ground mounted fence units and wall mounted fence units are at the same elevation.

3.3 GATE INSTALLATION

- A. Install gates plumb, level and secure for full opening without interference.
- B. Attach hardware by means which will prevent unauthorized removal.
- C. Adjust hardware for smooth operation.
- D. Core into tops of walls in locations indicated on plans and as permitted by modular wall manufacturer for fence installation along tops of walls. Core to depth shall not be less than the minimum required by the modular block manufacturer. Fill core with an approved non shrink grout to secure the fence posts and structurally stabilize. Core into tops of concrete walls.
- E. Grouted posts shall have cored holes filled flush with adjacent surface to enable positive drainage away from post and prevent water from standing at post base.
- F. Non shrink grout around posts shall not be mounded above the adjacent surfacing.

3.4 ACCESSORIES

- A. Install post caps and other accessories to complete fence.
- B. Provide heavy-duty, stainless-steel lever latch with keyed lock cylinder on all gates at the loading dock (2 locations). Levers shall be located on each side of the gates.
- C. Gates shall have a heavy duty self-closing mechanism and a catch to allow gate to be held in the open position.
- D. Gate hardware shall be powder coated to match gate system color.

3.5 CLEANING

- A. Clean up debris and unused material and remove from site.

ANNA REYNOLDS ELEMENTARY SCHOOL
NEWINGTON, CT

RENOVATIONS
STATE PROJECT #094-0109 RNV
KBA #21011.00

END OF SECTION 32 31 19

SECTION 32 31 20 – SITE PIPE AND TUBE RAILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Steel pipe railings for site handrails.
- B. Related Sections include the following:
 - 1. Division 03 Section "Cast-in-Place Concrete".
 - 2. Division 09 Section "Painting".

1.3 PERFORMANCE REQUIREMENTS

- A. General: In engineering railings to withstand structural loads indicated, determine allowable design working stresses of railing materials based on the following:
 - 1. Steel: 72 percent of minimum yield strength.
- B. Structural Performance: Provide railings capable of withstanding the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Handrails:
 - a. Uniform load of 50 lbf/ ft. applied in any direction.
 - b. Concentrated load of 200 lbf applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 - 2. Top Rails of Guards:
 - a. Uniform load of 50 lbf/ ft. applied horizontally and concurrently with 100 lbf/ ft. applied vertically downward.
 - b. Concentrated load of 200 lbf applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 - 3. Infill of Guards:
 - a. Concentrated load of 200 lbf applied horizontally on an area of 1 sq. ft.
 - b. Uniform load of 50 lbf/sq. ft. applied horizontally.

c. Infill load and other loads need not be assumed to act concurrently.

C. Thermal Movements: Provide exterior railings that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

D. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Manufacturer's product lines of mechanically connected railings.
2. Grout, anchoring cement, and paint products.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer, licensed in the State of Connecticut responsible for their preparation.

C. Welding certificates.

D. Qualification Data: For professional engineer.

E. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, according to ASTM E 894 and ASTM E 935.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of railing through one source from a single manufacturer.

B. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code--Steel."

1.6 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with railings by field measurements before fabrication and indicate measurements on Shop Drawings.

1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating railings without field

measurements. Coordinate wall and other contiguous construction to ensure that actual dimensions correspond to established dimensions.

2. Provide allowance for trimming and fitting at site.

1.7 COORDINATION AND SCHEDULING

- A. Coordinate installation of anchorages for railings. 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 or masonry. Deliver such items to Project site in time for installation.
- B. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not satisfy structural performance requirements.

PART 2 - PRODUCTS

2.1 METALS, GENERAL

- A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.
- B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails, unless otherwise indicated.

2.2 STEEL AND IRON

- A. Pipe: ASTM A 53/A 53M, Type F or Type S, Grade A, Standard Weight (Schedule 40), unless another grade and weight are required by structural loads.
 1. Provide galvanized finish for exterior installations and where indicated.
- B. Plates, Shapes, and Bars: ASTM A 36/A 36M.
- C. Castings: Either gray or malleable iron, unless otherwise indicated.
 1. Gray Iron: ASTM A 48/A 48M, Class 30, unless another class is indicated or required by structural loads.
 2. Malleable Iron: ASTM A 47/A 47M.

2.3 FASTENERS

- A. General: Provide the following:
 1. Steel Railings: Plated steel fasteners complying with ASTM B 633, Class Fe/Zn 25 for electrodeposited zinc coating.

- B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction indicated and capable of withstanding design loads.
- C. Anchors: Provide torque-controlled expansion anchors, fabricated from corrosion-resistant materials with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E 488 conducted by a qualified independent testing agency.

2.4 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
 - 1. For aluminum railings, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.
- B. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79.
 - 1. Use primer with a VOC content of 420 g/L (3.5 lb/gal.) or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
- C. Shop Primer for Galvanized Steel: Zinc-dust, zinc-oxide primer formulated for priming zinc-coated steel and for compatibility with finish paint systems indicated, and complying with SSPC-Paint 5.
- D. Galvanizing Repair Paint: High-zinc-dust-content paint for regalvanizing welds in steel, complying with SSPC-Paint 20.
- E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.
- F. Non-shrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.

2.5 FABRICATION

- A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.
- B. Assemble railings in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

- C. 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.
- D. Form work true to line and level with accurate angles and surfaces.
- E. Fabricate connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
- F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.
- G. Connections: Fabricate railings with welded connections.
- H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.
 - 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 flux immediately.
 - 4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.
- I. Form changes in direction as follows:
 - 1. By bending.
- J. Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
- K. Close exposed ends of railing members with prefabricated end fittings.
- L. Provide wall returns at ends of wall-mounted handrails, unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch or less.
- M. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work, unless otherwise indicated.
- N. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by railings. Coordinate anchorage devices with supporting structure.
- O. For railing posts set in concrete, provide steel sleeves not less than 6 inches long with inside dimensions not less than 1/2 inch greater than outside dimensions of post, with steel plate forming bottom closure.

2.6 FINISHES, GENERAL

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- D. Provide exposed fasteners with finish matching appearance, including color and texture, of railings.

2.7 STEEL AND IRON FINISHES

- A. Galvanized Railings:
 - 1. Hot-dip galvanize exterior steel and iron railings, including hardware, after fabrication.
 - 2. Comply with ASTM A 123/A 123M for hot-dip galvanized railings.
 - 3. Comply with ASTM A 153/A 153M for hot-dip galvanized hardware.
- B. Fill vent and drain holes that will be exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
- C. For galvanized railings, provide hot-dip galvanized fittings, brackets, fasteners, sleeves, and other ferrous components.
- D. For nongalvanized steel railings, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves, except galvanize anchors to be embedded in exterior concrete or masonry.
- E. Preparation for Shop Priming: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with metallic-phosphate process.
- F. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface preparation specifications and environmental exposure conditions of installed railings:
 - 1. Exterior Railings (SSPC Zone 1B): SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - 2. Interior Railings (SSPC Zone 1A): SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
- G. Apply shop primer to prepared surfaces of railings, unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and

Maintenance Painting of Steel," for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.

1. Do not apply primer to galvanized surfaces.
2. Stripe paint corners, crevices, bolts, welds, and sharp edges.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Fit exposed connections together to form tight, hairline joints.
- B. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.
 1. Do not weld, cut, or abrade surfaces of railing components that have been coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
 2. Set posts plumb within a tolerance of 1/16 inch in 3 feet.
 3. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet.
- C. Corrosion Protection: Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.
- D. Adjust railings before anchoring to ensure matching alignment at abutting joints.
- E. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.2 RAILING CONNECTIONS

- A. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in Part 2 "Fabrication" Article whether welding is performed in the shop or in the field.

3.3 ANCHORING POSTS

- A. Form or core-drill holes not less than 5 inches deep and 3/4 inch larger than OD of post for installing posts in concrete. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions.
- B. Cover anchorage joint with flange of same metal as post, welded to post after placing anchoring material.

- C. Anchor posts to metal surfaces with oval flanges, angle type, or floor type as required by conditions, connected to posts and to metal supporting members as follows:

- 1. For steel pipe railings, weld flanges to post and bolt to metal supporting surfaces.

3.4 ANCHORING RAILING ENDS

- A. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and welded to railing ends.

3.5 ADJUSTING AND CLEANING

- A. Clean aluminum and stainless steel by washing thoroughly with clean water and soap and rinsing with clean water.
- B. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
- C. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

3.6 PROTECTION

- A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.
- B. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit or provide new units.

END OF SECTION 32 31 20

SECTION 32 32 23 — SEGMENTAL RETAINING WALLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Segmental retaining walls with soil reinforcement.
 - 2. Capstone.
- B. Related Sections include the following:
 - 1. Division 31 Section “Site Clearing”.
 - 2. Division 31 Section “Earth Moving”.
 - 3. Division 33 Section “Storm Drainage”.

1.3 DEFINITIONS

- A. Form 816: “Standard Specifications for Roads, Bridges and Incidental Construction”, State of Connecticut, Department of Transportation, Form 816, 2004 edition, with 2005 supplement.

1.4 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide segmental retaining walls capable of withstanding the effects of loads due to soil pressures resulting from grades indicated.
 - 1. Design retaining walls according to NCMA’s “Design Manual for Segmental Retaining Walls”. Note location of adjacent chain link fence – modify design of wall and geogrids as required to permit full depth concrete fence foundations.

1.5 SUBMITTALS

- A. Product Data: For each type of segmental retaining wall and other manufactured products specified.
- B. Provide shop drawings of all walls, prepared and sealed by a Structural Engineer registered in the State of Connecticut responsible for their preparation. The information provided shall include design loadings and structural analysis. For walls over four feet in height, the Structural Engineer of record shall perform a global stability analysis utilizing the site soil properties provided in the Geotechnical Report included in the Project Manual.

- C. Provide detailed drawings indicating layout and elevations of wall, specifying “steps” in wall elevations consistent with per project grading requirements. Steps shall be designed with a consistent spacing and shall be limited to one course in height unless otherwise approved.
- D. Samples for Verification: Sets for each color, finish, and pattern of unit required. Include 5 or more samples; in each set showing the full range of variations expected.
- E. Qualification Data: Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
- F. Preconstruction Test Reports: Indicate and interpret test results for compliance with performance requirements.
- G. Product Test Reports: Indicate compliance of retaining wall units and soil reinforcement with requirements based on comprehensive testing of current products.
 - 1. Include test data verifying properties used as basis of structural design.
 - 2. Include test data required by “Source Quality Control” Paragraph 2.4 for each roll of soil reinforcement.
- H. Research/Evaluation Reports: Evidence of system’s compliance with building code in effect for Project from a model code organization acceptable to authorities having jurisdiction.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who has completed segmental retaining walls similar in material, design and extent to that indicated for Project that has resulted in construction with a record of successful in-service performance.
- B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the State of Connecticut and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of systems that are similar to those indicated for this Project in material, design and extent.
- C. Testing Agency Qualifications: An independent testing agency with the experience and capability to conduct the testing indicated without delaying the Work, as documented according to ASTM E 548.
- D. Mockups: Before installing segmental retaining walls, construct sample wall panels to verify selections made under sample submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for completed Work.
 - 1. Locate mockups as directed by Architect and Project Manager.
 - 2. Build mockups for each type of segmental retaining wall in sizes approximately 96 inches long by 36 inches high above finished grade at front of wall.
 - a. Include typical base and cap or finished top construction.
 - b. Include backfill to typical finished grades at both sides of wall.
 - c. Include 36 inch return at 1 end of mockup with typical corner construction.

3. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - a. Approval of mockups does not constitute approval of deviations from Construct Documents contained in mockups, unless such deviations are specifically approved by Architect in writing.
 - b. When directed, demolish and remove mockups from Project site.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials to Project Site in an undamaged condition.
- B. Store and handle retaining wall units and related materials to prevent deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breaking, chipping or other causes.
- C. Store accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.
- D. Store and handle geotextiles according to ASTM D 4873.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Retaining Wall Units Basis of Design: Concord Wall XL as manufactured by Unilock or approved equal.
 2. Other acceptable retaining wall manufacturers include the following:
 - a. Licensees of Allan Block Corp.
 - b. Licensees of Amastone Co.
 - c. Licensees of Anchor Wall Systems, Inc.
 - d. Licensees of ICD Corp.
 - e. Licensees of Keystone Retaining Wall Systems, Inc.
 - f. Licensees of Kiltie Corp.; Versa-Lock Retaining Wall Systems Division.
 - g. Licensees of Mesa Retaining Wall Systems.
 - h. Licensees of Reinforced Earth Co., (The).
 - i. Licensees of Rockwood Retaining Wall Systems.
3. Soil Reinforcement:
 - a. Amoco Fabrics and Fibers Co.
 - b. Huesker, Inc.
 - c. Nicolon Corp.; Nicolon/Mirafi Group.

- d. Strata Systems, Inc.
- e. Tensar Earth Technologies, Inc.

2.2 RETAINING WALL UNITS

- A. Concrete Units: High strength, regular weight concrete units, designed for use in segmental retaining walls, complying with ASTM C 1372, except with net area compressive strength of 3000 psi for average of 3 units and 2500 psi for individual unit, maximum water absorption of 8 percent, and variation in height limited to 1/8 inch.
 - 1. Provide units with lugs and recesses (tongue and groove connection) that locate successive courses in relation to the course below and maintain that alignment as backfill is placed. Units shall be solid concrete and interlock with units above and below.
 - 2. Maximum length/width variation – 1/8”.
- B. Colors: Provide units that result in colors of exposed wall surfaces to match the existing and complying with the following requirements.
 - 1. Provide Architect’s selections from manufacturer’s full range of colors for materials and products of type indicated. Selections shall include all standard and custom colors produced within New England. A minimum of 3 manufacturer’s colors shall be equal to Sierra, Granite and Almond Grove as manufactured by Unilock.
- C. Surface Texture: Provide units with machine split faces and smooth, as cast beds.
- D. Shapes: Provide units matching basic shapes and dimensions of the existing units as indicated by referencing manufacturer’s pattern designation. Depth to height ratio of 2:1 minimum.
 - 1. Exposed Face: Flat face with rough split texture.
 - 2. Batter: Provide units that offset from the course below to provide 1-1/2 inch per foot (1:8) batter.
- E. Special Units: Provide corner units, end units, cap units and other special shapes as necessary to produce retaining walls of dimensions and profiles indicated and to provide indicated textures on exposed surfaces.

2.3 WALL COPING

- A. Wall coping units shall be LedgeStone coping by Unilock, or equal. Submit manufacturer’s full range of colors for selection and approval by Architect. Coping shall be installed along the full length of wall with consistent alignment and overhang beyond face of wall units. Center on top of wall. Cut as required for tight fit and to conform with radii per manufacturer’s recommendations.

2.4 INSTALLATION MATERIALS

- A. Pins: Product supplied by retaining wall unit manufacturer for use with units provided, made from non-degrading polymer reinforced with glass fibers.
- B. Cap adhesive: Product supplied or recommended by retaining wall unit manufacturer for adhering cap units to units below.
- C. Base: Comply with requirements of Division 31, Section "Earth Moving" for granular base material.
- D. Drainage Fill: Washed gravel or washed crushed stone complying with ASTM D 448 for Size No. 57 and Form 816, Section M.02.06, Grade "C", $\frac{3}{4}$ " crushed stone.
- E. Filter Fabric: Nonwoven pervious geotextile manufactured from polyester, nylon, or polypropylene fibers, as follows:
 - 1. Apparent Opening Size: No. 1000 per ASTM D 4751.
 - 2. Permeability: 150 gpm/sq. ft. per ASTM D 4491.
 - 3. Grab Strength: 100 lbf per ASTM D 4632.
- F. Drainage Pipe: Refer to Division 33, Section "Storm Drainage".
- G. Drainage Pipe Grate: Wall drainage design shall primarily utilize drainage pipe behind the wall. Any required drainage pipe weeps along the face of the wall shall have color matching grates flush with the face of the wall. Secure grates and cut block per manufacturer to accommodate grates. Drainage grates may be pvc or composite material manufactured specifically for wall drainage applications. Submit full range of colors for selection.
- H. Soil Reinforcement: A geotextile or geogrid, specifically manufactured for use as soil reinforcement, and with necessary properties for completed segmental retaining walls to comply with performance requirements.
- I. Wall coping joint sealant: Sika or equal. Product shall be a color match. Contractor shall submit colors for approval by Architect.
- J. Concrete: Division 32, Section "Concrete Pavement and Curbs".

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect each roll of soil reinforcement at the factory for minimum average roll values for geosynthetic index property tests including the following:
 - 1. Weight.
 - 2. Roll size.
 - 3. Grab or single rib strength.
 - 4. Aperture opening.
 - 5. Rib or yarn size.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive segmental retaining walls and conditions under which walls will be installed, with Installer present, for compliance with requirements for excavation tolerances, condition of subgrades, and other conditions affecting performance of retaining walls.
 - 1. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 RETAINING WALL INSTALLATION

- A. General: Place units according to manufacturer's written instructions. Lay units in running bond, overlapping half units of course below.
 - 1. Form corners and ends by using special units.
 - 2. Do not use units with chips, cracks, voids, discolorations, and other defects that might be visible in finished work.
 - 3. Mix units from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
 - 4. Cut unit with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible.
- B. Leveling Base: Place and compact base material to thickness indicated and with not less than 95 percent of maximum dry density according to ASTM D 698. Install one layer of Unilock Drive Grid or equal between sub base material and base material to stabilize soil prior to placement of base and further compaction.
- C. First Course: Place first course of retaining wall units on leveling base/course for full length of wall. Place units in firm contact with each other, properly aligned and level.
 - 1. Tamp units into leveling base as necessary to bring tops of units into a level plane.
 - 2. Place and compact fill, either drainage fill or soil fill as indicated, to top of first course. Place fill without disturbing alignment of units. Fill voids between and within units with drainage fill.
- D. Subsequent Courses: Sweep excess fill from tops of course below. Place units in firm contact, properly aligned, and directly on course below.
 - 1. For units with lugs designed to fit into holes in units of adjacent course, lay units so lugs are accurately aligned with holes and bedding surfaces are firmly seated on beds of units below.
 - 2. For units with lips at front of units, slide units as far forward as possible for firm contact with lips of units below.
 - 3. Place and compact fill as each course is laid. Place fills on both sides of wall at same time, where both sides are indicated to be filled.
 - 4. Fill voids between and within units with drainage fill.

- E. Cap Units: Place cap units and secure with cap adhesive according to manufacturer's written instructions. 3/16" joint spacing with color match sealant at top and sides.

3.3 FILL PLACEMENT

- A. General: Comply with requirements Division 2, Section "Earthwork" and retaining wall unit manufacturer's written instructions.
- B. Place, spread, and compact fill in uniform lifts for full width and length of embankment as wall is laid. Begin at back of wall and place and spread fill toward embankment.
 - 1. Use only hand-operated compaction equipment within 36 inches of wall.
 - 2. Compact drainage fill to not less than 95 percent maximum dry density according to ASTM D 698.
 - 3. Compact reinforced soil fill to not less than 95 percent maximum dry density according to ASTM D 698.
- C. Place a layer of drainage fill at least 12 inches deep behind the wall to within 12 inches of finished grade.
 - 1. Wrap drainage pipe with filter fabric and place in drainage fill as indicated, sloped 1/4 inch per foot to drain.
 - 2. Place surface finish material over top edge of drainage fill layer as shown on Drawings.
 - 3. At shoreline installations only, install a geosynthetic filter fabric behind the drainage fill.
- D. Place soil reinforcement in horizontal joints of retaining wall where indicated and according to soil reinforcement manufacturer's written instructions. Embed reinforcement a minimum of 8 inches into retaining wall and stretch tight over compacted backfill. Anchor soil reinforcement before placing fill on it.
 - 1. Use additional soil reinforcement at corners and curved walls to provide continuous reinforcement and to comply with manufacturer's written instructions.
 - 2. Place geotextiles with sewn seams oriented with seams perpendicular to retaining walls. Overlap of the reinforcement in the design strength direction shall not be permitted.
 - 3. Do not dump fill material directly from trucks onto geotextile.
 - 4. Before compacting, place sufficient depth of fill over reinforcement to produce compacted depth of 4 inches for wheeled vehicles or 6 inches for tracked vehicles.
 - 5. Do not turn vehicles on fill until first layer of fill is compacted and second layer is placed over each soil reinforcement layer.

3.4 CONSTRUCTION TOLERANCES

- A. Variation from Level: For bed joint lines along walls, do not exceed 1/4 inch in 10 feet or 1 inch in 40 feet or more.
- B. Variation from Indicated Batter: For slope of face of wall, do not vary from indicated slope by more than 1/4 inch in 10 feet.

- C. Variation in Plan Position: For ends and faces of walls in relation to property lines, buildings, and other objects, do not vary from plan dimensions by more than 1 inch or from depicted plan relationship (scaled dimensions) by more than 3 inches.
- D. Variation in Linear Wall Line: For walls indicated as straight, do not exceed ¼ inch in 10 feet or 1 inch in 40 feet or more from a straight line.

3.5 FIELD QUALITY CONTROL

- A. Comply with requirements of Division 31, Section “Earth Moving” for in place soil density testing.
 - 1. In each compacted backfill layer, perform at least 1 field in place density test for each 100 feet or less of retaining wall length, but no fewer than 2 tests along a wall face.
 - 2. Perform additional testing if required by Project Manager or Architect.

3.6 ADJUSTING AND CLEANING

- A. Remove and replace segmental retaining walls of the following description:
 - 1. Broken, chipped, stained, or otherwise damaged units.
 - 2. Segmental retaining walls not matching approved samples and mockups.
 - 3. Segmental retaining walls not complying with other requirements indicated.
 - 4. Cracks in units longer than ½”.
- B. Replace in a manner which results in segmental retaining wall’s matching approved samples and mockups, complying with other requirements, and showing no evidence of replacement, at no additional cost to the Owner.

END OF SECTION 32 32 23

SECTION 32 80 00 IRRIGATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."

1.2 SUMMARY

- A. Base Bid: This design-build portion of the project consists of designing, providing and installing a complete underground irrigation system. The work includes but is not limited to the following:
 - 1. Automatic irrigation system including piping, fittings, sprinklers, and accessories.
 - 2. Controllers, control wire.
 - 3. Encasement for piping.
 - 4. Backflow preventer.
 - 5. Manual valves.
 - 6. Pressure-reducing valves.
 - 7. Automatic control valves.
 - 8. Automatic drain valves.
 - 9. Transition fittings.
 - 10. Miscellaneous piping specialties.
 - 11. Quick couplers.
 - 12. Boxes for automatic control valves.
 - 13. Rain Sensor.
 - 14. Testing.
 - 15. Excavation and backfilling irrigation work.
 - 16. Maintenance and warranty.
- B. Base Bid: Contractor shall remove cut and cap encountered irrigation lines and components as required to implement proposed improvements. Contractor may be directed to complete additional work utilizing project allowances for irrigation improvements as directed by owner.
- C. Related Sections: The following sections contain requirements that relate to this section:
 - 1. Division 31 Section "Earth Moving"
 - 2. Division 32 Section "Topsoil"
 - 3. Division 32 Section "Turf and Grasses"

1.3 REFERENCE STANDARDS

- A. Materials, equipment, and methods of installation shall comply with the following codes and standards:
 - 1. All local and State codes.
 - 2. National Fire Protection Association, (NFPA): National Electrical Code.
 - 3. American Society for Testing and Materials, (ASTM).
 - 4. National Sanitation Foundation, (NSF).
 - 5. The Irrigation Association, (IA).
- B. Installer's qualifications: minimum of five (5) years experience designing and installing irrigation systems of comparable size. The irrigation system subcontractor shall have an installation crew consisting of a minimum of three (3) persons who each have a minimum of three years experience installing irrigation systems.

1.4 SUBLETTING AND ASSIGNMENT

- A. The Irrigation Contractor shall not assign or sublet any portion of this work without written approval of the Owner of the specific sub-contractor prior to commencement of the work to be sub-contracted. Acceptance by the Construction Manager of the sub-contractor does not decrease or relieve the responsibility of the Irrigation Contractor.

1.9 ERRORS OR CONFLICTS IN DRAWINGS AND SPECIFICATION

- A. The Irrigation Contractor shall immediately notify the Architect and Owners representative should he find any errors or conflicts in the drawings and or specifications. Construction Manager will render his interpretation or instructions on the items as soon as possible.
- B. Any work undertaken by the Irrigation Contractor with regard to errors or conflicts will be done so at his own risk unless he has received written prior approval from the Construction Manager.

1.5 DEFINITIONS

- A. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.
- B. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.
- C. Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.
- D. 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.

1.6 PERFORMANCE REQUIREMENTS

- A. Irrigation zone control shall be automatic operation with controller and automatic control valves.
- B. Design 100 percent coverage irrigation system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 - 1. This irrigation system is being installed to provide watering of plant beds and lawn areas. A Geotechnical Report describing the findings of sub-surface investigations is attached to these Specifications for reference.
- C. Minimum Working Pressures: The minimum pressure requirements for piping, valves and specialties unless otherwise indicated shall match the existing water supply system. Contractor shall perform any testing required to determine working pressures.
- D. Final installed irrigation system of existing and new components shall be fully operational and provide full coverage.

1.7 SUBMITTALS

- A. General: Submit the following in accordance with the Conditions of Contract and Division 01 Specification Sections.
- B. A complete system design, including diagrammatic layout and specifications compliant with the requirements of this project and these specifications.
- C. Product Data: For each type of product indicated. Included rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- D. Wiring Diagrams: For power, signal and control wiring.
- E. Delegated-Design Submittal: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- F. Coordination Drawings: Irrigation systems, drawn to scale, on which components are shown and coordinated with each other, using input from Installers of the items involved. Also include adjustments necessary to avoid plantings and obstructions such as signs and light standards.
- G. Qualification Data: For qualified Installer.
- H. Zoning Chart: Show each irrigation zone and its control valve.
- I. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.
- J. Field quality-control reports.

- K. Operation and Maintenance Data: For sprinklers, controllers and automatic control valves to include in operation and maintenance manuals.
- L. Upon irrigation system acceptance, submit three (3) copies of written operating and maintenance instructions, including winterization procedure. Provide format and contents as directed by the Architect.
- M. Record Drawings:
 - 1. The Subcontractor shall provide and keep up to date a complete set of "As Built" record set of prints which shall be corrected as the work progresses, and show every change from the original drawings and specifications and the actual "As Built" dimensions and kinds of equipment. This set of drawings shall be kept on-site and shall be used only as a record set.
 - 2. These drawings shall also serve as progress sheets, and the subcontractor shall make neat and legible annotations thereon as the work proceeds, showing the work as actually installed. These drawings shall be available at all times for inspection and shall be kept in the Construction Manager's mobile office on location at all times for inspection.
 - 3. Record drawings shall show the location of all sprinklers, valve boxes, valve markers, controllers, pipe, wire trenches, multiple wire splice boxes and all pertinent material buried and not visible to the eye. Record drawings shall indicate dimensions from two permanent points of easily identifiable nature, if possible, such as sprinkler heads, permanent markers, concrete pads, corner of buildings, large caliper trees, etc.
 - 4. On or before the date of final acceptance, the subcontractor shall deliver the corrected and complete prints to the Architect to aid him in completing the "As Built" set of drawings. Delivery of the prints will not relieve the subcontractor of the responsibility of furnishing required information that may be omitted from the prints.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers that include a certified irrigation designer qualified by The Irrigation Association.
- 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.

1.9 DELIVERY, STORAGE AND HANDLING

- A. Deliver irrigation system components in manufacturer's original undamaged and unopened containers with labels intact and legible.
- B. Deliver plastic piping in bundles, packaged to provide adequate protection of pipe ends.
- C. Store and handle materials to prevent damage and deterioration.

- D. Provide secure, locked storage for valves, and similar components that cannot be immediately replaced, to prevent installation delays.

1.10 PROJECT CONDITIONS

- A. Each bidder shall visit the site of the proposed work and fully acquaint themselves with the conditions related to construction and labor and should fully inform themselves as to the facilities.
- B. Known underground and surface utility lines are indicated on the drawings. The site contractor shall obtain a utility locating company to locate utility lines of which information shall be provided to the irrigation contractor.
- C. Protect existing trees, plants, lawns and other features designated to remain as part of the final landscape work.
- D. Promptly repair damage to adjacent facilities caused by irrigation system work operations. The cost of repairs shall be at the subcontractor's expense.
- E. Contractor shall be responsible for reviewing site conditions and irrigation scope of work at bid time to confirm requirements for a complete new system within designated areas on plans.
- F. Remove and dispose of all existing in-ground irrigation system. Deliver working components in good condition to the Owner. Contractor shall dispose of salvaged materials if the Owner declines receipt.
- G. Exact locations of piping, sprinkler heads, valves and other components shall be established by the subcontractor in the field at the time of installation.
- H. Cutting and Patching:
 - 1. Cut through concrete and masonry for conduits with core drills. Jack hammers are not permitted.
 - 2. Materials and finishes for patching shall match existing cut surface materials and finish. Exercise special care to provide patching at openings in exterior walls water tight.
 - 3. Methods and materials used for cutting and patching shall be acceptable to the Architect.

1.11 CONDUCT OF WORK

- A. The Irrigation Contractor shall maintain a competent full-time superintendent/representative satisfactory to the Construction Manager, on work in progress, with authority to act in all matters pertaining to the work.
- B. As soon as the Irrigation Contractor starts work on the job, the Irrigation Contractor is to establish a daily log of activities. This log is to be signed by the Irrigation Contractor's Superintendent and the Construction Manager.

- C. The Irrigation Contractor shall coordinate his work with the other trades and in particular the Construction Manager and maintenance operations. The Irrigation Contractor shall also coordinate his work with that of his subcontractors.
- D. The Irrigation Contractor shall confine his operations to the area to be improved and to the areas allotted him by the Construction Manager for materials and equipment storage.
- E. During the work, the Site Contractor shall erect proper protective devices to warn and or prevent players/pedestrian/individuals and maintenance personnel or and from the danger of construction.
- F. The Architect assumes no responsibility in the supervision and inspection of the work involved in the execution of this contract beyond insuring, to the Owner's satisfaction, that the plans and specifications are being properly interpreted. This supervision and checking will not relieve the Irrigation Contractor of any responsibility for the performance of his work in accordance with the plans and these specifications.

1.12 WARRANTY

- A. For a period on one (1) year from the date of final acceptance of the irrigation system, the subcontractor shall promptly furnish and install, any parts which prove defective due to faulty product or faulty installation by the subcontractor.
- B. During the warranty period, the subcontractor shall extend to the Owner, any and all warranties that apply to equipment found to be defective in either materials or workmanship, as extended by the manufacturer and/or distributor to the subcontractor. The limits of this equipment warranty shall be expressly stated by the appropriate manufacturer/distributor in writing.

1.13 COORDINATION

- A. Coordinate work of this Section with that of other trades, under this and other Contracts with the Owner, affecting or affected by this work, and cooperate with the other trades as is necessary to assure the steady progress of work.
- B. Before proceeding with installation work, inspect all project conditions and all work of other trades to assure that all such conditions and work are suitable to satisfactorily receive the work of this Section and notify the Construction Manager in writing of any which are not. Do not proceed further until corrective work has been completed or waived.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Manufacturers:
 - 1. The Toro Company, distributed by Turf Products, LLC, Enfield, CT.
 - 2. Hunter International, Inc., San Marcos, CA.

3. Rain Bird Corporation, Azusa, CA.

2.2 MATERIALS

A. General

1. Provide only new materials, without flaws or defects and of the highest quality of their specified class and kind.
2. Comply with pipe sizes indicated. No substitution of smaller pipes will be permitted. Larger sizes may be used subject to acceptance of the Architect.
3. Provide pipe continuously and permanently marked with manufacturer's name of trademark, size schedule and type of pipe, working pressure at 73 degrees F. and National Sanitation Foundation (NSF) approval.

B. Pipe, Fittings and Connections

1. Polyvinyl chloride pipe: ASTM D2241, Type 1, Grade 1 rigid, unplasticized PVC, extruded from virgin parent material, conforming to CS256-63. Provide pipe homogeneous throughout and free from visible cracks, holes, foreign materials, blisters, wrinkles and dents.
 - a. All main line pipe and lateral pipe over 2-1/2" in size shall be PVC, SDR 26, Class 160 and shall have an o-ring gasketed connection.
 - b. All lateral piping over 1-1/4" in size shall be PVC, SDR 21, Class 200 and shall have solvent weld connections.
 - c. All piping for sleeves under roadways, sidewalks, etc., shall be Schedule 40, unless otherwise stated on the plans.
 - d. All pipe from the water supply connection through the backflow preventer and to a point five feet outside the buildings shall be copper, Type L, in sizes as indicated on the plans.
2. Polyethylene Pipe: ASTM D2239, Type II – PE 2306 high density, manufactured from virgin parent material. Provide pipe homogeneous throughout and free from visible holes, foreign materials blisters, wrinkles and dents. Polyethylene pipe shall be NSF approved.
 - a. All lateral pipes under 1-1/2" in size shall be polyethylene pipe and shall be SDR 11.5, 100 PSI.
3. Fittings:
 - a. All main line fitting over 2" in size shall be PVC, "o" ring gasketed fittings rated for a minimum of 200 psi. Fittings shall be manufactured in one piece of injection molded PVC, "o" ring gasketed fittings rated for a minimum of 200 psi. Fittings shall be manufactured in one piece of injection molded PVC compound meeting ASTM D1784. Fittings shall be produced in compliance with ASTM D-2241-80. Tapped outlets shall be the same size as valve assembly. Fabricated fittings will not be allowed.
 - b. Fittings for PVC lateral pipe shall be schedule 40 PVC fittings, suitable for solvent weld and threaded connections.

- c. Fittings for polyethylene pipe shall be PVC insert fittings. Stainless steel clamps shall be used to secure pipe to fittings. On pipe over 1" in size, two stainless steel clamps shall be used for each connection.
 - d. Fittings for electric valve assemblies and swing joint assemblies for quick coupling valves shall be brass, conforming to ASTM B16.15 and WW-P-460. Fittings shall have a minimum pressure rating of 125 psi at 400 degrees F. Fittings shall be of U.S. manufacture.
 - e. Fittings for copper pipe shall be wrought solder joint fittings, ANSI B16.22.
- C. Sprinklers, Valves, And Associated Equipment:
- 1. Rotary sprinklers shall be pop-up type with a pop-up height of 4". Sprinkler shall be constructed of plastic and shall have wiper seal, stainless steel retraction spring, and a factory installed drain check valve capable of checking a minimum of 10 feet of elevation change. Sprinkler shall have interchangeable nozzles, adjustable radius, and a variable stator which will not require changing stator when changing nozzles. Part circle sprinklers shall have adjustable arc (40° - 360°). Sprinkler shall have stainless steel retraction spring, stainless steel riser, permanent rubber cover and screw on cover with locking screw. Maximum exposed area of sprinklers shall be 2". Adjustable arc rotary sprinklers shall not be used for full circle rotary sprinklers. Sprinklers shall have five year exchange, non-prorated warranty.
 - a. Rotary sprinkler head assembly shall be connected to lateral line piping by installing three-way swing joint riser assembly. Swing joint riser assembly shall have a working pressure rating of 315 PSI at 73 degrees F, O-Ring(s) at each swivel joint, buttress threads at each swivel joint and inlet and outlet sockets conforming to ASTM Standards D 2467 and D 2464 respectively. Body wall thickness of all components shall conform to ASTM D 2464. Assemblies shall be of molded rigid polyvinyl chloride (PVC) Type 1, Cell Classification 12454-B per ASTM Standard D 1784, and shall be manufactured in such a way that both the male and female O-Ring sealing areas are free from mold parting lines. Swing joint riser assemblies shall have socket connection to the lateral piping and male thread into the sprinkler, with either solvent cement riser nipple factory assembled or unitized riser, and shall have a minimum diameter of the size of the sprinkler inlet. Swing joint riser assemblies shall have a three (3) year warranty.
 - 2. Spray sprinklers shall be pop-up type. Sprinkler shall be constructed of plastic and shall have wiper seal, stainless steel retraction spring and check-o-matic valve. Sprinklers located in lawn areas shall have a pop-up height of 4". Sprinklers located in plant beds shall have a pop-up height of 12".
 - a. Nozzles shall be matched precipitation with performances as indicated on the drawings. Nozzles shall be of plastic construction with radius adjustment screw and shall have screen. Adjustable arc nozzles shall be used where necessary for proper coverage.
 - b. Spray sprinklers shall be connected to the lateral piping using Funny Pipe.
 - 3. Install drip irrigation or appropriate spray sprinklers in plant beds.
 - 4. Manual Valves:
 - a. A manual gate valve shall be installed on the inlet side of all electric control valves. Manual gate valves shall be of bronze, non-rising stem, screw in bonnet, solid wedge, and red bronze cross handle, rated for 200 psi WOG. Valves shall meet Federal Specification WW-V-54 Class A, Type 1 & MSS SP-80. Valves shall

be installed in valve boxes as detailed on the plans. Manual gate valves shall be manufactured by Nibco, Model No. T-113 series or approved equal.

5. Electrically activated remote control valve shall be of plastic construction with stainless steel spring, normally closed with manual bleed lever and brass manual flow control stem. Flow control shall be brass and stainless steel with o-ring seal. Valve shall automatic pressure regulating device which works both electrically and manually. Solenoid shall be 24 volt AC with waterproof molded coil. Diaphragm shall be of rubber material. All parts shall be serviceable without removing valve from the line. Electric valves shall be sized as indicated on the plans.
6. Valve Access Boxes:
 - a. Valve access boxes shall be tapered enclosures of rigid plastic material comprised of fibrous components, chemically inert and unaffected by moisture corrosion and temperature changes. Provide lid of same material, green in color.
 - 1) Valve access boxes for electric valve assemblies shall be 12" deep with 13" X 18" base dimensions.

D. Controls:

1. The new controller for the irrigation systems shall be solid state type. Controllers shall be capable of automatic, semi-automatic or manual operation. Controller shall have a minimum of 12 stations. New irrigation controls shall be mounted inside ambulance bay area as indicated on the MEP plans. Final location shall be coordinated with architectural improvements Architect, MEP Engineer and the Owner. Coordinate final location of controls in field with building plumber, CM and Owner.
2. Controllers shall have battery backup which will retain program and real time in the event of a power failure and two separate sensor hook-ups. Controller shall have a "Water Budgeting" feature which changes all stations within a program from 25%-200% in 25% increments, and a rain shutdown feature which won't lose time or programs. Controllers shall be maintenance radio ready by way of single-plug connection. Controllers shall have four independent programs, and shall have a self diagnostic electronic circuit breaker that identifies and overrides electrical malfunction of a valve. Controllers shall be equipped with input and output lightning protection. Subcontractors shall supply batteries for the controller.
3. Irrigation controls shall incorporate a rain sensor to cancel the irrigation program if a preset amount of rain has fallen. Rain sensor shall use a water-absorptive material to measure rainfall, and have a U.V. stabilized thermoplastic switch housing and aluminum mounting bracket. Sensor shall be adjustable from 1/8"-1". Rain sensor to be installed where directed by the Landscape Architect.

E. Electrical Control Wire:

1. Electrical control and common wire from the controller to the electric valves shall be type UF, 600 volt, single strand, solid copper, direct burial, sized at 14 gauge. Conduit from the irrigation controller to a point five feet outside buildings shall be installed by others.

F. Backflow Preventer:

1. Install a backflow preventer as required to ensure proper operation of the irrigation system.

2.3 ACCESSORIES

- A. Drainage fill around valve boxes shall be 1/2" to 3/4" crushed stone.
- B. Trench backfill at field shall conform with details and project specifications.
- C. Fill shall be clean soil free of stones larger than 2" diameter, foreign matter, organic material and debris.
 - 1. Provide imported fill material as required to complete the work. Obtain rights and pay all costs for imported materials.
 - 2. Suitable excavated materials removed to accommodate the irrigation system work may be used as fill material subject to the Architect's review and acceptance.
- D. Wire connectors for 24 volt control wiring shall be as manufactured by Scotch, Model No. DBY or DBR.
- E. Rain Sensor.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine final grades and installation conditions. Do not start irrigation system work until unsatisfactory conditions are corrected.

3.2 PREPARATION

- A. Layout and stake the location of each pipe run and all sprinkler heads and sprinkler valves. Obtain Architect's acceptance of layout prior to excavating.
- B. All sleeves required for the installation of the irrigation system are to be installed by this Subcontractor. Wires are to be installed in separate sleeves. Coordinate irrigation route and sleeve installation with project site contractor and construction manager.

3.3 INSTALLATION

- A. Excavation and Backfill:
 - 1. Excavation shall include all materials encountered.
 - 2. Excavate trenches of sufficient depth and width to permit proper handling and installation of pipe and fittings.
 - 3. If the pulling method of pipe installation is used, the pipe "plow" shall be a vibratory type. Starting and finishing holes for pipe pulling shall not exceed a 2'-0" by 3'-0" opening.
 - 4. Excavate to depths required to provide 2" depth of earth fill or sand bedding for piping when rock or other unsuitable bearing material is encountered.

5. Fill to match adjacent grade elevations with approved earth fill material. Backfilling will be done by hand placing soil under, around and above pipe so that it is hand tamped to a point 6" above the pipe. Special care shall be taken to insure that this layer is completely free of stones and other deleterious material. The remainder of the trench may be machine filled with appropriate available soil. Machine placed backfill shall be compacted to a suitable density by machine tamping and approved rolling to prevent settlement in trench.
 - a. If within one (1) year from the date of final acceptance, settlement due to improper compaction occurs and an adjustment in pipes, valves and sprinkler heads, turf or paving is necessary to bring the system, turf or paving to the proper level of the permanent grades, the Contractor, as part of the work under this contract, shall make said adjustments without extra cost to the Owner.
 6. Except as indicated, install irrigation mains with a minimum cover of 20" based on finish grades, unless otherwise noted. Install irrigation laterals with a minimum cover of 12" based on finish grades.
 7. Excavate trenches and install piping and fill during the same working day. Do not leave open trenches or partially filled trenches open overnight.
 8. Contractor shall not sawcut existing paved surfaces. Coordinate sleeves with site contractor.
 9. Pipe shall be installed strictly in accordance with the printed recommendations of the manufacturer, including bedding of pipe in the bottom of trench and securely thrusting of any main line fittings at changes in direction of the pipe.
 10. All o-ring gasketed piping shall be thrust in accordance with the manufacturer's recommendations. Thrust blocks of poured-in-place concrete will be used. Concrete shall have a compressive strength of 2500 PSI, 28 day strength. In no case will sakrete, field stone or wood of any form be acceptable for thrusting. Thrust blocks shall bear against undisturbed trench walls.
- B. Plastic Pipe:
1. Pipe lines shall be installed of the size shown on the drawings and/or specifications and of the materials and workmanship herein specified.
 2. All main line piping to be installed in trenches as per the provisions of Section 3.03.A. Lateral piping may either be installed in trenches as above or by pipe pulling. Coordinate with existing utilities.
 3. Pipe shall be installed strictly in accordance with the printed recommendations of the manufacturer, including bedding of pipe in the bottom of trench.
- C. Sprinklers, Fittings, Valves and Accessories:
1. Install fittings, valves, sprinklers and accessories in accordance with manufacturer's instructions, except as otherwise indicated.
 2. Locate sprinklers where indicated on the drawings.
 3. A manual gate valve shall be installed on the pressure side of all remote control valves in the system for the purpose of isolating any control valve requiring service and/or repair work. The manual valve to be an integral part of the control valve assembly and installed as detailed on the drawings.
 4. Power for controllers shall be taken from a 120 volt circuit located within the building. All wiring inside the buildings shall be installed in electrical conduit. All work required for the power source for the irrigation controller shall be installed by the irrigation

contractor, and all control wiring shall be supplied and installed by this contractor. All wiring shall be performed in accordance with all applicable codes.

- a. Install rain sensors as recommended by the manufacturer. Rain sensor shall be installed so that it is not obstructed from rainfall or where water can be deflected on them. Install all exposed wiring in conduit. Install rain sensor a minimum of 10' above finish grade.
5. All remote control valves connected to main line threaded outlets shall utilize extra heavy brass fittings and brass nipples. Remote control valves shall be mounted in plastic valve boxes installed as per drawings.
6. Install valve access boxes on a suitable base of gravel to provide a level foundation at proper grade and to provide drainage of the access box. Gravel shall extend from the bottom of the valve to 3" below the bottom of the valve box. Valve box locations to be located on "As Built" drawing with measurements from two permanent markers to each valve box.
7. Seal all threaded connections with approved joint compound. Teflon tape shall not be used. Do not over tighten threaded connections.

D. Wire:

1. All wiring is to be installed in the piping trenches wherever possible. Approved wire ties shall be utilized approximately every 20' on wire runs installed in main line trenches or wire trenches.
2. All wires to be spliced to requirements of local and minimum regulations, or to the following specification. All splices shall be made by baring a minimum of 3/4" of copper conductor twisted together, connected and sealed with an approved splice kit. Procedures recommended by manufacturer shall be strictly followed. At splice location, slack shall allow the splice to be raised a minimum of 24" for inspection. Any underground splices not located at control valve sites shall be housed in a valve box for access.
3. Wire shall be installed with at least 1% slack and have expansion loops at end of 250' runs. Wire shall not be yanked, stretched, or excessively pulled during installation. Wire shall be laid on a firm, even bed in the trench which shall support the entire length. The Subcontractor shall take strict precautions to ensure that wires are not cut, scraped, or nicked during installation. Wire shall be laid above and to one side of the main line pipe, never directly over the pipe. Wherever possible, wire shall be laid on the same side of the trench throughout the entire job. All wiring shall be installed with a minimum depth of cover of 18".
4. All wiring shall be installed in accordance with all local, State and National codes.

E. Sleeves:

1. All sleeves for installation of the irrigation system are to be installed by Subcontractor. All wire shall be installed in separate sleeves. Spare sleeves shall be installed at each sleeve location as indicated on the drawings. Spare sleeves shall be installed with PVC caps on each end.

F. Testing:

1. The Subcontractor shall be responsible for all hydraulic pressure testing of main lines and lateral lines. The testing shall be on a continuous basis commencing when the first section of the installation is complete and available for testing. Final testing of the whole system under full operating conditions to be done following complete installation of all main and lateral piping, valves and sprinklers.

2. Prior to testing of the main line pipe, pipe shall be backfilled, thrust blocks poured and set. Testing for main line shall consist of a continuous application of water at a pressure of 150 PSI to the piping for a one hour period without visual evidence of leaks. If a leak is discovered within this period, the Subcontractor shall immediately repair the break and the system then retested for the period described above in this section. Testing of lateral lines shall be done on a zone by zone operating basis with any leaks or breaks repaired when evidenced

G. Adjusting the System:

1. Adjustment of the sprinklers, remote control valves, and automatic equipment will be done by the Subcontractor upon completion of the installation to provide optimum performance and balance throughout the irrigation system.

H. Service:

1. The Subcontractor shall return to the site during the fall seasons of the warranty period and winterize the system. Drain all water from the system and blow out the system with compressed air. Owner shall be present to observe proper system shut down.
2. The Subcontractor shall return to the site during the spring seasons of the warranty period, start-up the system and demonstrate to the Owner the proper procedures for the system start-up, operation, and maintenance. Owner shall be present to observe proper opening of system.

I. Coordinate tapping into water system with building plumbing contractor and GC. Coordinate backflow preventer as required in mechanical room.

J. Controller: Coordinate final controller location in the building and any irrigation related plumbing in the building with the Owner and MEP Engineer. Field adjust as required to install a fully operational system at no additional expense to the contract.

3.4 SPARE PARTS

A. Above and beyond the installation requirement, the Subcontractor shall leave with the Owner, the minimum following loose equipment (match final system design components):

1. (3) Full circle rotary sprinklers - 60' radius.
2. (3) Part circle rotary sprinklers - 60' radius.
3. (2) Part circle rotary sprinklers - 35' radius.
4. (5) 4" pop-up spray sprinklers.
5. (5) 12" pop-up spray sprinklers.
6. (5) 8' drip irrigation feeder line hoses and emitters
7. (1) 12' section of drip line
8. (2) Electric valve diaphragm for each size valve.
9. (2) Electric valve solenoids.

8. Lid for valve box of each size
9. DBY electrical connectors
10. DBR electrical connectors
11. 1 Set of tools for repair and maintenance of sprinklers supplied.
12. 1 Set of spare keys for controller cabinets.

3.5 DISPOSAL OF WASTE MATERIALS

- A. Remove from site and legally dispose of excavated material, including soils, rock, trash and debris.

3.6 ACCEPTANCE

- A. Test and demonstrate to the Architect and Construction Manager, the satisfactory operation of the system free of leaks.
- B. Instruct the Owner's designated personnel in the operation of the system, including adjustment of sprinklers, controllers and valves.
- C. Upon acceptance, the Owner will assume operation of the system.

3.7 CLEANING

- A. Perform cleaning during installation of the work and upon completion of the work. Remove from site all excess materials, soil, debris, and equipment. Repair damage resulting from irrigation system installation.

END OF SECTION 32 80 00

SECTION 32 91 01 – TOPSOIL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Testing, amending, screening, placing and finish grading all stockpiled and borrow topsoil.
 - 2. Provide all borrow topsoil necessary to properly complete all lawn and planting operations.
 - 3. CU Structural Soil for the tree planting beds at the playground.
- B. Related Sections include the following:
 - 1. Division 31 Section “Site Clearing”.
 - 2. Division 31 Section “Earth Moving”.
 - 3. Division 32 Section “Turf and Grasses”.

1.3 QUALITY ASSURANCE

- A. All work shall comply with all codes, rules, regulations, laws and ordinances for the Town of Newington, State of Connecticut, and all other authorities having jurisdiction.
- B. Topsoil:
 - 1. Testing: Representative samples of all stockpiled and borrow topsoil shall be completely analyzed/tested to determine:
 - a. Nutrient analysis using the Modified Morgan extractant for soil available P, K, Ca, and Mg.
 - b. Soil pH.
 - c. Organic content-determined by loss of weight on ignition.
 - d. Particle size analysis-sand, silt, and clay-analysis shall be determined using the hydrometer method of particle size analysis with size fractions based upon sized limits established by USDA.
 - e. Laboratory recommendations required for topsoil to achieve optimum nutrient levels for the establishment of lawn, trees and shrubs or special plantings (i.e. wetlands replication).
 - 2. Testing shall conform to “Recommended Soil Testing Procedures for the Northeastern United States”, Bulletin #493

3. Before delivery of any borrow topsoil, furnish the Architect with a 5 gallon sample of material.
4. Topsoil testing costs shall be borne by the Contractor.
5. Testing laboratory shall be:
Soil Nutrient Analysis Laboratory
Department of Plant Science
University of Connecticut
2019 Hillside Road, U-102
Storrs, Ct 06269-1102
6. Contractor may submit a written request to utilize an alternate testing laboratory, to the Owner and Architect for approval. This request must include the qualifications of the proposed alternate laboratory. This laboratory may not be retained by the Contractor until written permission is received from the owner and Architect.

1.4 SUBMITTALS

- A. Submit topsoil test results to the Architect for review. The Architect will be the sole judge of acceptability.
- B. 5-lb sample to the Architect for visual conformance confirmation.

1.5 PRODUCT HANDLING

- A. Coordinate delivery of borrow topsoil such that it is placed as delivered and no stockpiling is required.

PART 2 - PRODUCTS

2.1 BORROW TOPSOIL

- A. Shall be a sandy loam, or fine loamy sand (per USDA Soil Classification index), with a minimum 70% sand content by weight not to contain materials harmful to plant life, to be clean, fertile, friable, and well draining. All topsoil to be free of any subsoil earth clods, sod, stones over 3/4" in any dimension, sticks, roots, weeds, litter and other deleterious material. Topsoil shall be uniform in quality and texture and contain organic matter and mineral elements necessary for sustaining healthy plant growth.
- B. Topsoil shall have the following optimum ranges unless otherwise approved by the Architect.
 1. Organic Matter Content: 3 – 7%
 2. Acidity range: pH 6.0 to pH 7.4
- C. Nutrient levels shall be achieved by the Contractor's addition of amendments to the topsoil to meet the optimum nutrient levels specified in the testing laboratory report.

2.2 STOCKPILED TOPSOIL

- A. Stockpiled topsoil shall conform to all requirements of paragraph 2.1. **All** stockpiled topsoil material must be 1/2" screened, whether the material is to be used for project development, or will become excess material.
- B. Provide amendments to stockpiled topsoil (organic material, sand, etc.) to produce topsoil in conformance with the Soil Nutrient Analysis Recommendations and project requirements.
- C. Waste products from screening operations are the property of the Contractor and shall be removed from the site at the Contractor's expense.

2.3 STRUCTURAL SOIL FOR TREE PLANTING BED

- A. Structural Soil shall be CU Soil as manufactured by Amereq Inc. and supplied by Dunning Industries Custom Soil or equal.
- B. Soil shall be composed of a stone lattice and soil matrix specifically designed and manufactured as a growing media to support tree growth. Soil matrix shall have approximately 40% void and be structurally stable to enable surface improvements and prevent over compaction from pedestrian and vehicular surface activity. Soil shall be free draining and retain optimum level of moisture for plant growth.

PART 3 - EXECUTION

3.1 SHAPING AT ALL NEW LAWN AREAS

- A. After rough grading has been completed, shape and grade lawn subgrade areas to lines and levels as noted on the drawings and as required based on total amounts of approved topsoil to allow placement of uniform depth of topsoil. Adjustments may be necessary due to field conditions. Provide all shaping adjustments at no additional cost to the Owner.
- B. Cultivate and loosen the subgrade soil to min. 18" depth with a subsoiler or other approved machinery to correct over-compaction.
- C. After shaping of lawn subgrades remove all sticks, stones, or foreign material one (1) inch or greater in dimension. Remove debris and stone off-site.

3.2 TOPSOIL SPREADING

- A. **Do not apply topsoil to the prepared subgrade without approval by the Architect.** Once approved, no vehicular traffic will be allowed on finish subgrade. Topsoil will not be permitted to be spread until topsoil test reports have been submitted and approved. Topsoil shall not be delivered or worked in a frozen or muddy condition.
- B. Uniformly distribute and spread topsoil over all graded lawn areas to conform smoothly to the lines, grades, and elevations shown or otherwise required. If directed conduct field density tests to demonstrate friable subgrade conditions. All general lawn areas to have a minimum of 6" of

topsoil after compaction. All approved stockpiled topsoil is to be spread unless otherwise directed by the Owner. Maintain consistent depths of material throughout the project area.

1. Manually supply topsoil around all trees to remain. Avoid damage to root systems.
- C. Topsoil shall be spread in (2) equal lifts. Bottom lift shall be thoroughly mixed with the loosened subgrade by disking, harrowing, or other approved means, to a depth of 4 inches into the subgrade, to create a transition layer.
- D. Place topsoil only when it can be immediately followed by lawn development operations.
- E. Supply and replace topsoil to eroded, settled or damaged areas until all lawn areas are stabilized. Care shall be taken not to damage grass or pavement areas in the replacement to topsoil.

3.3 PROTECTION

- A. Remove weeds prior to lawn development operations. No weeds shall be allowed to go to seed.
- B. Keep heavy equipment, trucks, etc. off areas that have received topsoil, at all times.
- C. If compaction occurs, scarify to the full depth of the topsoil and regrade topsoil.

3.4 STRUCTURAL SOIL FOR TREE PLANTING BED

- A. Install Structural Soil/ CU Soil within in tree plant beds to depths and dimensions as detailed.
- B. Do not intermingle with other soils.
- C. Grade structural soils smoothly and consistently in preparation to receive surface improvements. Coordinate with proposed improvements. Compact CU soil to prevent settlement.
- D. Install separation fabric over structural soils prior to placement of finishing stone and surface layer of synthetic turf or EPDM mulch around tree.
- E. Pitch subgrade to perforated perimeter drains. Drains shall be a minimum of 4" diameter around the bottom of the tree planters and connect to adjacent drainage system. Perforated pipes shall be sleeved with filter fabric.

3.5 EXCESS TOPSOIL

- A. Material approved for reuse but not required to be installed remains the property of the Owner and shall be deposited by the Contractor at a location designated by the Owner in the Town of Newington. This surplus topsoil may require minor re-grading, shaping into berms, and seeding with temporary cover seed mix. This stabilization work is a part of this contract and shall be performed at no additional cost to the Owner.
- B. Material not approved for reuse remains the property of the Contractor and is to be removed from the site.

- C. Upon the final review of the stockpiled material, the Owner reserves the right to decline acceptance of any excess topsoil material. In this event, the Contractor shall remove from the site at their own expense.

END OF SECTION 32 91 01

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SECTION 32 92 00 – TURF AND GRASSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. The work of this Section includes the following:
 - 1. Fine grading and preparing lawn areas.
 - 2. Furnishing and applying soil amendments.
 - 3. Furnishing and applying fertilizers.
 - 4. Seeding new lawns.
 - 5. Sodding new lawns.
 - 6. Replanting unsatisfactory or damaged lawns.
 - 7. Maintenance of all lawns until acceptance.
- B. Related Sections include the following:
 - 1. Division 31 Section “Site Clearing”.
 - 2. Division 31 Section “Earth Moving”.
 - 3. Division 32 Section “Topsoil”.
 - 4. Division 32 Section “Plants”.

1.3 DEFINITIONS

- A. Form 816: “Standard Specifications for Roads, Bridges and Incidental Construction”, State of Connecticut, Department of Transportation, Form 816, 2004 edition, with 2005 supplement.

1.4 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for the following:
 - 1. Fertilizers.
 - 2. Limestone.
 - 3. Chemical preservatives and controls – also confirm that each of the materials proposed to be applied are permitted for use by the State of Connecticut.
- C. Certification of grass seed from seed vendor for each grass-seed mixture and sod grown stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of

packaging. Submit topsoil test of sod source to determine compatibility of sod material with project topsoil (borrow & stockpiled).

- D. Seed labels from actual bags/containers of the seed mix at the time of seeding.
- E. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and address of Architects and Owner, and other information specified.
- F. Material test reports from qualified independent testing agency indicating and interpreting test results relative to compliance of the following materials with requirements indicated.
 - 1. Analysis of existing surface soil.
 - 2. Analysis of imported topsoil.
- G. Planting schedule indicating anticipated dates and locations for each type of seeding or sodding.
- H. Maintenance instructions recommending procedures to be established by Owner for maintenance of lawns during an entire year. Submit before expiration of required maintenance periods.
- I. The Contractor must include, in the Schedule of Values, a separate line item for "Maintenance of Lawns". This item will include all costs assigned by the Contractor, for the expenditure of labor and materials anticipated from the time of lawn establishment, until acceptance.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who has completed lawn development work similar in material, design, and extent to that indicated for this Project and with a record of successful grass establishment.
 - 1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on the Project site during times that grass planting is in progress.
 - 2. Athletic field contractors must have completed 5 athletic fields in the past three (3) years, similar to the design and materials specified herein.
- B. Examine work to receive lawn development and notify the Architect of any defects. Specifically review the topsoil placement (depths, grades, and condition). Commencement of this work implies acceptance by Contractor of preparatory work by others.
- C. The application of herbicides and pesticides is prohibited by State of Connecticut Statutes.
- D. Pre-installation Conference: Conduct conference at Project site to comply with requirements of Division 01 Section "Project Meetings".

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Seed, Fertilizer and Lime: Deliver in original sealed, labeled, and undamaged containers, showing weight, analysis, and name of manufacturer.
- B. Sod: Harvest, deliver, store, and handle sod according to the requirements of the American Sod Producers Association's (ASPA) "Specifications for Turfgrass Sod Materials and Transplanting/Installing."
- C. Protect materials from deterioration during delivery and while stored at site.

1.7 GUARANTEE

- A. Duration of guarantee shall be until the completion of the specified maintenance period and until Owner's final acceptance of all lawn areas.

1.8 CHEMICAL CONFORMANCE

- A. All chemical applications shall conform to the State of Connecticut statutes and Town Integrated Pest Management (IPM) plans.
- B. Contractor shall provide all necessary data and information to the Owner for amending or filing an IPM plan, including, but not limited to proposed chemicals and EPA number, applicator name and license number, and proposed application dates.
- C. All fertilizer, pest and vegetation control applications must conform to the Town IPM, or in the absence thereof, must conform to the regulations of the State of Connecticut, in addition to any and all conditions listed in Division 1, Section "Project Environmental Permits" of this Specification.

PART 2 - PRODUCTS

2.1 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with the Association of Official Seed Analysts' "Rules for Testing Seeds" for purity and germination tolerances.
 - 1. Seed Mixture: Provide seed of grass species and varieties, proportions by weight, and minimum percentages of purity, germination, and maximum percentage of weed seed as indicated on Schedules at the end of this Section.

2.2 SOD

- A. Sod: Certified turfgrass sod minimum two years' old, complying with ASPA specifications for machine-cut thickness, size, strength, moisture content, and mowed height, and free of weeds and undesirable native grasses. Provide viable sod of uniform density, color, and texture of the following turfgrass species, strongly rooted, and capable of vigorous growth and development when planted. Pad thickness 3/4" (+1/4"), excluding thatch and top growth. Minimum size: 9 SF/piece.

1. Species: Provide sod of grass species and varieties, proportions by weight, and minimum percentages of purity, germination, and maximum percentage of weed seed as indicated on Schedules at the end of this Section.
2. Sod to be harvested from field, which is comprised of a “sandy loam” or “loamy sand” classification of soil.

2.3 LIME

- A. ASTM C 602, class T, agricultural ground limestone containing a minimum 50 percent total oxides (calcium oxide plus magnesium oxide), with a minimum 50 percent passing a 100 mesh sieve, and 98% passing a 20-mesh sieve, for powder form of lime.
 1. Provide lime in the form of dolomitic limestone.

2.4 FERTILIZER

- A. Phosphorus: Commercial, soluble; guaranteed analysis of 0-46-0.
- B. Starter Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast release water soluble nitrogen, derived from natural organic sources of urea ammonium phosphate, or similar material.
 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency, 14.28.14 guaranteed analysis.
- C. Secondary-Fertilizer: Granular fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium with guaranteed analysis of 15.15.15.
- D. Tertiary Fertilizer: guaranteed analysis of 46-0-0.

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.
- B. Peat Mulch: Provide peat moss in natural, shredded, or granulated form, of fine texture, with a pH range of 4 to 6 and a water-absorbing capacity of 1100 to 2000 percent.
- C. Fiber Mulch: Biodegradable dyed-wood cellulose-fiber mulch, nontoxic, free of plant growth or germination inhibitors, with maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.
- D. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application, nontoxic and free of plant growth or germination inhibitors.

2.6 EROSION CONTROL MATERIALS

- A. Material shall be a lightweight, nonwoven erosion control/revegetation blanket comprised primarily of virgin wood fiber. The blanket shall be manufactured by blending thermal mechanically – defibrated wood fiber with a small percentage of recycled synthetic fibers and forming them into a drapeable blanket. An accelerated photodegradable polypropylene netting shall be laminated to the surfaces of the blanket.
- B. Material shall be similar to “Futerra”, as manufactured by Conwed Fibers of Statesville, North Carolina, or approved equal.

2.7 SALT MARSH HAY

- A. Naturally harvested salt marsh hay, certified weed free.

2.8 CHEMICAL PREVENTATIVE AND CONTROLS

- A. Commercial materials for pest and vegetation controls shall conform with State of Connecticut Statutes. Any chemical preventative and control that is submitted by the contractor shall include State confirmation that it meets all regulations and is permitted for use in K-8 schools in Connecticut.

2.9 WATER

- A. Potable: The Contractor is responsible for furnishing all water necessary to complete the establishment and maintenance of lawns until acceptance by Owner.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive lawns and grass for compliance with requirements and for conditions affecting performance of work of this Section. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 COORDINATION AND SCHEDULING

- A. Planting Season: Sow lawn seed and install sod during normal planting seasons for type of lawn work required. Correlate planting with specified maintenance periods to provide required maintenance from date of Substantial Completion.
- B. Weather Limitations: Proceed with planting only when existing and forecast weather conditions are suitable for work.
- C. Construct lawns between August 15 and October 1, unless otherwise approved.

- D. Examine areas to receive seeding or sod and notify Architect of any problems prior to commencing work. Specifically review the topsoil placement (depths, grades and conditions). Commencement of this work implies acceptance by Contractor of preparatory work of others.

3.3 PREPARATION

- A. Protect structures, utilities, sidewalks, pavement, and other facilities, trees, shrubs, and plantings from damage caused by lawn and playing field development operations.
 - 1. Protect adjacent and adjoining areas from hydroseed over spraying.
- B. Provide erosion control measures to prevent erosion or displacement of soils and discharge of soil bearing water runoff or airborne dust to adjacent properties and walkways.

3.4 TOPSOIL PREPARATION - GENERAL

- A. Apply lime, and phosphorus at the rates recommended by the topsoil tests. Cultivate topsoil to its full depth by scarifying or other disking methods to thoroughly incorporate amendments into the topsoil. Maintain a loose friable seed bed. At no time will rubber tired loaders or graders having greater compaction than a small farm tractor be allowed on topsoil. Keep all heavy equipment and trucks off prepared topsoil. Do not prepare while ground is wet or frozen.
- B. Provide additional topsoil where and as required to properly meet all proposed finish grades.
- C. Remove any weeds, debris, foreign matter and stones having any dimension greater than 3/4 inch. Remove from property.
- D. Fine grade to a smooth uniform surface. The entire area shall present an even grade with no depressions where water will stand. Any protective fencing around existing trees shall be removed and disposed of by the Contractor at this time. Topsoil shall be smoothly blended to existing finish grades around erosion control devices and adjacent existing conditions, maintain existing surface drainage patterns. Round-off all top and toe of slopes. Reinstall erosion control devices and protective fencing as required.
- E. **Approval of surface by Architect shall be obtained before seeding or sodding operations begin.** Where directed, perform bulk density and nuclear compaction readings to monitor degree of soil compaction/seed bed friability.

3.5 LAWN DEVELOPMENT

- A. General: All disturbed areas not developed otherwise shall be topsoiled and developed as lawn as indicated on the Drawings and as specified.

3.6 SEEDING GENERAL LAWN AREAS

- A. Ensure that the soil has been prepared in accordance with Topsoil Paragraph of this Section. All disturbed areas not developed otherwise shall be developed as lawn.
- B. Seeding shall be done when wind does not interfere with uniform distribution of hydroseeding mixture.
- C. Sow seed at following rates:
 - 1. Seeding Rate: 5 lb. per 1000 sq. ft.
- D. Hydroseeding of general lawn areas, only, is permitted. Mix specified seed, fertilizer, and maximum 10% of fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogenous slurry suitable for hydraulic application.
 - 1. Mix slurry with non-asphaltic tackifier.
 - 2. Apply slurry uniformly to all areas to be seeded in a 2-step process. Apply first slurry application at the minimum rate required to obtain specified seed-sowing rate.
 - 3. Apply second slurry cover coat of fiber mulch at a rate of 1000 pounds per acre.

3.7 SODDING NEW LAWNS

- A. Lay sod within 24 hours of stripping. Do not lay sod if dormant or if ground is frozen. The prepared soil shall be watered within 12-24 hours prior to laying the sod. Sod should not be laid on soil that is dry and powdery.
- B. Lay sod in straight lines to form a solid mass with tight 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 of fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass. Provide full pieces on all perimeter edges.
 - 1. Lay sod across angle of slopes exceeding 1:3.
 - 2. Anchor sod on slopes exceeding 1:5 with wood pegs 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 2 hours of planting. During the first week, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below the sod.

3.8 EROSION PREVENTATIVES

- A. Install erosion control material on all seeded slopes one foot (1') vertical to three (3) feet horizontal or steeper, or any seeded areas which receive concentrated run-off water, and areas as required by the Architect or Owner. Joints in these materials shall overlap no less than one foot (1') and the material shall be secured as recommended by the manufacturer.

3.9 WATERING LAWN AREAS

- A. Maintain a moist seed and sod bed at all times. Water seedbed daily with 1/4" water/day using three sets, keeping the surface moist. Apply complete coverage to insure proper germination/root growth conditions. Maintain soil moisture at or near field capacity during the period of germination and seeding development.
- B. Contractor is responsible for installing and maintaining temporary irrigation as necessary to establish an acceptable stand of lawn in all areas, including sodded areas. This may include watering trucks or piped systems. Temporary irrigation measures shall not obstruct vehicular or pedestrian access to the site or building. Coordinate all proposed temporary measures with the Construction Manager, Owner, project schedule and other contractors. Temporary irrigation shall be removed by the contractor when an acceptable stand of lawn is established and approved by the project Architect.
- C. Protect all lawn areas with barricades, if necessary, to keep all traffic off the area. Repair all damage to lawn areas including topsoil replacement, at no additional cost to Owner.
- D. Adjust watering requirement as required at request of Owner and after a full ground cover has been achieved.

3.10 MAINTENANCE

- A. Begin maintenance of lawns, including sodded lawns immediately after each area is planted and continue until lawn is accepted, but for not less than the following periods.
 - 1. Seeded Lawns: 60 days after date of first mowing, and after a minimum of 5 mowings;
 - 2. Sodded Lawns: 45 days after date of first mowing, and a minimum of 3 mowings;
 - 3. When full maintenance period has not elapsed before end of growing season, or if lawn is not fully established at that time, continue maintenance during the next growing season.
- B. Maintain and establish all lawns by watering, fertilizing, weeding, mowing, trimming, replanting bare or eroded areas and redress to produce a uniformly smooth lawn.
- C. Continue to maintain and water all seeded lawns until accepted. Continue watering and maintenance of sodded lawns for a duration not less than the time when seeded lawns are accepted for turnover to the Owner.
- D. Replant bare, dead or dying areas with same materials specified for lawns and sod.
- E. Add new mulch in areas where mulch has been disturbed sufficiently to nullify its purpose. Anchor as required to prevent displacement.
- F. Crabgrass and broadleaf weed control.
 - 1. General: Treat all lawn areas with crabgrass or broadleaf weed control in conformance with manufacturer's recommendations as required (after diagnosis of weed/crabgrass presence) and in conformance with all State and Local regulations.
 - 2. Time: Conform to the manufacturer's recommendations.
 - 3. Rate: Conform to the manufacturer's recommendations.

G. Disease Control

1. General: Treat any diseased lawn areas with disease control in conformance with the manufacturer's recommendations as required (after diagnosis of disease organisms) and in conformance with all State and Local regulations.
2. Time: Conform to the manufacturer's recommendations.
3. Rate: Conform to the manufacturer's recommendations.

H. Mow lawns as soon as there is enough top growth to cut with reel mower set at mowing height of 1-1/2" (bench height). Repeat mowing as required to maintain specified height without cutting more than 30 percent of the grass height on maximum 5 day interval. Remove no more than 30 percent of grass-leaf growth in initial or subsequent mowings. Do not mow when grass is wet. Schedule mowing when grass attains a 2" height. Subsequent mowing to maintain following grass height. Subsequent mowing's to maintain following grass height.

1. Mow grass from 1-1/2 to 2 inches high.
2. Maintain reel blade and bed knife in sharp condition and evenly matched to provide a clean cut.

I. Secondary Fertilization: Apply secondary fertilization to entire lawn and play field areas two (2) weeks after seeding.

J. Tertiary Fertilizations: Apply three (3) tertiary fertilizations at two-week intervals (4, 6, and 8 weeks after seeding) to entire lawn and playing field areas.

3.11 EXISTING LAWN RENOVATION

A. Renovate existing lawn damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.

1. Reestablish lawn where settlement or washouts occur or where regrading is required.

B. Remove sod and vegetation from diseased or unsatisfactory lawn areas; do not bury in soil.

C. Remove topsoil containing foreign materials resulting from Contractor's operations, including oil drippings, fuel spills, stone, gravel, and other construction materials, and replace with new topsoil.

D. Mow, dethatch, core aerate, and rake existing lawn.

E. Remove weeds before seeding. Herbicides are not permitted, remove mechanically or manually.

F. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.

G. Till stripped, bare and compacted areas thoroughly to a soil depth of 12 inches.

- H. Apply soil amendments and initial fertilizers required for establishing new lawns and mix thoroughly into top 6 inches of existing soil. Provide new planting soil to fill low spots and meet finish grades.
- I. Apply seed and protect with straw mulch as required for new lawns.
- J. Water newly planted areas and keep moist until new lawn is established.

3.12 ACCEPTABLE LAWNS

- A. The Architect shall inspect all work for acceptance of lawns upon written request of the Contractor. The request shall be received at least 10 days before the anticipated date of inspection.
 - 1. Lawn areas will not be accepted in “pieces”, unless specifically agreed to by the Owner.
 - 2. If the lawn is in acceptable condition, the Contractor’s maintenance responsibility will end. If, in the opinion of the Architect, the grass stand is unacceptable, the Contractor’s complete maintenance responsibilities shall continue until an acceptable stand of grass is achieved.
- B. All lawns will be considered eligible for inspection and acceptance provided all requirements, including maintenance, have been met and a healthy, uniform, dense stand of grass is established, free of weeds, bare spots and surface irregularities, with coverage exceeding 90 percent over any 5 square feet selected by the Architect. The Architect will be the sole judge of acceptability. Lawns must be free of weeds, crabgrass, and other undesirable plants, with no disease present. Sodded lawns shall be free of open joints and uneven surfaces. Acceptance will not be made until all damaged areas, including areas outside the property limits, have been restored to original conditions.
- C. Prior to acceptance of turf playing fields, the Contractor shall perform a 6 inch deep core aeration. Allow the cores to dry, drag the cores, and top-dress with a one-quarter inch depth of sand to all playing field areas. Contractor must request a meeting with the Architect to establish specific timing of this operation.
- D. In no case will any lawns be accepted prior to Substantial Completion of the overall project.
- E. Replant lawns that do not meet requirements and continue maintenance until lawns are satisfactory. Upon stabilization of lawn areas, remove erosion control devices and protective fencing. Reseed bare areas as required.

3.13 WINTERIZATION

- A. At the end of the growing season, prior to the on-set of Winter, all newly-seeded areas, open earthen areas, or stockpiled earth materials, must be protected from erosion. This protection must form a continuous blanket over these areas. Protection may be:
 - 1. a hydro-seed mulch with a non-asphaltic tackifier, or;
 - 2. straw mulch spread uniformly at a rate of 2 tons per acre to form a continuous blanket 1-1/2 inches in loose depth over the areas with a slope not exceeding 1:6.

3.14 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by lawn work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto surface of roads, walks, or other paved areas. Broom clean all walks and pavements.
- B. Erect barricades and warning signs as required to protect newly planted areas from traffic, vandalism, and unauthorized use. Maintain barricades throughout maintenance period until lawn is established and accepted by the Owner.

3.15 LAWN MATERIAL INSTALLATION

- A. Lawns: Provide materials in not less than the following quantities:
 - 1. Weight of lime per 1000 sq. ft. as per topsoil test report.
 - 2. Weight of phosphorous per 1000 sq. ft.: as per topsoil test report.
 - 3. Weight of commercial fertilizer per 1000 sq. ft.: as per topsoil test report.
 - 4. Cellulose Pulp 'Fiber: 32# /1,000 SF.
 - 5. Grass Seed: 220 lbs./acre.
 - 6. Starter Fertilizer: 310 lbs./acre.
 - 7. Secondary Fertilizer: 300#/acre.
 - 8. Tertiary Fertilizer 50#/acre, providing 22# of nitrogen/acre.

3.16 SEED

- A. Provide fresh, clean, new –crop seed; blue tag certified complying with the tolerance for purity and germination established by the Office of Seed Analysis of North America. Provide seed of the grass species, proportions and maximum percentages of weed seed.
- B. Provide seed in cleaned, sealed, properly labeled containers. Seed that is wet, moldy, or otherwise damaged will not be accepted. Handle seed to manufacturer recommendations for exposure to extremes of heat, cold, or moisture.
- C. Lawn Seed Quality:
 - 1. Weed Seed: maximum of 0.50%, no noxious weed seed.
 - 2. Purity: minimum of 97% pure.
 - 3. Crop: maximum 0.50%
 - 4. Germination Rate: minimum 85%.
- D. Mixture for General Lawn Areas:

Mixture shall be "Northern Lawn Seed Mixture" as produced by the Chas. C. Hart Seed Company in Wethersfield CT or approved equal. Seed shall be non-endophyte enhanced.

TYPE OF SEED
Creeping Red Fescue

PERCENT BY WEIGHT
35%

Annual Ryegrass	30%
Perennial Ryegrass	20%
Kentucky Bluegrass	15%

E. Mixture for Wildflower Seed Mix:

Native wildflower mixture shall be similar to “Hart’s Northeastern Wildflower Mixture” or approved equal.

Apply wildflower seed mixture at a minimum seeding rate of 10 lbs. per acre. Broadcast wildflower seed on prepared bare soils of designated area and follow with low growing fescue hydroseed application.

Apply a quickly establishing, low-growing fescue mix similar to “Hart’s low Grow Mixture” at a minimum seeding rate of 250 lbs. per acre within a hydroseed slurry over broadcasted wildflower mix.

TYPE OF SEED	PERCENT BY WEIGHT
Viking H2O Hard Fescue	50%
Azure Blue Sheep Fescue	25%
Quatro Sheep Fescue	25%

3.17 TURFGRASS SOD

- A. Provide strongly rooted sod, not less than two (2) years old and free of weeds and undesirable native grasses and machine cut to pad thickness of weeds and undesirable native grasses and machine cut to pad thickness of 3/4” (+1/4”), excluding top growth and thatch. Provide only sod capable of vigorous growth and development when planted (viable, not dormant).
- B. Sod shall be “Versaturf” Blue./Fescue/Rye Blend as supplied by Tuckahoe Turf Farms, CT or approved equal.

TYPE OF SEED	PERCENT BY WEIGHT
America Kentucky Bluegrass	20%
Fullback (KBG)	15%
Midnight Star (KBG)	15%
Windward Chewings Fescue	15%
Jasper Creeping Red Fescue	15%
Secretariat II Perennial Ryegrass	20%

END OF SECTION 32 92 00

SECTION 32 93 00 — PLANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Providing and installing all plant materials.
 - 2. Source inspection
 - 3. Plant pit excavation and preparation and installation of all backfill mixtures.
 - 4. Planting all trees, shrubs, perennials, and groundcovers, including finishing operations, and transplanting of designated material.
 - 5. Mulch for all plant bed and saucer areas.
 - 6. Metal edging for plant beds.
 - 7. Protection, maintenance and replacement of plant material and related items.
 - 8. Weed fabric and anchoring pins for planting beds.
- B. Related Sections include the following:
 - 1. Division 31 Section “Earth Moving”.
 - 2. Division 32 Section “Topsoil”.
 - 3. Division 32 Section “Turf and Grasses”.

1.3 QUALITY ASSURANCE

- A. Standards
 - 1. Standards: All plants shall meet or exceed the specifications of Federal, State of Connecticut and County laws requiring inspection for plant disease and insect control.
 - 2. Quality, size and ball size shall conform with the latest edition of ANSI Z60.1 by the American Horticultural Association (AmericanHort) and its amendments.
 - 3. All plants shall be certified true to name by the nursery source. Sealed certificates from the nursery source shall be submitted prior to any plant material installation. One plant of each species shall be tagged with the name and size of the plant in accordance with the standards of practice of the American Horticultural Association. Botanical names shall take precedence over common names.
- B. Qualifications of Installers
 - 1. Provide at least one person who shall be thoroughly familiar with the type of materials being installed and shall direct all work performed under this Section.

C. Nursery Coordination:

1. Each specific plant type shall be provided from a single nursery source unless otherwise approved.

1.4 SUBMITTALS

A. Product Literature:

1. Tree wrap.
2. Fertilizers, including bone meal and dehydrated manure.
3. Tree anchors.
4. Anti-desiccant.
5. Peat moss/amendments.
6. Metal edging.
7. Weed control fabric.
8. Stakes for weed fabric.
9. Plant Warranty.

B. Samples: Shredded Bark Mulch

C. Topsoil: Testing reports/analysis, as per Division 2 Section "Topsoil": must be submitted prior to preparation of planting mixtures.

D. At completion of the installation of all plant materials, the Contractor shall submit a "Certification of Planting", on company letterhead stationary, indicating compliance with Drawings and Specifications in the installation of plant materials. This certification must be submitted to the Landscape Architect for approval.

1.5 NURSERY SOURCE INSPECTION AND ACCEPTANCE OF PLANT MATERIAL

A. All plant material(s) are subject to inspection and acceptance by the Architect at the nursery source or place of growth. Do not dig plant material until inspected, tagged and approved by the Architect. Contractor must provide all transportation and shall accompany the architect for all source inspections.

B. All plant material when inspected at the nursery source by the Architect is not to be "heeled-in" or "out-ground". Stockpiled material is not acceptable unless otherwise approved by the Architect.

C. All plant material is also subject to reinspection and approval by the Architect once the plant material has been delivered to the project site. All plant material shall arrive at the site with the Architect's permanent tags. Any plant material rejected by the Architect shall be immediately removed from the project site and replaced with acceptable plant material at no additional cost to the Owner.

- D. All plant material must be accompanied by nursery inspection certificates, as required by State of Connecticut or Federal Regulations.

1.6 PLANT LIST

- A. The Plant List appears on the Drawings and is for the Contractor's information only and no guarantee is expressed or implied that quantities therein are correct or that the list is complete. Contractor shall guarantee that all plant materials shown on the Drawings are included in the final project. The submission of a bid by the Contractor acknowledges that the plant material types and sizes shown on the Contract Documents are available.

PART 2 - PRODUCTS

2.1 TREES, SHRUBS, GROUND COVER, AND PERENNIALS

- A. Nursery grown unless otherwise noted. Transplanted material stored from previous site demolition/preparation operations.
- B. Hardy under climatic conditions similar to those in the locality of the project.
- C. Typical of their species or variety, with a normal habit of growth. Sound, healthy and vigorous. Well-branched and densely foliated when in leaf, free of disease, insect pests, eggs or larvae. Shall have healthy well-developed root systems. All trees shall have straight single trunks with their main leader intact unless otherwise stated. Stock shall have uniform height and spread to assure symmetry in planting.
- D. Substitutions will be permitted only upon written approval by the Architect.
- E. Sizes shall conform to the measurement specified on the Drawings. Take caliper measurements 6" above ground for trees up to 4" caliper size, 12" above ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches tip to tip. Plants larger than specified on the drawings may be used if approved by the Architect. Use of such plants shall not increase the Contract price.
- F. Quantities: If there is a discrepancy between plants shown on the drawings and quantities given, the greater number will prevail. Discrepancies will not entitle the Contractor to an extra.

2.2 PLANT PIT BACKFILL MIXTURES

- A. General: Provide mixtures as required. Bulk mix on-site, no off-site mixing allowed.
- B. Planting Mixture
 - 1. 1 Part dehydrated cow manure

2. 2 Parts peat moss
3. 5 Parts topsoil

2.3 TOPSOIL

- A. As per Division 32, Section “Topsoil”.

2.4 FERTILIZERS

- A. Deliver fertilizers in unimpaired condition, in sealed containers fully labeled according to applicable State of Connecticut Law.
 1. Bonemeal shall be finely ground commercial raw bonemeal having a minimum analysis of one (1) percent nitrogen and eleven (11) percent phosphoric acid.
 2. Plant fertilizers shall be a complete plant food with a guaranteed analysis of 10.10.10 unless otherwise approved by the Architect. Fertilizer shall contain 50% slow release nitrogen and 50% quick release.

2.5 PEAT

- A. Domestic or imported product consisting of partially decomposed vegetable matter of natural occurrence.

2.6 DEHYDRATED COW MANURE

- A. Dehydrated cow manure shall be Bovine, containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed and material harmful to plant growth.

2.7 STAKES

- A. 2” X 2” rough sawn or 3” diameter by minimum eight (8) foot long pointed cedar, oak or pressure treated stakes.

2.8 GUY WIRE FOR STAKING

- A. Two strands 11 gauge twisted bonded “Black” vinyl coated galvanized steel wire as manufactured by Colorguard Corporation (201) 526-0255 or approved equal.

2.9 TURNBUCKLES

- A. Galvanized steel of size and gauge to provide tensile strength equal to that of the wire.

2.10 FRICTION GUARDS FOR STAKING

- A. Black rubber reinforce hose not less than 1/2” I.D.

2.11 CLOTH TIES

- A. At the Contractor's option, in lieu of the guy wires, turnbuckles and friction guards specified above, the trees may be guyed to wooden stakes utilizing flat, woven polypropylene, 3/4 inch tie material, specifically manufactured for tree guying. Material shall have 900 pound breaking strength and be white in color. Guy fabric shall be similar to Arbor Tie, by Deep Root Partners, L.P., New York, NY, or approved equal.

2.12 FLAGS

- A. Shall be plastic, color – orange, min. 3" x 10".

2.13 TREE ANCHORING SYSTEM

- A. Similar to prepackaged kit components and accessories as manufactured by Foresight Products, Inc. Duckbill Model 68DTS. At special restricted areas, noted on Drawings, utilize Model 88BK, or approved equal.

2.14 MULCH

- A. Shall be finely shredded pine or cedar bark mulch. Sample to be approved.

2.15 TREE WRAPPING MATERIAL

- A. Six-inch-wide heavy duty, untreated burlap tree wrap as supplied by Good Product Sales, Inc., Kenilworth, New Jersey, (201) 245-5055 or approved equal. Twine for tying to be not less than 2 ply jute. Tape not permitted.
- B. At Contractor's option, tree wrap material may be creped paper, consisting of two 30 pound layers of Kraft paper, laminated with a 25 pound layer of asphalt, similar to Clark's Tree wrap, or approved equal.

2.16 ANTI-DESICCANT

- A. "Vaporguard" as manufactured by Miller Chemical Fertilizer Corporation; Hanover, Pennsylvania or approved equal.

2.17 METAL EDGING

- A. Steel edge restraints shall be black painted commercial steel edging with loops pressed from, or welded to, the face, in order to receive anchor stakes at 36 inches on center. Steel stakes shall be 15 inches long. Fabricate, bend, trim and form accurately to the lines indicated and as detailed. Size of edging to be 1/4 inch by 5 inches, by required length. Edging shall be similar to Ryerson Steel Edging, or approved equal.

2.18 WATER

- A. Potable. This Contractor is responsible for furnishing all water necessary to complete the establishment and maintenance of all plantings associated with this project until accepted by Owner. This requirement includes providing all water in irrigated areas, if any, until irrigation system is activated.

2.19 SAFETY BARRICADE

- A. Refer to Section "Site Clearing" of this specification.

2.20 WEED CONTROL FABRIC & ANCHOR PINS

- A. Weed control fabric shall be Dewitt Pro-5 weed fabric as manufactured by Dewitt Company Inc. Sikeston, MO. 63801, or approved equal. Material shall be polypropylene with 3.0 scrim and 2.0 cap, permeability of 12 gal./min/sf. With all strength characteristics of Dewitt Pro-5. Product shall meet or exceed >70 percent strength retained after ultraviolet exposure ASTM D-4355.
- B. Weed fabric shall be secured by 8"x2"x8"11 gauge galvanized anchor pins as manufactured by Dewitt Company, or approved equal.

PART 3 - EXECUTION

3.1 PRODUCT HANDLING

- A. Delivery and Storage:
 - 1. Deliver all items to the job site in their containers with all labels intact and legible at the time of inspection. Root balls shall not be cracked or broken. Notify Architect of delivery schedule at least two (2) days in advance so plant material may be inspected upon arrival at job site. Remove unacceptable plant material immediately from job site. Do not prune plants prior to delivery.
 - 2. Use all means necessary to protect plant materials before, during, and after installation and to protect the work and materials of all other trades.
 - 3. If planting is delayed more than 6 hours after delivery, set trees and shrubs in shade, protect from weather and mechanical damage, and keep roots moist. Cover root ball with mulch, peat moss, etc. Water and feed plant foliage and roots as often as necessary to maintain plant viability.
- B. Replacements: In the event of damage, immediately make all repairs and replacements necessary to no additional cost to the Owner.
- C. Delivery: Deliver fertilizer to site in original unopened containers bearing manufacturer's guaranteed chemical analysis, name, trade name and conformance to state law.

3.2 PLANTING SEASON

- A. Progress with planting only under favorable weather conditions. Planting will not be permitted when ground is frozen or excessively moist. Time of planting is at the discretion of the Contractor except as noted.

3.3 JOB CONDITIONS

- A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to the proper and timely completion of the work. Do not proceed until unsatisfactory conditions have been corrected. Coordinate work with other related site work that is not included in this Contract. Maintain proper sequencing of operations. Commencement of work implies acceptance by Contractor of preparatory work by others.
- B. The Contract drawings show the approximate locations of utility structures in the area of proposed landscape development. Exercise care when digging in these areas. The Contractor is responsible for any damage and shall replace or repair any damage at the Contractor's expense. Changes in the locations of plant material due to utility obstructions shall not be cause for extra compensation.
- C. Notify the Architect at least two (2) days prior to commencing any of the planting operation included in this Section.
- D. Plant locations on the Drawings are approximate and are to be used only as a guide. Contractor shall provide all field engineering services to accurately stake out locations for all plants outlines of plant beds. **Do not begin excavation until Architect has approved specific layout.** Relocate the planting, without extra compensation if directed prior to final installation.
- E. Upon completion of planting remove from the site all excess soil, mulch, materials and debris resulting from work operations of this Section. Restore to original conditions all damaged pavements, structures and lawn areas resulting from landscaping operation. Broom clean all walks and pavements. Dispose of all debris off-site in a satisfactory legal manner.
- F. Maintain the site area in a neat and clean condition at all times.

3.4 PLANTING MIXTURE

- A. Provide planting mixtures for specific plants, shrubs, and groundcover, as specified. Thoroughly mix all amendments to topsoil prior to commencing planting operations.
- B. Schedules.
 - 1. Groundcover Areas: 12" depth
 - 2. Perennial Plantings: 12" depth
 - 3. Continuously Excavated Shrub Beds: 18" depth.

3.5 PLANTING AND TRANSPLANTING PROCEDURES

- A. Balled and Burlapped Planting:

1. Stake all plant locations in the field as per the planting plan. Obtain Architect's approval of all plant locations.
2. Excavate plant pits as detailed, remove excess excavated material. Scarify bottom and sides of each plant pit. Tree pits minimum 24" greater in diameter than the plant ball, and 6" deeper except as detailed. Shrub excavations shall be minimum 12" greater in diameter than ball and 6" deeper.
3. All plant pits must be free draining. Notify the Architect if positive drainage does not exist.
4. Set all plants in the center of plant pits, plumb and straight and as detailed on the Drawings.
5. Handle balled and burlapped plants from the ball only.
6. Face each plant to give best appearance and as accepted by the Architect.
7. Carefully remove only surplus bindings and synthetic material that do not readily decompose. Cut off or fold back top third of burlap away from the plant. Remove portions of any wire baskets, if present.
8. Backfill all pits 2/3 their depth with prepared plant backfill mixture, water thoroughly and allow to settle, then tamp around to fill all voids and air pockets. Complete backfilling to conform to required elevation after settlement. Do not allow excavated material to be mixed with plant backfill material. Minimum 3 guys per tree.
9. Form saucer and install mulch over entire plant pit and saucer area as detailed.
10. Transplant designated materials to locations indicated. Conform to current AN & LA standards, including root ball size determination.

3.6 CONTINUOUS EXCAVATION

- A. All perennial and shrub plant beds to be continuously excavated to depths required to allow installation of specified backfill mixture.
- B. Backfill completely with specified Plant Mix.
- C. Install plants as per Planting and Transplanting paragraph of this Section.

3.7 METAL EDGING

- A. Install edging around the perimeter of all planting beds to comply with manufacturer's instructions. Install stakes at all edging loops, to hold edge in place during and after plant and mulch installation.

3.8 FERTILIZERS FOR PLANTS IN SAUCERS

- A. Fertilize each plant area or plant saucer area at a uniform rate, as per topsoil test report and manufacturer's recommendations.

3.9 FINISHING OPERATIONS

- A. Guying and Staking Trees:
 1. Guy, stake and anchor each tree as shown on the applicable drawings immediately after planting. Fasten anchors to trees with cable and run through a rubber hose (friction guard)

- and tighten cables or guy wires. Each friction guard shall be placed around a minimum of 3 main stems on all multi-stemmed plants. Keep trees plumb and taut. Guying procedures may be modified only if acceptable to the Architect
2. Place rubber hoses of sufficient length to prevent injury to tree trunks around cables or guy wires.
 3. Guying cables and wires not to interfere with lower limbs and to be equally spaced and under same tension. Place tree stakes as detailed. Installed guy wires at least 6 feet above finish grade for all trees of 3' caliper and over. Install guy wires at least 5' above finish grade for all and trees of less than 3" caliper.
- B. Wrapping: Wrap all deciduous trees immediately after planting. Wrap the trunks of all trees spirally from the ground line to above the lowest main branches. Overlap wrapping material by 50% and securely tie in at least five places including the top, middle and bottom. Use twine for tying. Tape not permitted.
- C. Mulching: Mulch all plant and shrub beds with a four (4) inch deep layer of bark mulch, except as noted for groundcover areas. Each saucer to be left in neat orderly condition.
- D. Anti-Desiccant: Spray all trees with one (1) application of anti-desiccant in accordance with manufacturer's directives. Apply protective film over all parts of branches, twigs and foliage. Spray as per manufacturer's recommendations.
- E. Watering Plants: Thoroughly water all plants to a maximum root depth immediately after planting and as necessary to guarantee the plant material.
- F. Pruning: The amount of pruning to be limited to the minimum necessary to remove dead wood or injured twigs or branches. All cuts to be made flush, leaving no stubs. Prune all deciduous trees and shrubs in accordance with current AN & LA standards, and to the requirements of the Architect.
- G. The Contractor shall provide Safety Barricade fencing at all areas along walks where planting may be susceptible to damage by pedestrian traffic, specifically at walk intersections, high traffic areas, and areas determined by the Landscape Architect. The fence shall remain in place and be maintained by the Contractor until the Landscape Architect or Owner determines that the plant material has developed sufficiently to deter or withstand pedestrian traffic.
- 3.10 REPAIR OF LAWN AREAS
- A. Repair all lawn areas damaged/disturbed during all planting operations. Keep pavements clean and work area in an orderly condition.
 - B. Provide sediment and erosion control measures as required to protect unestablished areas from erosion.
- 3.11 DISPOSAL OF SURPLUS AND WASTE MATERIALS
- A. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash and debris and legally dispose of it off the Owner's property.

3.12 MAINTENANCE

- A. Required maintenance period begins immediately after planting and includes all transplanted materials. Contractor shall continue maintenance until Architect's approval of 'Certification of Planting' and the commencement of the guarantee period.
- B. Maintenance responsibilities include pruning, cultivating, watering, weeding, fertilizing, restoring plant saucers, tightening and repairing stakes and guy supports, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Restore or replace damaged tree wrappings.
- C. Correct defective work as soon as possible after detection. Obviously dead plant material shall be removed immediately, regardless of replacement plant timing. Correct dangerous conditions immediately.

3.13 GUARANTEE REQUIREMENTS

- A. **The planting guarantee period for all plants will begin upon the Architect's approval of 'Certification of Planting' submitted by the Contractor at completion of the planting.**
- B. The planting guarantee shall be one year from acceptance of 'Certification of Planting', and shall warranty all plants against defects including death and unsatisfactory growth, except for defects caused by neglect or abuse by the Owner, or incidents that are beyond the Contractor's control.
- C. Plant material is eligible to receive final acceptance one (1) year from the date of the 'Certification of Planting' at Substantial Completion. Planting done in late Fall (after November 1st), shall be maintained through the following spring's leafing, at which time, if acceptable, the guarantee periods shall begin.

3.14 FINAL INSPECTION AND ACCEPTANCE

- A. Final Acceptance will be made if all plants meet the guarantee requirements as specified. A sum sufficient to cover the cost of possible replacement plantings will be withheld from the Contractor if plant material is not accepted.

END OF SECTION 32 93 00

SECTION 33 05 00 – SITE UTILITIES

PART 1 – GENERAL

1.1. RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

The work in this section consists of the following:

General: This Section shall consist of the furnishing of all labor, equipment, and materials necessary and incidental to the providing of required Site Utilities. Meters and meter settings shall be as required by the Utility Companies. Any utility company costs shall be at the expense of the Owner except where otherwise indicated on the Contract Drawings. Also included is the arranging and coordination of work with the utility companies by the Contractor.

- A. Supplying and installation of Electrical conduits, handholes, manholes, transformer bases, transformers, encasements, slabs and appurtenances in accordance with requirements of Eversource, and the Contract Drawings. Supplying of primary cables and installation of primaries shall be by Eversource. Owner shall pay connection fees, and cable charges imposed by Eversource. Transformer pads are to be supplied and installed by the Contractor. Transformers shall be supplied and installed by Eversource. Owner shall pay necessary fees for transformers. Contractor shall install pull wires in empty conduits.
- B. Supplying and installation of Telephone Service conduits, ducts, encasements, handholes, manholes and appurtenances in accordance with requirements of Frontier and the Contract Drawings. Cable supplying and installations shall be by Frontier at Owners expense. Contractor shall install pull wires in empty conduits.
- C. Coordination with Connecticut Natural Gas Company for gas service installation. Gas services shall be supplied and installed by Connecticut Natural Gas Company. Trenching and backfilling shall be by Contractor. Owner shall pay any necessary utility company fees and costs for service installations.
- D. Refer to Section 31 20 00 – Earth Moving for excavation and backfill requirements.
- E. Supplying and Installation of Cable Television Service conduits, ducts, encasements, handholes and appurtenances in accordance with requirements of the Contract Drawings and Comcast Cable Company. Cable supplying and installations shall be by Comcast Cable Company at Owners expense. Contractor shall install pull wires in empty conduits.

1.3 SUBMITTALS

- A. Sources of Supply: Approval of sources and types of all material shall be obtained from the Engineer and Utility Companies prior to delivery of material and samples shall be submitted as directed by the Engineer and/or Utility Company.
- B. Product Data: Submit manufacturer's technical product data and installation instructions for electric and telephone materials and products.
- C. Record Drawings: At project closeout, submit record drawings of installed telephone, electrical, cable television and gas utilities and products, in accordance with requirements of General Conditions.
- D. Maintenance Data: Submit maintenance data and parts lists for system materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual; in accordance with requirements of General Conditions

1.4 QUALITY ASSURANCE

- A. Codes and Standards: Comply with applicable portions of Electrical and Building Code requirements pertaining to selection and installation of electrical, telephone, gas system and cable television materials and products. Comply with the National Electrical Code Connecticut State Electrical Code and standards of Underwriters Laboratories, Inc., National Electrical Contractors Association, and National Electrical Manufacturers Association.
- B. Manufacturer's Qualifications: Firms regularly engaged in manufacture of systems products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

PART 2 - PRODUCTS

- A. Underground-Type Plastic Line Markers: Manufacturers standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6" wide x 4 mils thick. Provide colored tape with black printing reading "CAUTION "NAME OF UTILITY" LINE BURIED BELOW"
- B. Telephone Conduits: Schedule 40 or 80 per Contract Drawings and/or as required by Comcast, PVC with fittings and adapters conforming to ASTM D1785 and D2665. Size as required by SBC or as indicated on Contract Drawings. Ends and fittings shall be bell and spigot. Individual duct size shall be per Comcast requirements or as indicated on Contract Drawings. Provide manhole terminators, expansion couplings, cements and primers per conduit manufacturers requirements.
- C. Cable Television Conduits: Schedule 40 PVC with fittings and adapters conforming to ASTM D1785 and D 2665. Size as required by Comcast Cable Company or as indicated on Contract Drawings. Ends and fittings shall be bell and spigot type.

- D. Transformer Bases: Precast or cast in place concrete conforming to specifications and requirements of Eversource and as indicated on the Contract Drawings. Ground rod shall be 8 foot minimum length galvanized with #2 copper conductor. Supply and install 6-inch diameter steel pipe bollards for vehicle protection if shown on Contract Drawings and per Eversource requirements.
- E. Electric Conduit: Polyvinyl Chloride Schedule 40 or 80 per Contract Drawings, rigid heavy wall complying with all requirements of Underwriters Laboratories Standards and stamped "UL Approved". Electric conduit shall be encased with concrete where shown on the Contract Drawings or per Eversource requirements.
- F. Non-Shrink Grout: Conforming to ASTM C827 allowing 3 percent expansion, compressive strength of 4,500 psi.
- G. Pull Boxes and Handholes: For conduit installation shall be as required by utility companies and purchased from the utility companies. Otherwise, pull boxes and handholes shall be cast heavy wall PVC for exterior installation 6 inches by 6 inches and larger or not less than the minimum size required by the National Electrical Code with screw fastened gasketed covers to ensure watertight fit.
- H. Manholes if required shall conform to utility company requirements for precast manholes, frames and covers.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUIT AND FITTINGS

- A. General: During backfilling top soiling of electric or telephone systems, install continuous underground type plastic line marker located directly over buried line at 6 to 8 inches below finished grade or as indicated on Contract Drawings. Install conduit in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.
- B. Inspect Conduit before installation to detect apparent defects. Mark defective materials with white paint and promptly remove from site.
- C. Lay Conduit beginning at low point of system, true to grades and alignment indicated, with unbroken continuity of invert. Maintain offsets required by utility companies or by code from water, electric, gas, and other utilities. Install conduits with pull strings for future cable pulling.
- D. Place bell ends or groove ends of conduit facing towards advancing direction of laying, predominantly uphill.
- E. Install gaskets in accordance with manufacturers recommendations for use of lubricants, cements, and other special installation requirements.
- F. Plastic Conduit: Install in accordance with manufacturer's recommendations, and in accordance with ASTM D2321 and the Contract Drawings. Burial depth to be not less

than 3 feet for electric conduit and 30 inches for telephone conduit. Pitch all conduits to drain. Use long sweep curves to accomplish changes in direction.

- G. Cleaning Conduit: Clear interior of piping of dirt and other superfluous material as work progresses. Maintain swab or drag in line and pull past each joint as it is completed.
Place plugs in ends of uncompleted conduit at end of the day or whenever work stops.
Flush lines between manholes or conduit ends if required to remove collected debris.
- H. Joint Adapters: Make joints between different types of conduit with standard manufactured adapters and fittings intended for that purpose if required.
- I. Close open ends of Conduit with threaded metal caps, plastic plugs, or other acceptable methods for size and type material being closed. Wood plugs are not acceptable.
- J. Interior Inspection: Inspect conduit to determine whether line displacement or other damage has occurred.

Make inspections after lines between manholes, or conduit ends have been installed and approximately 2-ft of backfill is in place, and again at completion of project.

If inspection indicates poor alignment, debris, displaced conduit or other defects, correct such defects and reinspect.

- K. Conduit Laying - All conduit shall be laid true to line and grade with bells or grooves upgrade. The sections of the conduit shall be so laid and fitted together, that when complete the conduit will have a smooth uniform invert. The conduit shall be kept thoroughly clean so that jointing compounds will adhere. Each conduit shall be inspected for defects before being lowered into the trench. Avoid creating low spots in conduit runs that will collect water and debris. Pitch conduits back to pull boxes, etc. to promote positive drainage.

At the start of each job, when the Contractor is in a position to start laying conduit, he shall notify the proper representative of the Utility Company and the supplying conduit company who will come to the job and thoroughly instruct the Contractor, his men and the Owner's Representative in the proper methods of laying said conduit. The Contractor shall notify his men who are actually doing the laying that this method shall be strictly enforced.

At any time during conduit-laying operations, if the occasion arises, when instruction or advice is required from a utility representative, he shall be notified and shall come to the site of conduit-laying operations for consultation before any further conduit is laid involving any such problems. Under such conditions the Contractor shall have no claim for delays.

Not more than 100 feet of trench shall be opened in advance of conduit laying unless permitted by the Engineer. The excavation of trenches shall be fully completed a sufficient distance in advance of laying of the conduit, and the exposed end of conduits shall be fully protected with a board or other approved stopper to prevent earth or other substances from entering the conduit.

Any conduit delivered to the site in a damaged condition shall be removed from the job site immediately.

Any fitting showing a crack and any fitting or conduit which has received a blow that may have caused an incipient fracture, even though no such fracture can be seen, shall be marked as rejected and removed at once from the site.

PVC conduit shall be installed in accordance with the manufacturer's recommendations. Particular care should be taken to keep fine materials from interfering with proper joint assembly. Mating surfaces of a joint shall be wiped clean. The surfaces shall then be coated with a lubricating material prescribed by the manufacturer to overcome the frictional resistance encountered when shoving the conduit home. Conduit that is not marked with a depth mark shall be marked before assembly to assure that the spigot end is inserted to the full depth of the joint.

Except as otherwise approved, all cutting of conduit shall be done with an approved powder driven cutter or pipe cutter.

A thin film of gasket lubricant shall be applied to either the inside surface of the gasket or the spigot end of the conduit or both. Gasket lubricant shall be supplied by the conduit manufacturer and approved by the Engineer.

- L. Dewatering - The Contractor shall provide all necessary pumps, dams, drains, ditches, flumes, well points and other means for excluding and removing water from trenches and other parts of the work. Water shall not be allowed to rise around the joint until it has set.
- M. Foundations - The conduit shall be laid on a foundation and backfilled where shown on the Contract Drawings.

Where the soil in subgrade is found to be soft, loose, freshly-filled earth, unstable or unsuitable as a base for the proposed conduit or appurtenances, the Engineer may, at his discretion, order it excavated to such additional depth and width as he may deem proper and replaced with gravel fill, borrow, concrete, or similar materials as he may direct.

Concrete encasement where called for on the Contract Drawings or required by the Utility Company shall be of Class A concrete. The concrete shall conform to the requirements of Division 3. The encasement shall be as detailed on the Contract Drawings, or per the requirements of the respective Utility Company.

Where conduit is to be encased in concrete, the conduits will be laid on wooden cross sills of adequate size and areas to support the conduits to grade and line after excavating to required subgrade. Wooden wedges or shims and tie downs will be used to secure conduits in place and to proper lines and grades.

- N. Manufactured Plugs - Manufactured watertight plugs shall be used. The material of the plug shall be compatible with the conduit. Conduit shall be closed with the plug having a gasket set into the bell of the conduit in accordance with the manufacturer's recommended installation procedures and as approved by the Engineer.

- O. Pull boxes and Handholes shall be furnished and installed under this Section of the Specifications where indicated on the Contract Documents and wherever else such a box may be deemed necessary to facilitate the pulling or splicing of wire and cable.

All such boxes must be made accessible and shall be built in locations approved by the Engineer in off road and off sidewalk areas. Conduits shall enter these boxes through tight fitting clearance holes grouted as necessary. The covers shall be designed for quick removal. Provide markers at each pull box for determining as-built location.

3.2 TRANSFORMER BASES AND MANHOLES

- A. General: Place precast concrete sections as indicated on the Contract Drawings. Set top of transformer base 3" above finish surface, unless otherwise indicated. Set manhole frame and covers equal to finished grade.
- B. Install in accordance with ASTM C 891.
- C. Provide rubber joint gasket complying with ASTM C 443 at joints of sections. Excavation, supports and backfilling for installation of transformer bases shall conform to the requirements of Division 2 and the appropriate utility company.

Openings shall be provided in the precast reinforced concrete sections to receive entering and exiting conduits, and these openings may be made at the place of manufacture or they shall be cut in the field.

- D. Install transformer vaults per Eversource requirements and the Contract Drawings. Install a 8 foot long Galvanized ground rod in trench and connect a #2 copper conductor from rod through base opening and extending 5 feet above base. For each base install precast base top elevation 3 inches above finished grade.

END OF SECTION 33 05 00

SECTION 33 10 00 — WATER UTILITIES

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.02 DESCRIPTION

- A. Work Included: Furnishing and installing ductile iron water mains and fittings, and appurtenant valves and fittings, complete in place, as shown on the Drawings and as specified.
- B. Related Sections:
 - 1. Section 31 20 00 – Earth Moving;
 - 2. Section 31 23 33 – Trenching and Backfilling;
 - 3. Section 32 12 16 – Asphalt Paving.

1.03 REFERENCES

- A. ANSI/ASTM D2922 – Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
- B. AWWA C104 – American National Standard for Cement-Mortar Lining for Cast-Iron and Ductile-Iron Fittings for Water.
- C. AWWA C110 – American National Standard for Gray-Iron and Ductile-Iron Fittings, 2 in. through 48 in. for Water and Other Liquids.
- D. AWWA C111 – American National Standard for Rubber Gasket Joints for Cast Iron and Ductile Pressure Pipe and Fittings.
- E. AWWA C151 – American National Standard for Ductile-Iron Pipe, Centrifugally cast in Metal Molds or Sand-Lined Molds for Water or Other Liquids.
- F. AWWA C153 – American National Standard for Ductile-Iron Pipe Compact Fittings 3 Inch through 12 Inch for Water and Other Liquids.
- G. AWWA C500 – Metal-Seated Gate Valves for Water Supply Service.
- H. AWWA C502 – Dry-Barrel Fire Hydrants.

- I. AWWA C550 – Protective Epoxy Interior Coatings for Valves and Hydrants.
- J. AWWA C600 – Installation of Gray and Ductile Iron Water Mains and Appurtenances.
- K. AWWA C651 – Disinfecting Water Mains.

1.04 QUALITY ASSURANCE

- A. Qualifications of installers: Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.
- B. Comply with local water authority standards. The local water authority is The MDC.

1.05 SUBMITTALS

- A. Submit data on the following:
 - 1. Product Data: Provide data indicating pipe, fittings, valves, and pipe accessories.
 - 2. Manufacturer's Installation Instructions: Indicate special procedures required to install the products specified.
 - 3. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Protection: Use all means necessary to protect the materials of this Section before, during, and after installation, to protect the work and materials of all other trades, and to protect all objects designated to remain.
- B. Protection of utilities: Protect existing utilities as specified in Section 31 20 00 – Earth Moving.
- C. Delivery and Storage: Deliver all materials to the job site in their original containers with all labels intact and legible at time of use. Store in strict accordance with the manufacturers' recommendations as accepted by the Engineer.
- D. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the acceptance of the Engineer and at no additional cost to the Owner.

1.06 REFERENCES

- A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction Form 818 (2020) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

1.07 REGULATORY REQUIREMENTS

- A. Relation to sanitary sewer lines: Lay water lines at least 10 feet horizontally from any existing, or proposed, sewer lines if possible. If conditions prevent a lateral separation of 10 feet, a water line may be laid within 10 feet of a sanitary sewer if:
1. It is laid in a separate trench, or if it is laid in the same trench with the sanitary sewer line located at one side of a bench of undisturbed earth, and if;
 2. In either case the elevation of the bottom of the water line is at least 18 inches above the top of the sanitary sewer line. Where water lines cross over sewer lines, install the water line so that the bottom of the water line is at least 18 inches above the top of the sewer line. When water, or sewer, location cannot be varied to provide separating distance, construct water line with mechanical joint pipe for a distance of 10 feet either side of sewer. One full length of water line is to be centered over sewer so that both joints will be as far from the sewer as possible.
 3. Where it is not possible to obtain horizontal or vertical separation specified above, construct both water line and sewer line of mechanical joint, cement lined ductile iron pipe. Pressure test both pipes at 200 psi in accordance with AWWA C600.

PART 2 – PRODUCTS

2.01 PIPE MATERIALS

- A. Ductile Iron Pipe: AWWA C151, Class 54, cement lined in accordance with AWWA C104, 18 foot nominal laying length, push on joints with SBR gaskets in accordance with AWWA C111.
- B. Fittings (4"-12"): Compact ductile iron fittings in accordance with AWWA C153, cement lined in accordance with AWWA C104, mechanical joints with SBR gaskets, Corten nuts and bolts and ductile iron retainer glands, where required.
- C. Retainer Glands: Ductile iron conforming to ASTM A536, 250 psi minimum working pressure, 2:1 minimum safety factor, Corten nuts and bolts, MEGALUG as manufactured by EBBA iron, Inc.
- D. Tapping Sleeve: Fabricated carbon steel with fusion bonded epoxy coating, 200 psi minimum working pressure, SBR gaskets and sealing material, stainless steel bolting materials, provide with NPT test port and plug.

2.02 METAL SEATED GATE VALVES AND TAPPING VALVES

- A. Valve: Conform to AWWA C500, mechanical joints ends, ductile iron retainer glands, SBR gaskets, Corten mechanical joint bolts and nuts, non-rising stem, 2" nut operator, 200 psi working pressure, type 304 stainless steel bonnet and O-ring stem seal bolting hardware. All valves shall open per the Avon Water standards.
- B. Valve Box: 5-1/4 inch diameter, cast iron, flared base, slip type, flange top, tapered cover with long skirt and two pick holes, coal tar epoxy coated. Cover to have water identification markings.
- C. Valve Extension Stem (if required): Provide self-centering steel valve extension stem with 2" nut operator, coal tar epoxy coated. Top of extension stem to be 1 foot below finished grade.

2.03 HYDRANTS

- A. Hydrants shall have a 6" branch pipe with a 6" gate valve controlling each hydrant.
- B. All hydrants shall open counterclockwise and shall have two 2-1/2" nozzles and one 4-1/2" nozzle.
- C. Hydrants shall conform to the MDC Project Manual (January 2017)

2.03 BEDDING MATERIAL

- A. Sand: Use sand or sandy soil conforming to the requirements of Article M.08.08-21, DOT Specifications.

PART 3 – EXECUTION

3.01 GENERAL

- A. Examine the areas and condition under which work of this Section will be performed. Correct conditions detrimental to the timely and proper completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Hand trim excavations to required elevations. Correct over excavation as specified in Section 31 20 00 – Earth Moving.
- B. Remove large stones or other hard matter, which could damage pipe or impede consistent backfilling or compaction.
- C. Clean pipe and fitting interiors prior to lowering into trench. Keep clean during laying operations.

3.03 BEDDING

- A. Excavate pipe trench in accordance with Section 31 20 00 – Earth Moving for work of this Section. Hand trim excavation for accurate placement of pipe to elevations indicated.
- B. Place and compact bedding material at trench bottom, level materials in continuous layer.

3.04 INSTALLATION

- A. General
 - 1. Carefully examine each pipe prior to placing. Promptly set aside all defective pipe and all damaged pipe. Clearly identify all defects. Do not install defective pipe or damaged pipe.
 - 2. Install pipe, fittings and accessories in accordance with AWWA C600 and manufacturer's instructions. Seal joints watertight.
 - 3. Place all pipe to grades and alignment shown on the Drawings.
 - 4. Provide all equipment for lowering pipe safely into the trenches.
 - 5. Lay pipe by proceeding upgrade with the spigot ends of bell-and-spigot pipe pointing in the direction of flow.
- B. When the Engineer has accepted conditions at the bottom of the trench, place and compact the bedding of sand. Provide a bedding surface to support the barrel of the pipe throughout its entire length. Accurately shape the bedding to conform to the lower quarter of the pipe. Make depressions in the bedding for making pipe joints.
- C. Make watertight pipe joints. Use gaskets as specified for each kind of pipe. Do the jointing in accordance with the pipe manufacturer's instructions and as follows:
 - 1. Clean gaskets and mating surfaces of pipes. Use lubricant on gaskets and pipes if required by pipe manufacturer. Align pipe to be installed with previously installed pipe, and, with gasket in place, put joint together. After pipes are put together, inspect joint to verify that gasket is properly positioned and that joint has been properly made and is tight. If, while making the joint, the gasket becomes loose or displaced, remove the pipe and remake the joint to the acceptance of the Engineer.
 - 2. Pipe to be installed "in the dry". Do not use pipe for trench drainage. Keep trench dry to prevent pipe floatation.
 - 3. Cap ends of pipe when work is not in progress.
 - 4. All mechanical joint fittings, bends, etc. shall be restrained a minimum of three (3) pipe lengths on either side of the fitting per New Britain Water standards.

3.05 INSTALLATION OF TAPPING SLEEVE AND VALVE

- A. Tapping of the water main shall be performed by the New Britain Water company. The Contractor shall coordinate all work and pay all necessary fees to the Utilities Department. The Contractor shall excavate as necessary to provide adequate space for tapping sleeve and valve installation.

3.06 INSTALLATION OF GATE VALVES

- A. Install valves at locations indicated on the Drawings.
- B. Provide a firm foundation and side support by tamping bedding material under and at the sides of the valves. Install valves with valve stems vertical.
- C. Install valve boxes over valves such that vertical stems of valves are coincident with centerlines of valve boxes. Set boxes firmly in place by tamping bedding material under and at the sides of the boxes. Support valve boxes during backfilling; maintain vertical alignment. Install so that top of valve box is flush with final grade.
- D. Install valve stem extensions of correct lengths on valves.

3.07 CONCRETE CRADLES, CONCRETE ENCASEMENTS AND CONCRETE THRUST BLOCKS

- A. Construct concrete cradles, concrete encasements and concrete thrust blocks for additional support or protection of pipe at locations indicated on the Drawings or as directed by the Engineer.

3.08 COVER AND BACKFILL FOR PIPES

- A. Protect finished installation from damage.
- B. Place and compact sand blanket to two (2') feet above pipe so that all the space in the trench on each side of the pipe is entirely filled and well compacted.
- C. Place warning tape over pipe as shown on the drawings. Tape shall clearly indicate "Buried Water Line" and be composed of a metallic material so as to be detectable by magnetic underground location indicators.
- D. Place and compact suitable backfill material over sand blanket. Backfill in accordance with the requirements specified under Section 31 23 33 – Trenching and Backfilling.

3.09 PRESSURE TESTING AND DISINFECTION

- A. The Contractor shall perform all testing and disinfecting required, at no additional cost to the Owner.
- B. Arrange for local water authority to witness this work.

- C. After installation of each waterline section, pipelines shall be tested for water tightness in accordance with AWWA C600. For these tests, the Contractor shall furnish suitable testing plugs or caps, all necessary pressure pumps, pipe connections, gages, or other equipment, all labor, and all water required.
- D. Conduct leakage test at a pressure of 200 psi unless otherwise specified and maintain this pressure for 2 hours.
- E. Before being placed in service, the completed water distribution system shall be disinfected in accordance with AWWA 651, "Standard Procedure for Disinfecting Water Mains." The Engineer shall approve the specific procedure before doing the work.
- F. Water used to disinfect the water distribution system shall be chlorine neutralized as it is discharged from the system.
- G. Perform bacterial and water quality testing to demonstrate compliance with applicable water quality standards. Sampling to be accomplished through sampling taps. Use of hydrants for sampling is prohibited.
- H. Disinfect, flush and test water distribution system, repeatedly as required at Contractor's expense, to comply with applicable water quality standards.

END OF SECTION 33 10 00

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SECTION 33 30 00 — SANITARY SEWERAGE UTILITIES

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.02 DESCRIPTION

- A. Work Included: Construction of sanitary sewers, manholes and related work, complete in place, as shown on the Drawings and as specified. Leakage testing of sanitary sewers and manholes will also be required.
- B. Related Sections:
 - 1. Section 31 20 00 – Earth Moving;
 - 2. Section 31 23 33 – Trenching and Backfilling;
 - 3. Section 31 25 00 – Erosion and Sedimentation Controls.

1.03 QUALITY ASSURANCE

- A. Qualifications of installers: Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

1.04 SUBMITTALS

- A. Submit Product Data
 - 1. Manufacturers' descriptive literature for all items proposed to be furnished and installed under this Section, including Material Safety Data Sheets (MSDS) on all PVC adhesives and primers.
 - 2. Manufacturer's specifications and other data required to demonstrate compliance with the specified requirements.
 - 3. Verification of installer's qualifications.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Protection: Use all means necessary to protect the materials of this Section before, during, and after installation, to protect the work and materials of all other trades, and to protect all objects designated to remain.
- B. Delivery and Storage: Deliver all materials to the job site in their original containers with all labels intact and legible at time of use. Store in strict accordance with the manufacturers' recommendations as accepted by the Engineer.
- C. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the acceptance of the Engineer and at no additional cost to the Owner.

1.06 REFERENCES

- A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction Form 818 (2020) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

PART 2 – PRODUCTS

2.01 PIPE MATERIALS

- A. Polyvinyl Chloride Pipe
 - 1. Pipe: ASTM D3034, SDR 35 (Sizes: 4-15 in.)
 - 2. Joints: Bell and spigot with O-ring gasket compressed between the bell and the spigot.
 - 3. Gasket: Rubber gasket conforming to the requirements of AASHTO M198 or elastomeric gasket conforming to the requirements of ASTM D3212.
- B. Provide fittings or couplings for joining pipes of different materials or provide concrete for fabricating a concrete collar where pipes of different materials are joined.

2.02 MANHOLE MATERIALS

- A. Precast Reinforced Concrete Manhole Sections: Bases, manhole entrance slabs, riser sections, and conical sections shall conform to dimensions as shown on the Drawings and to the requirements of ASTM C478. All joints between sections shall be tongue and groove joints with recesses for rubber O-ring gaskets.
- B. Rubber O-ring gaskets for joints shall conform to the requirements for rubber gaskets as specified under 5.9 Rubber Gaskets, ASTM C361.

- C. Manhole Steps: Copolymer Polypropylene Plastic Manhole steps with serrated safety tread. Do not install steps by drilling and mortaring in place after casting of manhole sections.
- D. Holes shall be preformed in the walls of base sections to accept sewer pipe. Flexible sleeves shall be cast into the preformed holes, as shown on the Drawings. The sleeves shall be made to fit and to be clamped around the pipe with stainless steel bands.
- E. Alternatively, sleeves with internal-expanding stainless steel clamps may be used to install sleeves in preformed pipe holes.
- F. Grout shall conform to Subarticle M.03.01-12 of the DOT Specifications.
- G. Lubricant for use on joints and for use on O-ring rubber gaskets shall be an accepted vegetable soap compound.
- H. Mortar shall conform to Article M.11.04 of the DOT Specifications.
- I. Concrete grading rings, if used, shall conform to the requirements of ASTM C139.
- J. Bricks used for adjusting frames to grade shall conform to the requirements of AASHTO M91, Grade MS. Bricks used for constructing inverts shall conform to the requirements of AASHTO M91, Grade SM.
- K. Manhole frames and covers shall be standard models as shown on the Drawings. Material shall be cast iron conforming to the requirements of AASHTO M105, Class 25. Covers shall bear uniformly on their supports.
- L. Dampproofing material and primer shall conform to the requirements of Article M.12.05 of the DOT Specifications.

2.03 BEDDING, COVER AND BACKFILL MATERIALS

- A. Crushed stone for bedding shall be sound, tough and durable; it shall be free from soft, thin elongated, or laminated pieces and vegetable or other deleterious substances. Grading Article M.01.01, DOT Specifications. Size: As indicated on the Drawings.
- B. Sand Blanket for Cover: Use sand or sandy soil conforming to the requirements of Article M.08.08-21 of the DOT Specifications.
- C. Geotextile Filter Cloth: Section 31 23 33 – Trenching and Backfilling.
- D. Suitable Backfill Material: Section 31 23 33 – Trenching and Backfilling

PART 3 – EXECUTION

3.1 GENERAL

- A. Examine the areas and condition under which work of this Section will be performed. Correct conditions detrimental to the timely and proper completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.
- B. All work under this item shall be in conformance with the appropriate sections of the City of New Britain Standards.

3.2 HANDLING SANITARY WASTEWATER FLOWS

- A. The Contractor is responsible for maintaining and handling existing sanitary wastewater flows throughout construction

3.3 EXCAVATING FOR PIPES AND MANHOLES

- A. Excavate in accordance with the provisions of Section 31 20 00.
- B. Protect bottoms of excavations from frost. Do not place bedding, pipe, structures, or fill materials on frozen ground.
- C. Provide dewatering as specified under Section 31 20 00. Keep excavations dry.

3.4 LAYING PIPE; JOINTING PIPE

- A. General
 - 2. Carefully examine each pipe prior to placing. Promptly set aside all defective pipe and all damaged pipe. Clearly identify all defects. Do not install defective pipe or damaged pipe.
 - 3. Place all pipes to the grades and alignment shown on the Drawings.
 - 4. Provide all required equipment for lowering pipe safely into the trenches.
 - 5. Lay pipe by proceeding upgrade with the spigot ends of bell-and-spigot pipe, and the tongue ends of tongue-and-groove pipe pointing in the direction of flow.
- B. When the Architect has accepted conditions at the bottom of the trench, place and compact the bedding of crushed stone. Provide a bedding surface to support the barrel of the pipe throughout its entire length. Accurately shape the bedding to conform to the lower quarter of the pipe. Make depressions in the bedding for making pipe joints.

- C. Make watertight pipe joints. Use gaskets as specified for each kind of pipe. Do the jointing in accordance with the pipe manufacturer's instructions and as follows:
 - 2. Clean gaskets and mating surfaces of pipes. Use lubricant on gaskets and pipes if required by pipe manufacturer. Align pipe to be installed with previously installed pipe, and, with gasket in place, put joint together. After pipes are put together, inspect joint to verify that gasket is properly positioned and that joint has been properly made and is tight. If, while making the joint, the gasket becomes loose or misplaced, remove the pipe and remake the joint to the acceptance of the Architect.
- D. Fill depressions under joints with crushed stone bedding and compact the material thoroughly.
- E. Joining pipe of different materials: Provide fittings or couplings made for the pipe materials joining, or provide a concrete collar.
- F. Joining Pipe to Manholes
 - 2. If manhole base sections are equipped with flexible sleeves, slide pipe through sleeve until end of pipe is approximately flush with inside wall of manhole. Install and secure sleeve to pipe with stainless steel clamp. Comply with sleeve manufacturer's instructions.
 - 3. If the joint is a grouted joint, place pipe through hole in manhole base section until end of pipe is approximately flush with inside wall of manhole. Mix and place grout all around pipe, to the full manhole wall thickness. Make a watertight joint.

3.5 BEDDING PIPES

- A. For reinforced concrete pipe and ductile iron pipe 10 inches or less in diameter, and for polyvinyl chloride pipe of all diameters:
 - 1. Place and compact crushed stone at both sides of pipe, to top of pipe as shown so that all the space in the trench on each side of the pipe is entirely filled and well compacted.
 - 2. Place filter cloth over crushed stone for full width and full length of trench. Turn filter cloth up 6 inches at trench walls as shown. At joints, overlap filter cloth panels by one foot.
 - 3. Place and compact sand blanket over filter cloth as shown on the Drawings.
- B. For reinforced concrete pipe and ductile iron pipe 12 inches or more in diameter:
 - 1. Place filter cloth over crushed stone bedding on each side of pipe. Turn filter cloth up 6 inches at wall and at pipe as shown.
 - 2. Place and compact sand blanket over filter cloth and at both sides of pipe as shown so that all space in the trench on each side of the pipe is entirely filled and well compacted.
 - 3. Continue placing and compacting sand blanket over pipe as shown on the Drawings.

- C. Place warning tape over pipe as shown on the drawings. Tape shall clearly indicate
 - 1. "Buried Sewer Line" and be composed of a metallic material so as to be detectable by magnetic underground location indicators.
- D. Place and compact suitable backfill material over sand blanket. Backfill in accordance with the requirements specified under Section 31 23 00.

3.6 CONCRETE CRADLES AND CONCRETE ENCASEMENTS FOR PIPES

- A. Construct concrete cradles and concrete encasements for additional support or protection of proposed and/or existing pipes at locations indicated on the Drawings or as directed by the Architect. Use Class "A" concrete.

3.7 CONSTRUCTING MANHOLES

- A. When the Architect has accepted conditions at the bottom of the excavation, place and compact the bedding of crushed stone. Provide a bedding surface for the entire base area of the manhole base section. Set manhole base section at proper line and grade and so that it is uniformly supported on the bedding material.
- B. Jointing: Clean all joint surfaces. Lubricate the gasket recess and the gasket. Install gasket in recess and equalize the gasket all around the joint. Complete the jointing by bringing the sections together. Set manhole sections vertical, in true alignment, and so that manhole steps are aligned to form a continuous ladder.
- C. Concrete Invert with Brick Lining: Using Class "A" concrete, construct concrete invert with brick lining inside manhole base section. Plan construction such that final brick lining will be at proper elevation, so that the brick lining diameter will match that of entering and leaving pipes, and so that, in plain view, the centerline of the invert will have the longest possible radius. Set bricks in full beds of mortar. Make joints no greater than 1/2 inch and finish smooth and flush.
- D. Frames and Covers: Install manhole frames and covers using bricks or concrete grading rings in quantities as required to bring top of frame to final grade. Set bricks, grading rings, and frames in full beds of mortar. Joints shall not exceed 1/2 inch and shall be pointed.
- E. Dampproofing: Apply primer and dampproofing material to exterior surfaces of manhole as specified under Section 7.08 of the DOT Specifications.

3.8 BACKFILLING

- A. Backfill and compact backfill material in accordance with the provisions of Section 31 23 33.
- B. Where accepted by the Architect, sheeting and portions of bracing used may be left in place. Do not leave untreated sheeting in place beneath structures or pavements.

3.9 TESTING AND INSPECTING

- A. General: Provide all equipment and personnel necessary, and make all tests required to demonstrate that the work of this Section has been completed in strict accordance with the design and the specified requirements.
- B. Closing-in uninspected work: Do not cause or allow any of the work of this Section to be covered up or enclosed until after it has been completely tested, inspected, and accepted by the Architect.
- C. Make air leakage test on sanitary sewer pipelines and hydrostatic leakage test on manholes as indicated below.

3.10 AIR LEAKAGE TEST FOR SANITARY SEWERS

- A. This test may not be used when the groundwater level is more than 9.25 feet above the invert of the pipe.
- B. At the time of the air leakage test, the Contractor shall determine the groundwater elevation from observation wells, excavations, or by other means acceptable to the Architect.
- C. The leakage test using low-pressure air shall be made on each manhole-to-manhole section of pipeline after placement of the backfill.
- D. The Contractor shall do all the work and shall provide all the equipment necessary for the performance of the leakage test. The Contractor shall use equipment specifically designed and manufactured for the purpose of testing sewer pipelines using low-pressure air.
- E. Pneumatic plugs shall have a sealing length equal to or greater than the diameter of the pipe to be tested. Pneumatic plugs shall resist internal test pressures without requiring external bracing or blocking.
- F. All air used shall pass through a single control panel. The air control equipment shall include a shut-off valve, a pressure regulating valve, a pressure reduction valve, and a monitoring pressure gage. The pressure reduction valve shall be set so that the internal air pressure in the pipeline cannot exceed 8 psig.
- G. An individual pressure-sensing line shall be provided from the sealed pipeline to the monitoring pressure gage. An entirely separate line shall be provided for introducing the air into the sealed pipeline.
- H. The monitoring pressure gage shall have a range from 0 to 10 psig. The gage shall have minimum divisions of 0.1 psi and an accuracy of 0.1 psi.

- I. Low-pressure air shall be introduced into the sealed line until the internal air pressure reaches a pressure that is 4 psig. greater than the maximum pressure exerted by groundwater that may be above the invert of the pipe at the time of the test. However, the internal air pressure in the sealed line shall not be allowed to exceed 8 psig. (When the maximum pressure exerted by the groundwater is greater than 4 psig. or 9.25 feet of water, the Contractor shall conduct only an infiltration test as prescribed by the Architect.
- J. At least two minutes shall be allowed for the air pressure to stabilize in the section under test. After the stabilization period, the shut-off valve shall be closed and the low-pressure air supply hose shall be quickly disconnected from the control panel. The time required in minutes for the pressure in the section under test to decrease from 3.5 to 2.5 psig. (greater than the maximum pressure exerted by groundwater that may be above the invert of the pipe) shall not be less than that shown in the following table:

<u>Pipe Diameter in Inches</u>	<u>Minutes</u>
4	2.0
6	3.0
8	4.0
10	5.0
12	5.5
15	7.5
18	8.5
21	10.0
24	11.5

- K. When the sewer section being tested contains more than one size of pipe, the minimum allowable time shall be based on the largest diameter pipe in the section, and shall be the time shown in the table reduced by 0.5 minutes.
- L. Repair, Replacement: Should any section of the sewer fail to meet the above requirements , the Contractor shall locate, repair, or replace defective joints and work at no additional expense to the Owner. Also, at no additional expense to the Owner, he shall repeat the test. This repair/replace/retests procedure shall be repeated until the sewer section meets the above requirements.

3.11 LEAKAGE TEST FOR MANHOLES

- A. When the construction of manholes and installation and sealing of entering-and-leaving sewer pipes have been completed, leakage tests shall be conducted on the manholes. All tests shall be observed by the Architect.
- B. Infiltration Test
 1. If the groundwater table should be above the highest joint in the manhole and if the Architect does agree that infiltration test will be satisfactory, an infiltration test shall be used to evaluate the watertightness of the manhole.
If the Architect does determine that there is no leakage into the manhole and does

approve the manhole as being watertight, no further testing will be required. However, if the Architect is not satisfied that the manhole is watertight, the Contractor shall lower the water table and carry out exfiltration test as described below.

C. Exfiltration Test

1. The Contractor may backfill around the manhole before or after the following leakage test. The Contractor shall hereby be advised that it may be to his benefit to backfill following the leakage testing. If the Contractor should backfill before testing and if unacceptable leakage should occur, the Contractor will be required to re-excavate as necessary to correct the leakage and no extra payment will be made for this work. In addition, if the Contractor should backfill prior to the leakage test, he shall take any steps necessary to assure the Architect that the water table is below the bottom of the manhole throughout the test. Gravity sewer pipes entering and leaving manhole shall be temporarily plugged.
2. Manholes shall be filled with water to the top of the cone section. If the excavation has not been backfilled and observation by the Architect indicates no visible leakage, that is, no water visibly moving down the outside surface of the manhole, the manhole will have satisfactorily passed the test. If the manhole has visible leakage, as determined by the Architect, or if the manhole excavation has been backfilled, the test shall be continued or conducted as follows. The Contractor may allow water to set in manholes for a period of time to allow for absorption. At the end of this period, the manhole shall be refilled to the top of the cone, if necessary, and the test time of at least eight hours begun. At the end of the test time, the amount of water required to refill the manhole to the top of the cone shall be determined. A calculation shall be made to determine the 24-hour leakage rate per foot of manhole depth. The leakage for each manhole shall not exceed one gallon per vertical foot for a 24-hour period. If the test fails this requirement, but the leakage does not exceed three gallons per vertical foot per 24-hour period, repairs shall be made as approved or directed by the Architect to bring the leakage within the allowable rate of one gallon per foot per 24-hour period. If the leakage exceeds three gallons per vertical foot per 24-hour period, the manhole will be rejected. The Contractor shall then uncover the manhole, as necessary, and shall disassemble and reconstruct or replace it, as directed by the Architect. The manhole shall then be retested. This procedure shall be repeated until manholes pass leakage test.

3.3 CONNECTIONS

- A. Where a new pipe is to be connected into an existing manhole, the Contractor shall carefully cut into the existing manhole to obtain the minimum diameter hole required to construct the sewer to the line and grade indicated on the plans. The use of blunt instruments or excessive force will not be permitted.
- B. The hole around the pipe shall be carefully sealed with non-shrink grout to obtain a watertight connection. A suitable invert channel, compatible with the existing formed invert, shall then be formed in the bottom of the existing manhole to the satisfaction of the Engineer.

3.4 CLEANING PIPELINES, MANHOLES AND APPURTENANCES

Upon completion of construction, all dirt and other foreign material shall be removed from pipelines and manholes. No materials shall be left to impede sewage flows.

3.01 GENERAL

- A. Examine the areas and condition under which work of this Section will be performed. Correct conditions detrimental to the timely and proper completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.02 CONNECTIONS

- A. Where a new pipe is to be connected into an existing manhole, the Contractor shall carefully cut into the existing manhole to obtain the minimum diameter hole required to construct the sewer to the line and grade indicated on the plans. The use of blunt instruments or excessive force will not be permitted.
- B. The hole around the pipe shall be carefully sealed with non-shrink grout to obtain a watertight connection. A suitable invert channel, compatible with the existing formed invert, shall then be formed in the bottom of the existing manhole to the satisfaction of the Engineer.

3.03 CLEANING PIPELINES, MANHOLES AND APPURTENANCES

- A. Upon completion of construction, all dirt and other foreign material shall be removed from pipelines and manholes. No materials shall be left to impede sewage flows.

END OF SECTION 33 30 00

SECTION 33 40 00 — STORM DRAINAGE UTILITIES

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.02 DESCRIPTION

- A. Work Included: Storm drain pipes, catch basins, manholes and related work, complete in place, as shown on the Drawings and as specified.
- B. Related Sections:
 - 1. Section 31 20 00 – Earth Moving;
 - 2. Section 31 23 33 – Trenching and Backfilling;
 - 3. Section 31 25 00 – Erosion and Sedimentation Controls.

1.03 QUALITY ASSURANCE

- A. Qualifications of installers: Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

1.04 SUBMITTALS

- A. Product Data:
 - 1. Manufacturers' descriptive literature for all items proposed to be furnished and installed under this Section, including Material Safety Data Sheets (MSDS) on all PVC adhesives and primers.
 - 2. Manufacturer's specifications and other data required to demonstrate compliance with the specified requirements.
 - 3. Manufacturers' recommended installation procedures which, when accepted by the Owner, shall become the basis for inspecting and accepting or rejecting actual installation procedures used on this Work.
 - 4. Verification of installer's qualifications.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Protection: Use all means necessary to protect the materials of this Section before, during, and after installation, to protect the work and materials of all other trades, and to protect all objects designated to remain.
- B. Delivery and Storage: Deliver all materials to the job site in their original containers with all labels intact and legible at time of use. Store in strict accordance with the manufacturers' recommendations as accepted by the Architect.
- C. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the acceptance of the Architect and at no additional cost to the Owner.

1.06 REFERENCES

- A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction Form 818 (2020) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

PART 2 – PRODUCTS

2.01 PIPE MATERIALS

- A. Polyvinyl Chloride Pipe
 - 1. Pipe: ASTM D3034, SDR 35 (Sizes: 4-15 in.)
 - 2. Joints: Bell and spigot with O-ring gasket compressed between the bell and the spigot.
 - 3. Gasket: Rubber gasket conforming to the requirements of AASHTO M198 or elastomeric gasket conforming to the requirements of ASTM D3212.
 - 4. For Perforated pipe, make perforations 5/8-in. diameter on 5-in. centers, 120 degrees apart.
- B. Reinforced Concrete Pipe
 - 1. Pipe: Article M.08.01-6, DOT Specifications.
 - 2. Gasket: Article M.08.01-20, DOT Specifications.
- C. High Density Polyethylene Pipe
 - 1. Pipe: All high-density polyethylene pipe shall have corrugated exterior and smooth interior and shall meet the following:

Sizes 3" to 10"

AASHTO M252, ASTM D3350 324420C

Sizes 12" to 38" AASHTO M294, ASTM D3350 335420C

2. Coupling: Water Tight: Couplings designated on the drawings as watertight shall be gasketed, bell and spigot in accordance with the respective AASHTO specification. The bell shall be an integral part of the pipe for sizes up to and including 36" and shall provide a minimum pull apart strength of 400 pounds. Joints shall be accepted as water tight after passing a field air test after installation to ensure a leakage rate not to exceed 200 GPD/in = dia/mile or, in lieu of a field test, shall be accepted as water tight based on the manufacturer's certification that the leakage rate does not exceed 200 GPD/in-dia/mile based on laboratory testing.

2.02 CATCH BASINS, YARD DRAINS, AND MANHOLES

- A. Materials shall conform to the requirements of Article M.08.02 of the DOT Specifications.
- B. Protective compound material: Article M.03.01-11 of the DOT Specifications.
- C. Mortar: Article M.11.04 of the DOT Specifications.
- D. Pervious material: Article M.02.05 of the DOT Specifications.
- E. Galvanize steel frames and grates in accordance with the requirements of Article M.06.03, DOT Specifications. Do not galvanize cast iron frames and grates.

2.03 BEDDING, BASE, COVER AND BACKFILL MATERIALS

- A. Crushed stone for bedding shall be sound, tough and durable; it shall be free from soft, thin elongated, or laminated pieces and vegetable or other deleterious substances. Grading Article M.01.01, DOT Specifications. Size: As indicated on the Drawings.
- B. Suitable Backfill Material: Section 31 23 33 – Trenching and Backfilling.

PART 3 – EXECUTION

3.01 GENERAL

- A. Examine the areas and condition under which work of this Section will be performed. Correct conditions detrimental to the timely and proper completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.02 EXCAVATION

- A. Make excavations for catch basins, infiltration basins, yard drains, manholes, pipes and other drainage items in accordance with the provisions of Section 31 20 00 – Earth Moving and Section 31 23 33 – Trenching and Backfilling.

- B. Protect bottoms of excavations from frost. Do not place bedding, structures, pipes, or fill materials on frozen ground.
- C. Provide dewatering as specified under Section 31 20 00 – Earth Moving. Keep excavations dry.

3.03 LAYING PIPE; JOINTING PIPE

- A. General
 - 1. Carefully examine each pipe prior to placing. Promptly set aside all defective pipe and all damaged pipe. Clearly identify all defects. Do not install defective pipe or damaged pipe.
 - 2. Place all pipe to grades and alignment shown on the Drawings.
 - 3. Provide all equipment for lowering pipe safely into the trenches.
 - 4. Lay pipe by proceeding upgrade with the spigot ends of bell-and-spigot pipe, and the tongue ends of tongue-and-groove pipe pointing in the direction of flow.
- B. When the Owner has accepted conditions at the bottom of the trench, place and compact the bedding of crushed stone. Provide a bedding surface to support the barrel of the pipe throughout its entire length. Accurately shape the bedding to conform to the lower quarter of the pipe. Make depressions in the bedding for making pipe joints.
- C. Make watertight pipe joints. Use gaskets as specified for each kind of pipe. Do the jointing in accordance with the pipe manufacturer's instructions and as follows:
 - 1. Clean gaskets and mating surfaces of pipes. Use lubricant on gaskets and pipes if required by pipe manufacturer. Align pipe to be installed with previously installed pipe, and, with gasket in place, put joint together. After pipes are put together, inspect joint to verify that gasket is properly positioned and that joint has been properly made and is tight. If, while making the joint, the gasket becomes loose or displaced, remove the pipe and remake the joint to the acceptance of the Architect.
- D. Fill depressions under joints with granular fill bedding material and compact the material thoroughly.
- E. Joining pipe of different materials: Provide fittings or couplings made for the pipe materials joining, or provide a concrete collar.
- F. Place and compact bedding material (granular fill or in the case of underdrains, crushed stone) around both sides of pipe and over the top of the pipe as shown on the Drawings.
- G. Place warning tape over pipe as shown on the drawings. Tape shall clearly indicate "Buried Storm Line" and be composed of a metallic material so as to be detectable by magnetic underground location indicators.

- H. Place and compact suitable backfill material over bedding (cover) material as shown on the Drawings and in accordance with the requirements of Section 31 20 00 – Earth Moving and Section 31 23 33 – Trenching and Backfilling.

3.04 CONSTRUCTION OF CATCH BASINS, YARD DRAINS AND MANHOLES

- A. When conditions at the bottom of the excavation are satisfactory to the Owner, place and compact the granular fill base. Bring the top of the granular base to the proper grade. Make granular base flat to uniformly support catch basin, yard drain, or manhole.
- B. Construct catch basins, manholes, etc. and join pipes to structures in accordance with requirements of Article 5.07.03 of the DOT Specifications. Those requirements include:
 - 1. Lay masonry units and metal frames in full mortar beds. In addition to the requirements of Article 5.07.03, apply a field coat of SS-1 emulsion to metal frames, grates and covers immediately before installation.
 - 2. Plan to backfill with pervious material to extent indicated; provide a drainage opening in each wall immediately above the bottom of the pervious material, as indicated.
 - 3. If cast-in-place concrete is used for tops, use bar reinforcement and apply protective compound material as indicated. Comply with other applicable requirements of Article 5.07.03.
- C. When structures are constructed in sandy soils, apply damp proofing to outside wall surfaces.
- D. Coordinate the backfilling work using suitable backfill material where indicated and pervious backfill material where indicated. Conform to backfilling requirements of Section 31 20 00 – Earth Moving and Section 31 23 33 – Trenching and Backfilling.

3.07 PIPE CONNECTIONS TO EXISTING DRAINAGE STRUCTURES

- A. When connecting a new pipe into an existing drainage structure, carefully cut into the structure to produce the smallest possible hole for the pipe. Do not use blunt instruments or excessive force in cutting the hole. Locate the hole so that, when connected, the pipeline will be at line and grade indicated on the Drawings.
- B. Carefully seal around the pipe with an acceptable non-shrink grout to obtain a watertight connection.

3.08 BACKFILLING

- A. Backfill and compact backfill material in accordance with the provisions of Section 31 20 00 – Earth Moving and Section 31 23 33 – Trenching and Backfilling.
- B. Where accepted by the Owner, sheeting and portions of bracing used may be left in place. Do not leave untreated sheeting in place beneath structures or pavements.

3.09 RAISING MANHOLES AND CATCH BASINS

- A. Within the project area, raise all existing manholes and catch basins to finished grade.
- B. Precast Concrete Manholes and Catch Basins
 - 1. Raise by adding additional precast riser sections or by adding courses of brick or block as indicated on the Drawings.
 - 2. If the total depth of adjusting brick or block exceeds 12 inches, raise by using precast riser sections. With brick or block, final adjustment not to exceed 12 inches.
- C. Brick or Block Manholes and Catch Basins
 - 1. Raise manholes in kind.
 - 2. If the total depth of the manhole or Catch Basin (top of frame to lowest invert) will be increased to more than eight feet, rebuild the manhole or catch basin using 12-inch thick brick or block.
- D. Reset existing frames and covers except where the Drawings call for replacement.

END OF SECTION 33 40 00

SECTION 33 49 23 — STORM DRAINAGE WATER DETENTION STRUCTURES

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.02 DESCRIPTION OF WORK

- A. Work Included:

- 1. Provide excavation and base preparation per Geotechnical Engineer’s recommendations and/or as shown on drawings, to provide adequate support for project design loads and safety from excavation sidewall collapse.
 - 2. Provide piping and backfill materials. Install detention piping, chambers, inlet and outlet pipe with connections, and cleanout risers in accordance to the manufacturer’s instructions and as specified under this section.

- B. Related Work:

- 1. Section 31 20 00 – Earth Moving;
 - 2. Section 33 40 00 – Storm Drainage Utilities.

1.03 QUALITY ASSURANCE

- B. Installation: Performed only by skilled work people with satisfactory record of performance on pipe, chamber, or pond/landfill construction projects of comparable size and quality.

1.04 SUBMITTALS

- A. Submit manufacturer’s product data and installation instructions.
- B. Submit material certificates for base course, and backfill materials.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Protect pipe from damage during delivery and store on smooth surfaces, free from debris.

1.06 PROJECT CONDITIONS

- A. Review installation procedures and coordinate work with other work affected, such as grading, excavation, utilities, construction access, erosion control to prevent all non-installation related construction traffic over the completed installation, especially with loads greater than design loads.
- B. Cold Weather:
 - 1. Do not use frozen materials or materials mixed or coated with ice or frost.
 - 2. Do not build on frozen work or wet, saturated or muddy subgrade.
 - 3. Care must be taken when handling detention chambers when air temperature is at or below 32 degrees F.
- C. Protect partially completed pipe installation against damage from other construction traffic when work is in progress, and following completion of backfill, with highly visible construction tape, fencing, or other means until construction is complete.
- D. Protect adjacent work from damage during pipe installation.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Base of Excavation: Shall be smooth soil, level and free of lumps or debris. Compact to at least 95% or as required by Engineer. Use 6" of $\frac{3}{4}$ " crushed stone as fill layer, free from lumps, debris or any other sharp materials (ASTM D2321 Class 1A for infiltration tank, ASTM D2321 Class 1B for line detention tank). Stone shall be compacted to 95% Proctor Density, or as specified by engineer.
- B. Geotextile: Shall be non-woven PP with a weight of at least 8 oz. per square yard, appropriate for the soil type and depth conditions, placed on the floor of the excavation, the sides of the chamber, and chambered top.
- C. Liner: Shall be Linear Low Density Polyethylene, PVC, or as specified by the engineer and manufacturer.
- D. Chambers: ADS Stormtech MC3500 Storm Water Management System or approved equal.
- E. Side Backfill: $\frac{3}{4}$ " crushed stone, free from lumps, debris or any other sharp materials to backfill along the sides of the modular structure (ASTM D2321 Class 1A for infiltration tank, ASTM D2321 Class 1B for lined detention tank). Compaction by suitable mechanical compaction means in lifts that do not exceed 12" to 95%, to provide a settlement-free surface over the sides of the structure. Side fill should be minimum of 12" around entire perimeter of installation to eliminate the effects of surrounding soils.

- F. Top Backfill: Use 3'-3" minimum depth of cover over chamber installation to achieve load rating. A maximum depth of 11 ft. is allowed from the bottom of the installed modules to the finished surface. $\frac{3}{4}$ " crushed stone, free from lumps, debris or any other sharp materials required for the first 12" of total backfill compacted to 95%, regardless of surface fill, i.e. asphalt, concrete, etc. (ASTM D2321 Class 1A for infiltration tank, ASTM D2321 Class 1B for lined detention tank). Remaining top fill to be suitable materials for road base compacted to 95% or as specified by engineer.
- G. Utility Marker: Use metallic tape at corners of install to mark the area for future utility detection.

PART 3 – EXECUTION

3.01 INSPECTION

- A. Examine prepared excavation and conditions for smoothness, compaction and level. Do not start pipe installation until unsatisfactory conditions are corrected. Check for presence of high water table, which must be kept at levels below the bottom of the pipe system at all times.
- B. Installation constitutes acceptance of existing conditions and responsibility for satisfactory performance. If existing conditions are found unsatisfactory, contact Project Manager for resolution.

3.02 INSTALLATION

- A. Install piping as shown on the plans. Place metallic tape on top corners of install to mark the area for future utility detection. Place geotextile fabric layer over the top and sides to prevent soil entry into the chamber. Take great care to avoid damage to fabric liner material during placement.
- B. Place sufficient sandy gravel backfill material over geotextile fabric to ensure support of design loads. Place cover backfill in 6" lifts and compact with vibrating plates or walk-behind rollers (do not use drivable rolling compactors) to a minimum of 95%, with a minimum depth of 3'-3" and a maximum depth of 4'-3". Take care to place backfill on top of structure and avoid damage to structure or fabric using low pressure tire or track vehicles.
- C. Ensure that all non-chamber construction traffic be kept away from the limits of excavation until the project is complete and final surface materials are in place.
- D. Place surfacing materials, such as groundcovers (no shrubs or trees), or paving materials over the structure with care to avoid displacement of cover fill and damage to surrounding areas.

3.03 CLEANING

- A. Perform cleaning during the installation of work and upon completion of the work. Remove from site all excess materials, debris, and equipment. Repair any damage to adjacent materials and surfaces resulting from installation of this work.

END OF SECTION 33 49 23

SECTION 32 31 13 – VEHICULAR BARRIER SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section “Summary.”

1.2 SUMMARY

- A. This Section includes the following:
 - 1. This section includes the furnishing and installation of a Vehicle Barrier System. Provide a complete system that has been fabricated and tested for proper operation at the factory.
 - 2. System includes barrier arm (beam) section, hinge and receiver and buttresses (stanchions).
- B. Related Sections include the following:
 - 1. Division 31 Section “Earth Moving”.
 - 2. Division 32 Section “Topsoil”.
 - 3. Division 32 Section “Fences & Gates”.
 - 4. Division 03 Section “Cast-In-Place Concrete”.

1.3 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data in the form of manufacturer’s technical data, specifications, and installation instructions for each type of fence system, including gate posts, fabric, gates, and accessories, including mill certificates.
- C. Submit shop drawings showing location of gates, pertinent dimensions, general construction, component connections and location, anchorage methods and location, hardware, accessories and installation detail.
- D. Shop drawings shall be signed and sealed by an engineer licensed in the State of Connecticut. Shop drawings shall also include footing designs for lift arm and stanchion.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who has completed fence systems similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

- B. Deliver material to job site in manufacturer's packaging undamaged, complete with installation instructions.
- C. Store off ground, under cover, protected from weather and construction activities.
- D. Installers shall have installed a minimum of 5 similar complete vehicle lift arm systems in the last 2 years.

1.5 PROJECT CONDITIONS

- A. Field Measurements: Verify layout information for the vehicle barrier system shown on the Drawings in relation to the property survey and existing structures. Verify dimensions by field measurements.
- B. Install vehicle barrier system including excavation, trenching and concrete foundation pads per manufacturer's printed instructions.

1.6 WARRANTY

- A. Two (2) years from date of shipment on manufactured components and workmanship. This warranty excludes normal wear on finishes or damage that occurs due to impact, abuse, misuse.
- B. Accessories shall be covered by manufacturer's warranty.

PART 2 - PRODUCTS

2.1 VEHICLE BARRIER MANUFACTURER

- A. The manually operated vehicle barrier system shall be TVB-MO Beam Vehicle Barrier as manufactured by Tymetal Corp. specifications and shall be supplied by Tymetal Corp or approved equal., 2549 State Route 40, Greenwich, NY 12834 - (800) 328 - 4283

2.2 VEHICLE BARRIER

- A. The complete vehicle barrier system assembly consists of a receiver stanchion, hinge stanchion, aluminum arm, stanchion covers and counterbalance. This unit was designed using the latest technology in parts and assembly including the use of self-aligning bearings.
- B. Mechanical Components:
 - 1. Buttress (stanchions): The hinge and receiver buttresses are manufactured of steel components and welded steel elements.
 - 2. Locking: Beam shall be capable of being locked in vertical position and horizontal position to prevent tampering with by unauthorized users. Provide locks and keys to owner.

3. Hinge Butress: The hinge butress assembly includes internal bearings and stainless steel axle allowing the beam arc from 0 degrees up to 90 degrees when in fully open position. A cushioning device is included to reduce beam oscillation. Covers are included to conceal operating system and prevent debris, ice or snow accumulation.
4. Receiver Butress: Receiver butress is designed to guide the beam into place when lowered and retain the beam during vehicle impact. The receiver butress includes a locking pin to prevent unauthorized operation of the unit when unattended.
5. Beam: Beam is constructed of rectangular aluminum extrusion. The beam is finished in stock standard white polyester powder coating and reflective red and white safety tape to increase visibility.
6. Counter Balance: An integral counter weight shall be incorporated into the beam design to allow for manual operation by a single user.
7. Concrete: All concrete for installation is at or below grade. Above ground concrete/forming for buttresses/stanchions is not permitted allowing stanchion placement in close proximity to adjacent objects, walls etc.

C. Finishes:

1. The TVB-MO vehicle barrier system shall be delivered painted black (buttresses) with a three part epoxy paint process: First mechanical and then chemical cleaning followed by a high density zinc primer application and completed with 2 part epoxy paint for corrosion resistance. Other colors available, contact manufacturer for details.
2. The beam shall be finished in stock standard white polyester powder coating and striped with reflective red and white safety tape to increase visibility. The Power Unit is painted industrial gray.
3. Retro reflective surface shall be adhered to the lift arm beam. 3M or equal full length of each side.

2.3 CONCRETE/FOOTINGS

- A. Concrete: Provide concrete consisting of portland cement per ASTM C 150, aggregates per ASTM C 33, and potable water. Mix materials to obtain concrete with a minimum 28 day compressive strength of 4,000 psi. Use at least four sacks of cement per cu. yd., 1-inch maximum size aggregate, 3 inch maximum slump.
- B. Provide standard cylindrical cardboard tube liners for full depth of footing, where required by Architect if excavations are not held vertical and smooth.
- C. FIRE ACCESS STATION / KNOX BOX
 1. (1) Knox box installed at the vehicle barrier system shall be capable of securely storing several keys for access to gate and other site features. Furnish and install American Access Systems Inc. Model 15-014 or approved equal. Knox box shall be heavy duty powder coated steel. Supply pad lock with 3 sets of keys to owner. Provide and install steel mounting plates to securely fasten to nearest fence framework or stanchion with tamper resistant mounting hardware. 1/4" heavy duty steel mounting plate and hardware shall be powder coated to match fence. Size plate to accommodate mounting of knox box. Mounting plates may also be welded to post if it does not damage finish and interrupt gate operation.

- 2.4 GROUT: exterior Portland-cement based non-shrinking grout with 8,000 psi compression strength at 7 days, similar to Super Por-rok, by Minwax Company and distributed by Lambert Corporation, or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install fence to comply with the project details and ASTM F 567. Do not begin installation and erection before final grading is completed, unless otherwise permitted.
 - 1. Apply fabric to outside of framework. Install fencing on boundary lines inside of property line established by survey as required by Division 1.
- B. Excavation: Drill or hand excavate (using post hole digger) holes for posts to diameters and spacing indicated, in firm, undisturbed or compacted soil. Excavation to be vertical – tapered excavations are not permitted. Install posts and foundations for fences in paved areas, prior to the installation of pavement material. Augering holes in pavement for fence post installation will NOT be permitted.
 - 1. Excavate holes for each post to minimum diameter recommended by fence manufacturer, but not less than four times the largest cross section of post.
 - 2. Unless otherwise indicated, excavate hole depths approximately 3 inches lower than post bottom, with bottom of posts set not less than 48 inches below finish grade surface.
 - 3. Provide full-length tube form liners if directed by Architect, due to inconsistent faces of excavation.
- C. Buttress Installation: The hinge and receiver buttress are cast in a concrete foundation below grade.
- D. Set units level and plumb and in line with adjacent structures or roadway. Anchor securely into place. Coordinate footing elevations and layout with proposed improvements. Provide adjustments in shop drawings to work with field conditions at no additional expense to contract.
- E. Minimum footing size indicated on drawings and details. Contractor shall install footings and reinforcement per engineered shop drawings at no additional expense to the contract.
- F. System Testing:
 - 1. Test system functions smoothly.
 - 2. Adjust beam arm, hardware for smooth and proper performance.
 - 3. Review system operation with Owner. Review safety points concerning basic operational guidelines of the vehicle barrier system.
 - 4. Installer shall review all safety, code and manufacturer's requirements prior to completion to ensure the product is safe and operating as intended.
- G. Install locking system. Provide owner with keys.

- H. Fire Access Knox Box: Install (1) Knox Box adjacent to each (4) sliding gate vehicle access locations. Field locate box in an accessible location and secure per manufacturers recommendations. Mounting panel and box shall be located within proximity to gate latch locking point (max. 10'). Review and coordinate the final location with owner and fire marshal prior to installation. Fasten/secure mounting plate to fence post with tamper proof fittings, fasteners or welding or as recommended by the Knox Box manufacturer. Provide mounting method in shop drawings with fencing submittal for review and approval.

3.2 VEHICLE BARRIER INSTALLATION

- A. Install vehicle barrier plumb, level, and secure for full opening without interference. Install ground set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary. Install gates according to manufacturer's instructions, plumb, level, and secure.

END OF SECTION 34 75 13

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