ROCKLAND COUNTY HIGHWAY DEPARTMENT

CONSTRUCTION CONTRACT

HON. ED DAY
COUNTY EXECUTIVE

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INFORMATION FOR BIDDERS
AND
STANDARD AGREEMENT
AND
PERFORMANCE AND PAYMENT BONDS
AND
SPECIFICATIONS
VOLUME 3 OF 3

FOR FURNISHING ALL LABOR AND MATERIAL NECESSARY AND REQUIRED FOR:

ROCKLAND COUNTY HIGHWAY FACILITY

TOWN OF CLARKSTOWN
TOWN OF RAMAPO, VILLAGE OF CHESTNUT RIDGE
COUNTY OF ROCKLAND
STATE OF NEW YORK

CONTRACT 3414

DATE OF BID 12/12/19
TIME – 11:00 AM

BID SET

Prepared By:
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Job No. 130439

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APPENDICES

END

SECTION 230529 - COMMON WORK RESULTS FOR HVAC

PART 1 -

1.1 RELATED DOCUMENTS

A. These basic Mechanical Requirements apply to all Division 23 Sections.

B. The work of this Section consists of providing of all materials, labor and equipment and the like necessary and/or required for the complete execution of all HVAC and related work for this project, as required by the contract documents.

1.2 RELATED DOCUMENTS

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

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER RESPECTIVE SECTIONS OF THIS DIVISION

A. Motor starters shall be furnished under this Division. Refer to Specification Section 230513 Common motor requirements for HVAC equipment" for technical information.

1.4 REFERENCES

A. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers Guides and Standards, latest editions.

B. SMACNA - Sheet Metal and Air Conditioning Contractors National Association.

C. ASME - American Society of Mechanical Engineers.

D. UL - Underwriters Laboratory.

E. NFPA - National Fire Protection Association.

1.5 REGULATORY REQUIREMENTS

A. All equipment and installation methods shall conform to the applicable standards and/or recommendations set forth in the New York State Building Code, Local Codes as well as all Codes and Standards listed in the general requirements sections of the specification

B. Plumbing: IPC 2015

C. Mechanical; IMC 2015

D. Energy; IECC 2015

E. Obtain permits, and request inspections from authority having jurisdiction.

1.6 QUALITY ASSURANCE

A. The Contractor shall have the work indicated on the drawings and/or specified in each section performed by vendors or mechanics experienced and skilled in its implantation or by a “Specialist”, “Specialty Contractor” or “Specialty Subcontractor” under contractual agreement with the Contractor. These terms mean an individual or firm of established reputation, or, if newly organized, whose personnel have previously established a reputation in the same field, which is regularly engaged in, and which maintains a regular force of workmen skilled in either manufacturing or fabricating items required by the Contract, installing items required by the Contract, or otherwise performing work required by the Contract.

B. Where the Contract Specifications require installation by a "Specialist," that term shall also be deemed to mean either the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform such work under the manufacturer's direct supervision.

1.7 PROJECT/SITE CONDITIONS

A. Install Work in locations shown on Drawings, unless prevented by Project conditions.

B. Prepare drawings showing proposed arrangement of Work to meet Project conditions, including changes to Work specified in other Sections.

1.8 SCOPE OF WORK

A. This Contractor shall be responsible for coordinating his work with all other trades.

B. The Contractor shall provide all materials, labor, equipment, tools, appliances, services, hoisting, scaffolding, supervision and overhead for the furnishing and installing of all mechanical work and related work including but not limited to the following:
1. Boilers.
2. Hot water pumps.
3. Water chiller.
4. Chilled and Hot water pumps.
5. Air Handlers, and specialties.
6. Packaged RTU
7. Supplemental AC systems
8. Indoor and outdoor gas fired furnaces
9. Expansion tanks.
10. Fans.
11. HW, gas and electric unit heaters
12. Convectors
13. Hot water and chilled water coils.
14. Hydronic piping, valves, fittings, and specialties.

15. Refrigerant pipe, valves, fittings, and specialties
16. Glycol feed pumps
17. Ductwork and specialties.
18. Pipe and duct insulation.
19. New VAV boxes
20. Equipment Supports
21. Automatic temperature controls.
22. Grilles, registers, louvers, and diffusers.
23. Vibration isolation.
24. Equipment supports.
25. Motor starters and disconnects.
26. Protection.
27. Identification.
28. Coordination.
29. Phasing.
30. Rigging.
31. Testing and Balancing Reports Air and Water.
32. Shop Drawings.
33. As-Built Drawings and Maintenance Manuals.
34. Warrantees.
35. Commissioning

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 GENERAL

A. Construct all apparatus of materials and pressure ratings suitable for the conditions encountered during continuous operation.

B. Construct all equipment in accordance with requirements of all applicable codes. All pressure vessels and safety devices that fall within the scope of the ASME Code shall conform to the Code and bear the ASME label or stamp.

C. Match and balance all system components to achieve compatibility of equipment or satisfactory operation and performance throughout the entire operating temperature and control ranges. All installations shall be in accordance with manufacturer's recommendations.

D. Provide all controls, wiring, piping, valves, accessories and other components necessary to make all systems complete and operable.

E. The contractor shall warranty all work, including labor and materials, and equipment furnished and installed as part of this contract for a minimum period of year from the date of acceptance by the owner, in writing. Certain equipment, such as underground fuel tanks, may have longer warranties as indicated in the specifications. In such cases the longer of the two warranties shall prevail.

3.2 SHOP DRAWINGS AND SUBMITTALS (COORDINATE WITH DIVISION 1)

A. Shop drawings and samples shall be prepared and submitted in accordance with the requirements established in the contract and shall consist of the all items listed in the following paragraphs.

B. Manufacturer's data or shop drawings giving full information as to dimensions, materials, and all information pertinent to the adequacy of the submitted equipment shall be submitted for review. Shop drawings shall include, but not be limited to the following:

C. Submit all Mechanical equipment noted and scheduled on plans including but not limited to the following:

1. Automatic Temperature Controls, Operation Sequences & Wiring Diagrams, and Control Diagrams hardware and software
2. Motor Starters and Controllers
3. Hot and chilled water, and piping and specialties
4. Expansion, and Water Treatment Equipment Tanks
5. Boilers.
6. Hot water pumps.
7. Water chiller.
8. Chilled and Hot water pumps.
9. Air Handlers, and specialties.
10. Packaged RTU
11. Supplemental AC systems
12. Indoor and outdoor gas fired furnaces
13. Fans.
14. HW, gas and electric unit heaters
15. Convectors
16. Hot water and chilled water coils.
17. Refrigerant pipe, valves, fittings, and specialties
18. Glycol feed pumps
19. Ductwork and specialties.
20. Pipe and duct insulation.
21. New VAV boxes
22. Equipment Supports
23. Pumps and bases
24. Vibration isolation
25. Glycol data sheets
26. Glycol feed pump and mixing tank
27. Hangers and Inserts
28. Equipment Supports and Vibration Eliminators
29. Sheet Metal Construction Standards
30. Piping Layout (1/4 scale)
31. Ductwork Layout (1/4 scale)
32. Insulation (piping and ductwork)
33. Piping, Valves, fittings, and Specialties
34. Filters
35. Fan Curves and Sound Rating
36. Coils
37. Fire dampers, Motorized Dampers, Smoke dampers
38. Diffusers Registers and Grilles

39. Balancing Reports, Air and Water
40. Coordinated Composite Drawings on Mylar with Piping, Ductwork, Conduits, Lights, registers Grilles and Smoke Detectors, etc.

D. The contractor shall, upon award, submit a schedule for the engineer's review indicating when each of the above shop drawings shall be submitted. Submittals shall be made in a timely manner as the project progresses in accordance with the Construction manager or General contractor's work schedules. The contractor shall allow sufficient time for the engineers to perform his review. A minimum of 10 business days shall be required. Untimely submittals shall be cause for the owner to make a delay against the contractor.

E. Demolition, purchase and or installation shall not begin until shop drawings pertaining to the equipment associated with any related potion of the work have been submitted.

F. Sheet metal shop drawings shall indicate all existing and/or new lights, walls, piping, structural elements, existing work, etc. and dimension locations of ductwork including elevations in relation to these items.

G. Where shop drawings have been reviewed by the Engineer, such review shall not be considered as a guarantee of measurements or building conditions. Where drawings have been reviewed, said review does not mean that drawings have been checked in detail; said review does not substantiate any quantities and in any way relieve the Contractor from his responsibility nor the necessity of furnishing materials or performing work required by the Contract Drawings and Specifications. It does not relieve the contractor of the responsibility to perform all work to accepted industry standards and in a code compliant manor. Approval of shop drawings containing errors does not relieve the contractor from making corrections at his expense.

H. Where substitutions are submitted for approval the review shall be for general performance comparison to the specified product. Products shall not be reviewed for size, clearance or coordination with other trades. Coordination with other trades shall be the responsibility of the contractor. And changes to existing conditions or changes required to the work of other trades such as a result of substituted material or equipment approved or not shall be the responsibility of this contractor.

I. Approval of shop drawings

1. The Contractor shall be specifically responsible for checking equipment dimensions and clearances and confirming that equipment will fit into the designated space and connect properly to adjoining equipment and/or materials.

2. Submittals marked "Make Corrections Noted" give authority to proceed in accordance with the notes. However, if drawings are also marked "Amend and Resubmit", corrected drawings must be resubmitted for final review.

3. Submittals marked "Rejected" do not give authority to proceed with any portion of the work shown there-on. Drawings must be resubmitted.

4. Submittals marked "Rejected" or "Amend and Resubmit" shall include a specific written response to the engineer's comments. Resubmission of a submittal without a written response to the engineer's comments will be considered incomplete and shall be returned un-reviewed.

3.3 CHARTS AND TAGS

A. The Contractor shall provide three sets of charts and diagrams of all piping systems indicating the number and location of valves, controls, etc.

B. All valves, dampers, and controls shall be designated with brass tags. Refer to section 23 05 23 Identification for HVAC Piping and equipment

3.4 FEES & PERMITS

A. The Contractor shall obtain all permits and pay all fees required related to this scope of work

3.5 PAINTING

A. All motors, fans and all other factory manufactured and assembled apparatus shall be factory coated with one coat of primer and one coat of machinery enamel standard color at the factory and after installation, all finishes shall be cleaned and touched up to repair any damage incurred during construction.

B. All piping shall be painted in colors conforming with OSHA Standards. All new and existing exposed iron and supplementary dunnage steel shall be finished according to specifications.

C. All supports, nuts, bolts and hanger fasteners located outside shall be galvanized or nickel plated.

3.6 RIGGING

A. Furnish all labor, materials and equipment required to rig equipment and materials.

B. The rigger shall secure any necessary permits and comply with all applicable Federal, State and local safety regulations. A copy of permits to be kept at both the project site and Engineer's Office.

C. The rigger shall have a minimum of five (5) years of practical experience and hold a master riggers license if required.

D. The procedure for rigging shall be submitted to the Engineer for review. All possible precautions should be taken to prevent damage to the structure, streets, sidewalks, curbs, lawns, etc.

3.7 CUTTING AND PATCHING

A. All cutting and patching required for piping, ductwork, control conduits, etc., passing through walls, floors, and roof shall be provided by the this Contractor under this contract unless otherwise noted. This Contractor shall be responsible for any damage done to the structure due to his negligence.

B. Patching materials and application shall match existing construction.

C. Where applicable, new holes for piping installation shall be core drilled.

D. Pipe Sleeves & Fire-stopping:
   1. Provide for all pipes, conduits ducts, and other elements passing through floors, walls, partitions and structural elements, sleeves as specified. Sleeves shall be of adequate diameter to allow for a minimum of 3/4 inches clear all around sleeve and pipe. When pipe, conduit ducts or other such element penetrates other than fire rated assembly and is insulated, insulation shall pass continuously through sleeves with 1/2 inch clearance between insulation and sleeve.
   2. Where pipes, conduits and other such elements penetrate fire rated assemblies, or where holes or voids are created to extend mechanical systems through fire rated assemblies (walls, floors, ceilings, structure, etc.); sleeves and fire-stopping systems shall be installed.

E. Furnish access doors, to the General Contractor for installation where required in finished walls, partitions and the like for access to junction boxes, controls, valves, etc, concealed behind finished construction.

F. Submit location drawings and sizes for review prior to installation.

3.8 PROTECTION-COORDINATE WITH DIVISION 1

A. Special protection is required for installation of a Derrick or other device for rigging purposes. This Contractor shall coordinate with the rigger to facilitate rigging work.

B. B.Recommendations and Provisions of ANSI Bulletin A10.2 and OSHA shall be complied with in-so-far as applicable to the work.

C. The Contractor shall provide temporary partitions or tarpaulins to protect adjacent spaces and/or equipment. He shall be responsible for any damage or injury to person or property of any character resulting from any act, omission, neglect or misconduct in his manner or method of executing his work.

D. The Contractor shall restore at his own expense such property to a condition similar or equal to that existing before such damage or injury in an acceptable manner.

E. The Contractor, furthermore, shall conduct his operations in such a manner as to prevent dust and debris from transferring on to adjoining property or into existing spaces.

F. All openings cut in walls, floors, roof or ceilings of the building, for conduit, pipe, ductwork, etc., shall be closed off with box-type temporary protective enclosures of ¼" tempered hardboard, except when mechanics are actually working at the particular opening. Enclosures shall be constructed of fireproof 2x4 frame, four (4) sides covered and made completely dust and water tight.

G. All finished floor areas through which the contractor must pass with materials or equipment shall be protected with a layer of ¼" hardboard, "Masonite", laid with joints taped together

3.9 EQUIPMENT SUPPORTS

A. A.Provide supplementary steel dunnage, curbs, angle iron stands, etc., to properly set and install all equipment, including supports necessary to properly pitch piping.

3.10 WELDING

A. A.Welding and equipment shall conform to the American Welding Society's Code for Welding in Building Construction, latest edition as well as state and local laws and ordinances.

B. The handling and storage of all welding materials, acetylene and oxygen tanks, burners, and other equipment required for the execution of welding and cutting work shall be subject at all times to the approval of the Owner and/or Architect. All welding materials and gas tanks shall be promptly removed from the premises upon completion of each day's work or stored in a manner satisfactory to the owner. Welding and equipment shall conform to the American Welding Society's Code for Welding in Building Construction, latest edition as well as state and local laws and ordinances.

C. Provide all temporary ventilation, and ventilation air systems required during welding operations as required by OSHA.

3.11 AS-BUILT DRAWINGS

A. The Contractor shall provide a complete set of As-Built drawings showing actual installation and locations of all new and existing equipment, piping, and ductwork in the entire building. Schedules shall be revised to indicate actual equipment installed.

B. As-Built drawings shall be submitted as per contract requirements in accordance with Division 1 and shall be submitted in paper format for review. Accepted as builts shall then be submitted in AutoCAD format on hard disc.

3.12 CONDITIONS

A. Inspection: Prior to all work of this Section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence. Verify that the work of this Section may be completed in strict accordance with all pertinent codes and regulations, the approved Shop Drawings, and the Manufacturers' recommendations.

B. Discrepancies: In the event of discrepancy, immediately notify the Engineer. Do not proceed in areas of discrepancy until all such discrepancies have been fully resolved.

3.13 INSTALLATION OF EQUIPMENT

A. Locations: Install all equipment in the locations shown on the approved Shop Drawings except where specifically otherwise approved on the job by the Owner and/or Engineer.

B. Interferences: Avoid interference with structure, and with work of other trades, preserving adequate headroom and clearing all doors and passageways to the approval of the Engineer.

C. Inspection: Check each piece of equipment in the system for defects, verifying that all parts are properly furnished and installed, and that all items function properly, and that all adjustments have been made.

3.14 CLOSING-IN OF UNINSPECTED WORK

A. General: Do not allow or cause any of the work to be covered up or enclosed until it has been inspected, tested, and accepted by the Engineer and by all other authorities having jurisdiction.

B. Uncovering: Should any of the work of this Section be covered up or enclosed before it has been completely inspected, tested, and approved, do all things necessary to uncover all such work. After the work has been completely inspected, tested, and approved, provide all materials and labor necessary and make all repairs necessary to restore the work to its original and proper condition at no additional cost to the owner.

3.15 BUILDING ACCESS

A. The Contractor shall inform himself fully regarding peculiarities and limitations of space available for the passage and installation of all equipment and materials under the Contract.

B. Verify and coordinate removal of existing construction and/or knock-down of equipment to suit conditions. Special attention should be given to equipment installation. Provide all labor and material to facilitate installation.

3.16 COOPERATION WITH OTHER TRADES PHASING

A. Cooperate with other trades in order that all systems in the work may be installed in the best arrangements.

B. Coordinate as required with all other trades to share space in common areas and to provide the maximum of access to each system.

C. This Contractor shall submit fully coordinated shop drawings showing all piping, ductwork and equipment, as well as relevant work of all other trades such as light, conduits, structural and steel, which may impact the final size or placement of piping, ductwork, equipment, diffusers and grilles.

D. The work shall be scheduled and phased in accordance with the requirements of the contract and the client. Prior to the commencement of work the HVAC contractor shall submit a schedule in writing to the Architect and owner for approval. There shall be no shut downs of any systems without prior written approval from the owner. The contractor shall include in his bid all costs associated with providing temporarily piping controls, ductwork and fans and air conditioning units to maintain operations in the phase II area while work is being performed on the Phase I area. It shall also be noted that ductwork, piping and controls will have to be extended through the phase II work areas in order to reach the area(s) under construction in

phase I as part of this work. The contractor shall include in his bid all provisions to perform such phasing work

3.17 CLEANING

A. It is the intent of the contract documents that all work, including the inside of equipment be left in a clean condition. All construction dirt shall be removed from material and equipment.

B. All removed items shall be taken off the premises and discarded in a manner satisfactory to the Owner.

3.18 COMPLETENESS

A. It is the intent of the contract documents to provide complete systems. Completeness shall mean not only that all material and equipment has been installed properly, but that all material and equipment is installed, adjusted, and operating as per the design intent in the opinion of the Engineer and in accordance with generally accepted industry good practice.

B. Upon completion of all phases of work or before there is any danger from freezing the contractor fill the cooling systems with a 35% Dow therm propylene glycol solution.

3.19 FIRE PREVENTION DURING HOT WORK

A. Before starting operations, the Contractor shall furnish trained personnel to provide fire watches for locations where hot work is to be performed. One fire watcher may observe several locations in a relatively small contiguous area. Contractor shall furnish suitable type, fully-charged, operable portable fire extinguisher to each fire watcher.

B. The Contractor shall provide fire watchers who know how to operate the fire extinguisher, how to turn on a fire alarm and how to summon the fire department.

C. Before starting operations, take suitable precautions to minimize the hazard of a fire communicating to the opposite side of walls, floors, ceilings and roofs from the operations.

3.20 SAFETY MEASURES

A. Hot work shall not be done in or near rooms or areas where flammable liquids or explosive vapors are present or thought to be present. A combustible gas indicator (explosimeter) test shall be conducted to assure that each area is safe. The Contractor is responsible for arranging and paying for each test.

B. Insofar as possible, the Contractor shall remove and keep the area free from all combustibles, including rubbish, paper and waste within a radius of 25 feet from hot operations.

C. If combustible material cannot be removed, the Contractor shall furnish fireproof blankets to cover such materials. At the direction of the owner floors, walls, and ceilings of combustible

material shall be wetted thoroughly with water before, during, and after operations sufficiently to afford adequate protection.

D. Where possible, the Contractor shall furnish and use baffles of metal or gypsum board to prevent the spraying of sparks, hot slag and other hot particles into surrounding combustible material.

E. The Contractor shall prevent the spread of sparks and particles of hot metal through open windows, doors, and holes and cracks in floors, walls, ceilings and roofs.

F. Cylinders of gas used in hot work shall be placed a safe distance from the work. The Contractor shall provide hoses and equipment free of deterioration, malfunction and leaks. Suitable supports shall be provided to prevent accidental overturning of cylinders. All cylinder control valves shall be shut off while in use with the gas pressure regulator set at 15 psi or less.

G. When hot work operations are completed or ended for the day, each location of the days work shall be inspected by the Contractor 30 to 60 minutes after completion of operations to detect for hidden or smoldering fires and to ensure that proper housekeeping is maintained. Contractor shall cleanup the area of work at the end of each shift or workday.

H. Where sprinkler protection exists, the sprinkler system shall be maintained without interruption while operations are being performed. If operations are performed close to automatic sprinkler heads, gypsum board sheets or damp cloth guards may be used to shield the individual heads temporarily. The heads shall be inspected by the Contractor immediately after hot work operations cease, to ensure all materials have been removed from the heads and that the heads have not been damaged.

I. Suitable type, fully-charged, operable portable fire extinguisher shall be available at all times during hot work operations.

J. If any of the above safeguards are not employed, or are violated, the Contracting owners Representative may, by written notice, stop the work until compliance is obtained. Such stoppage shall not relieve the Contractor form performing his work within the Contract period for the Contract price.

3.21 USE OF OWNERS EQUIPMENT

A. The contractor shall not use any the owner’s HVAC system or equipment, new or existing, for any purpose. The contractor shall provide temporary HVAC equipment, ductwork, power, and controls for use during construction for the purpose of ventilation, or heating during the construction process. All such equipment, ductwork, power, and controls shall be removed and the completion of work.

END OF SECTION

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SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Division 24 - Equipment Wiring Systems: Electrical characteristics and wiring connections.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

1.4 REFERENCES

A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. NEMA MG 1 - Motors and Generators.

D. NFPA 70 - National Electrical Code.

1.5 REGULATORY REQUIREMENTS

A. Conform to UL Component Recognition for appropriate sizes.

B. Conform to NFPA 70 applicable electrical code, Underwriters Laboratories, Inc., and NEMA

C. Conform to IEC 2015.

1.6 DELIVERY, STORAGE, AND PROTECTION

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.7 WARRANTY

A. Provide five-year manufacturer warranty for all motors larger than ½ horsepower.

PART 2 - PRODUCTS

MANUFACTURERS

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

1. Gould.
2. Century.
3. General Electric.
4. Square D

2.2 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

C. All electric motors of sizes and types as specified for driving mechanical equipment shall be provided under this section.

D. Electrical Service: All motors shall be 60 Hertz unless otherwise noted. Refer to Electrical Specifications for required electrical characteristics.

E. Motors: Design for continuous operation in 40° C environment, and for temperature rise in accordance with ANSI/NEMA MG limits for insulation class, Service Factor, and motor enclosure type. Motors shall be of sufficient size for duty to be performed.

F. Visible Nameplate: Indicating manufacturer's name and model number, motor horsepower, RPM, frame size, voltage, phase, cycles, full load amps, insulation system class, service factor, maximum ambient temperature, temperature rise at rated horsepower, minimum efficiency, power factor.

G. Electrical Connection: Conduit connection boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide screwed conduit connection in end frame. Size motor boxes to receive motor feeders and ground cable indicated on electrical drawing schedules.

H. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

I. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 MOTOR EFFICIENCY

A. Electric motors shall meet the minimum efficiency requirement of the following tables in accordance with International Energy conservation code when tested in accordance with DOE CFR 431. Performance data shall be certified by approved testing agency.

B. Subtype I motor – NEMA premium efficiency as per table NEMA MG 1 table 12-12 and International Energy Conservation code table 405.8(1). This shall apply to general purpose, T-frame, single speed, squirrel cage, induction type; 230/460-V, NEMA Designs A or B, continuous rated, 60 Hz, from 1 to 200 hp, 2-, 4- and 6-pole (3600-, 1800- and 1200-rpm), open and enclosed. Subtype I motors 250 hp to 500 hp motor efficiency shall be able NEMA MG 1 table 12-11 and International Energy Conservation Code table 405.8(1).

C. Subtype II motors – NEMA efficiency as per table NEMA MG 1 table 12-11 and International Energy Conservation code table 405.8(2). This shall apply to general purpose motors but can configured as U-frame motors; NEMA Design C motors; close-coupled pump motors; footless motors; vertical solid shaft normal thrust motors (as tested in a horizontal position); eight-pole (900 rpm) motors, and polyphase motors with a voltage of not more than 600 V (other than 230 or 460 V).

D. Minimum average full load efficiency of polyphase small electric motors up to 3 hp shall be in accordance with Table C405.8(3) of the International Energy Conservation Code

E. Minimum average full load efficiency for capacitor-start, capacitor-run and capacitor-start induction-run small electric motors up to 3 hp shall be in accordance with Table C405.8(4) of the International Energy Conservation Code.

2.4 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Service Factor: 1.15.

C. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

D. Multispeed Motors: Separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.Grease lubricated anti-friction ball bearings with housings equipped with plugged

provision for relubrication, rated for minimum AFBMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt centre line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

G. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay with wiring to terminal box.

H. Sound Power Levels: To NEMA MG 1.

I. Temperature Rise: Match insulation rating.

J. Insulation: Class B or better.

K. Code Letter Designation:

1. Motors [15] HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

L. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.5 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Use part winding Start above 254T Frame Size: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.

C. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

D. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.6 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.

3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, pre-lubricated sleeve ball bearings.

2.7 POWER FACTOR CORRECTION

A. Provide a capacitor for each three phase, single speed motor rated 3 HP or larger shall be provided to correct the full load power factor to 95%. The capacitor shall be mounted at the motor for connection across the motor terminals by Electrical Contractor

B. Capacitors;
1. Capacitors shall be totally enclosed, fused and with discharge resistors.
2. Capacitors based on nominal motor RPM shall be provided in accordance with the following table to correct power factor to 95% and verify sizes with motor manufacturer.

Motor HP	Capacitor KVAR 3600 RPM Motor	Capacitor KVAR 1800 RPM Motor
3	1.5	1.5
5	2	2
7.5	2.5	2.5
10	3	3
15	4	4
20	5	5
25	6	6
30	7	7
40	9	9
50	12	12
60	14	14

2.8 STARTERS

A. GENERAL

1. See specification Section 16485 and Division 1 for additional information.

2. Starters for motors operating at 120 volts shall be manual starters unless otherwise indicated. Starters for motors operating at other than 120 volts shall be magnetic starters.
3. All starters shall be enclosed. Enclosures shall be surface mounted NEMA 1 unless otherwise indicated.
4. Where weatherproof starters are required, the enclosure shall be NEMA 4.
5. It shall be verified that the correct overload heaters have been installed in the starter before energizing any motor. Sizing shall be based on motor nameplate current and taking into account any reduction in current due to power factor correction.
6. Alternate Manufacturers –
   a. Allen-Bradley
   b. Crouse-Hinds Co.
   c. Cutler-Hammer, Inc.
   d. General Electric Co.
   e. Square D Co.
   f. Westinghouse Electric Corp.

B. MANUAL STARTERS

1. Two-pole, toggle operated, thermal overload device in each phase leg, handle guard for padlocking toggle handle and with indicated control and signal devices.

2. Where a motor is controlled automatically by an interlock or pilot device, a "HAND-OFF-AUTO" switch shall be provided in the starter cover. Where the rating of the interlock or pilot device is inadequate to control the motor currents directly, a properly rated contactor shall be provided between the controlling device and the motor.

3. An "ON" pilot light shall be provided in the starter cover.

C. MAGNETIC STARTERS

1. Starters shall be sized in accordance with NEMA standards and the following table except that starters shall not be smaller than NEMA size 0. Starters shall be provided with one N.O. electrical holding interlock, under voltage protection and two additional auxiliary contacts within the same enclosure. NEMA size starters shall be provided as follows

STARTER SIZE	MAX HP AT 460 VOLTS
0	5
1	10
2	25

2. All starters shall be combination type with the starter and disconnect in the same enclosure. All starters shall be Type 2 coordination protected. Fuses shall be Bussman "Low Peak" type or equal sized at 125% of motor nameplate rating. Verify and coordinate requirements for fused disconnect switches with the Electrical Contractor prior to ordering starters.

3. Provide S.S.P.B. or H-O-A switches and pilot light in covers as required to facilitate control operation sequences.

D. CRITICAL FAULT

1. Where starters are not integral to equipment and are furnished and installed separately from equipment by the contractor, provide a 3 phase line voltage monitor by ICM Controls model 450 or approved equal. Unit shall be installed in the motor starter or in a separate enclosure with the same rating as the starter. It shall be arranged to monitor critical faults including phase loss or reversal, and when detected, de-energize the load. It shall monitor non-critical faults including high/low voltage, voltage unbalance and when detected, after a time delay de-energize the load.

PART 3 - EXECUTION

A. Suitable starting and controlling equipment and devices shall be furnished and installed as specified hereinafter and as shown on the Drawings. The starting equipment shall be arranged, generally, in control groups, or in certain cases, as isolated combination starters as specified or indicated. The Heating Ventilating and Air Conditioning Sequences of Operation, drawings and specifications shall be referred to for the manner of control, operation and monitoring of motors and the electrically operated equipment.

B. A starter and disconnect switch or combination motor starter disconnect shall be provided for every motor and each and every electrically operated piece of equipment by this contractor except where complete starters and controls are furnished by the manufacturer of the motor or piece of equipment. Starters shall be internally wired to provide the required control operation and monitoring. All control devices such as push buttons, break-glass stations, alternators, relays, pilot lights, etc., shall be provided as required for operation of mechanical equipment. All roof top and remotely located equipment shall have remote starters as located on plan and shall have local disconnect switches. All equipment located in equipment rooms can use combination starters/disconnects located with in line of site of controlled equipment. All starters and disconnect switches shall be in enclosures suitable for the environment in which they are installed. Starters and disconnect switches located in machine rooms shall use NEMA 1. Starters and disconnect switches located outdoors shall use NEMA 4x. Starters and disconnect switches located in machine rooms which are subject to potential water damage shall use NEMA 2

C. Starting equipment and devices specified in this section (and section 23 29 13 Variable Frequency Controllers), shall be furnished by the mechanical subcontractor and shall be installed by the Electrical subcontractor. In general, the mechanical subcontractor shall furnish all motor starters and disconnect switches except where they are an integral part of a motor control center, in this case starters and disconnects shall be provided, (furnished and installed), by the electrical contractor. The Electrical subcontractor shall also provide all wiring necessary to supply power to the electric motors specified under this section, including connections from the starters to the motors. Starters and disconnects shall also include variable frequency drives.

D. The mechanical Contractor shall furnish and install all wiring between control devices and controlled equipment furnished under this Section, including interlock control wiring between motor starters, and all automatic temperature control wiring. All wiring shall be installed in

conformance with applicable codes and the requirements of the Electrical Division of the Specifications.

E. The Electrical Contractor shall furnish a 120 volt power source to temperature control panels and equipment requiring a separate 120 volt control power source. Power for control circuits for all devices connecting to motor starters shall be obtained from 120-volt control transformers provided in each starter operating at other than 120 volts. Provide transformers for all low voltage control systems as required.

F. Furnish detailed composite wiring diagrams and such other information necessary to assure the proper connection, operation and control of motorized equipment, including interlocks, automatic controls, safety controls and all auxiliary circuits.

G. All control units shall be furnished with a nameplate indicating which device or equipment it controls, the voltage. Additional nameplates on each push button, selector switch and pilot light indicating their functions shall be provided. Nameplates shall be laminated phenolic with white letters on black background, minimum 2" high.

H. All motors supplied either with equipment or installed separately that are to be used in conjunction with variable frequency drive shall be inverter duty motors.

END OF SECTION 230513

SECTION 230517 - SLEEVES AND ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Escutcheons.
7. Floor plates.
8. Acoustic split seal rings

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

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

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

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

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

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

1. Advance Products & Systems, Inc.
2. Airex Manufacturing.
3. CALPICO, Inc.
4. Metraflex Company (The).
5. Link Seal

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

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

2.4 SLEEVE-SEAL FITTINGS

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

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

B. Description: Manufactured heavy rubber or EPDM, sleeve-to-pipe water stop assembly. Unit has rubber water stop collar with center opening to match piping OD. Connected with stainless steel hose clamps. Made for copper or plastic carrier pipes. Size up to 4” sleeve and 3” carrier pipe.

2.5 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

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

D. Packaging: Premixed and factory packaged.

2.6 ESCUTCHEONS

A. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

B. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

C. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

D. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.7 FLOOR PLATES

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

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

2.8 ACOUSTIC SPLIT SEAL RINGS

A. Acoustic Split Seals; consist of pipe halves with minimum 3/4" thick neoprene sponge cemented to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Grout seals to make it integral with the floor, wall or ceiling in masonry construction. Seals shall project a minimum of 1" past either face of the wall. Where temperatures exceed 240F, 10 lb. density fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

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

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

F. Install acoustic split seals on all piping connected to motor driven equipment that passes through Mechanical equipment room walls.

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

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

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

C. Coordinate the minimum size of sleeves with the pipe. Sleeves for plumbing piping shall be 2x the diameter of the service pipe.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water stop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

1. Exterior Concrete Walls above Grade:

    a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves Sleeve-seal fittings.
    b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves.

2. Exterior Concrete Walls below Grade:

    a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system Sleeve-seal fittings.

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

    b. Piping and Larger: Galvanized-steel wall sleeves with sleeve-seal system.

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

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system.

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

b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves with sleeve-seal system.

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

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves or Stack-sleeve fittings with Sleeve-seal fittings.
b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves or Stack-sleeve fittings.

5. Interior Partitions:

a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves

3.6 ESCUTCHEON INSTALLATION

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

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
f. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge or split-plate, stamped-steel type with exposed-rivet hinge.

2. Escutcheons for Existing Piping:(not used)

a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.

b. Insulated Piping: Split-plate, stamped-steel type with concealed or exposed-rivet hinge.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge.
f. Bare Piping in Equipment Rooms: Escutcheons not required
g.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.
2. Existing Piping: Split-casting, floor-plate type.

3.7 FIELD QUALITY CONTROL

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

END OF SECTION 230517.5

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SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Filled-system thermometers.
3. Liquid-in-glass thermometers.
4. Thermowells.
5. Dial-type pressure gages.
6. Gage attachments.
7. Test plugs.
8. Test-plug kits.

B. Related Sections:

1. Section 23 21 13 Hydronic Piping
2. Section 23 21 16 "Hydronic Piping Specialties"

1.3 ACTION SUBMITTALS

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

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

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 Thermometer Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Trerice, H. O. Co.
2. Watts; a Watts Water Technologies company.
3. Weiss Instruments, Inc.
4. Weksler Glass Thermometer Corp.

2.2 BIMETALLIC-ACTUATED THERMOMETERS

A. Standard: ASME B40.200.

B. Case: Liquid-filled and sealed type(s); stainless steel with 5-inch nominal diameter.

C. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F and deg C.

D. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.

E. Connector Size: 1/2 inch, with ASME B1.1 screw threads.

F. Stem: 0.25 or 0.375 inch in diameter; stainless steel.

G. Window: Plain glass.

H. Ring: Stainless steel.

I. Element: Bimetal coil.

J. Pointer: Dark-colored metal.

K. Accuracy: Plus or minus 1 percent of scale range.

2.3 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
1. Standard: ASME B40.200.
2. Case: Sealed type, cast aluminum or drawn steel; 5-inch nominal diameter.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
5. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
6. Pointer: Dark-colored metal.
7. Window: Glass.
8. Ring: Stainless steel.

9. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.
10. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

11. Accuracy: Plus or minus 1 percent of scale range.

2.4 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: Cast aluminum; 6-inch nominal size.
3. Case Form: Back angle unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
6. Window: Glass or plastic.
7. Stem: Aluminum or brass and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

8. Connector: 3/4 inch, with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle Back angle unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
6. Window: Glass.
7. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

8. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.5 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.6 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.7 PRESSURE GAGES

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

a. Trerice, H. O. Co.
b. Watts; a Watts Water Technologies company.
c. Weiss Instruments, Inc.
d. Weksler Glass Thermometer Corp.

B. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Standard: ASME B40.100.

2. Case: Liquid-filled Sealed Solid-front, pressure relief type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Metal.

10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

C. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: Liquid-filled Sealed type; cast aluminum or drawn steel; 4-1/2-inch nominal diameter with back flange and holes for panel mounting.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi psi and kPa.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Metal.
10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.8 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of brass or stainless-steel pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.9 TEST PLUGS

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

1. Trerice, H. O. Co.
2. Watts; a Watts Water Technologies company.
3. Weiss Instruments, Inc.
4. Weksler Glass Thermometer Corp.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Core Inserts: EPDM self-sealing rubber.

2.10 TEST-PLUG KITS

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

1. Sisco Manufacturing Company, Inc.
2. Trerice, H. O. Co.
3. Watts; a Watts Water Technologies company.
4. Weiss Instruments, Inc.

B. Furnish one test-plug kit(s) containing two thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig.

F. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids (except steam).

K. Install valve and syphon fitting in piping for each pressure gage for steam.

L. Install test plugs in piping tees.

M. Install flow indicators in piping systems in accessible positions for easy viewing.

N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

O. Install flowmeter elements in accessible positions in piping systems.

P. Install wafer-orifice flowmeter elements between pipe flanges.

Q. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

R. Install permanent indicators on walls or brackets in accessible and readable positions.

S. Install connection fittings in accessible locations for attachment to portable indicators.

T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

U. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Two inlets and two outlets of each chiller.
4. Inlet and outlet of each hydronic coil in air-handling units.
5. Two inlets and two outlets of each hydronic heat exchanger.
6. Inlet and outlet of each thermal-storage tank.
7. Outside-, return-, supply-, and mixed-air ducts at air handling units

V. Install pressure gages in the following locations:

1. Inlet and Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller, boiler, air handling unit, and pump
3. Domestic water makeup

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each **hydronic zone** shall be one of the following:

1. Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Test plug with EPDM self-sealing rubber inserts.
5. Industrial-style, liquid-in-glass type.

B. Industrial type, liquid in glass type thermometers shall be installed at all the inlets and outlets of each of the following equipment;
1. Hydronic boiler
2. Chiller
3. Air handling units
4. Provide test with EPDM self-sealing rubber inserts

C. Thermometers at inlet and outlet of each **hydronic coil in air-handling units or duct mounted** and built-up central systems shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Test plug with EPDM self-sealing rubber inserts.

D. Thermometers at inlet and outlet of each hydronic **heat-recovery unit** shall be the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct orRemote-mounted, metal-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.
4. Test plug with EPDM self-sealing rubber inserts.

E. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal-case, vapor-actuated type.
3. Compact or Industrial-style, liquid-in-glass type.

F. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 150 deg F.

B. Scale Range for Condenser-Water Piping: 0 to 150 deg F.

C. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F.

D. Scale Range for Steam and Steam-Condensate Piping: 0 to 250 deg F.

E. Scale Range for Air Ducts: 0 to 150 deg F.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at all the inlet and discharge connections of each of the following equipment shall be liquid filled and sealed direct mounting, metal case.
   1. Hydronic pumps
   2. Hydronic boiler
   3. Chiller
   4. Air handling and duct mounted units coils
   5. Provide test with EPDM self-sealing rubber inserts

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 200 psi.

B. Scale Range for Condenser-Water Piping: 0 to 150 psi.

C. Scale Range for Heating, Hot-Water Piping: 0 to 160 psi.

D. Scale Range for Steam Piping: 0 to 100 psi.

END OF SECTION 230519

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SECTION 230523.11 - VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bronze angle valves.
2. Globe valves.
3. Ball Valves
4. Butterfly Valves.
5. Check Valves
6. Gate Valves
7. Chainwheels.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle and globe valves closed to prevent rattling.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

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

C. Refer to HVAC valve schedule articles for applications of valves.

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

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

F. Valves in Insulated Piping:

1. Include 2-inchstem extensions.
2. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

G. Valve Actuator Types:

1. Gear Actuator: For valves NPS 8 and larger.
2. Handlever: For valves NPS 6 and smaller.
3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Valve Installation" Article.

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

a. Apollo Valves; Conbraco Industries, Inc.
b. Crane; Crane Energy Flow Solutions.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Stockham; Crane Energy Flow Solutions.
f. Watts; a Watts Water Technologies company.
g. Keystone

GLOBE VALVES

2.2 BRONZE GLOBE VALVES

A. Class 125 Bronze Globe Valves:

1. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem and Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 150 Bronze Globe Valves:

1. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Bronze or PTFE.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

2.3 IRON GLOBE VALVES

A. Class 125 Iron Globe Valves:
1. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.
g. Operator: Handwheel or chainwheel.

B. Class 250 Iron Globe Valves:
1. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 500 psig.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.

e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.
g. Operator: Handwheel or chainwheel.

BALL VALVES

2.4 BRASS BALL VALVES

A. One-Piece Brass Ball Valves:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 400 psig.
c. Body Design: One piece.
d. Body Material: Forged brass.
e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Brass.
h. Ball: Chrome-plated brass.
i. Port: Reduced.

B. Two-Piece Brass Ball Valves with Full Port and Brass Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full.

C. Two-Piece Brass Ball Valves with Full Port and Stainless-Steel Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

D. Two-Piece Brass Ball Valves with Regular Port and Brass Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Regular.

E. Two-Piece Brass Ball Valves with Regular Port and Stainless-Steel Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Brass or bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Regular.

2.5 BRONZE BALL VALVES

A. One-Piece Bronze Ball Valves with Bronze Trim:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 400 psig.
c. Body Design: One piece.
d. Body Material: Bronze.
e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Bronze.
h. Ball: Chrome-plated brass.
i. Port: Reduced.

B. One-Piece Bronze Ball Valves with Stainless-Steel Trim:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig.
c. Body Design: One piece.
d. Body Material: Bronze.

e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel, vented.
i. Port: Reduced.

C. Two-Piece Bronze Ball Valves with Full Port and Bronze or Brass Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full.

D. Two-Piece Bronze Ball Valves with Full Port and Stainless-Steel Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

E. Two-Piece Bronze Ball Valves with Regular Port and Bronze or Brass Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Regular.

F. Two-Piece Bronze Ball Valves with Regular Port and Stainless-Steel Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Regular.

2.6 IRON BALL VALVES

A. Class 125 Iron Ball Valves:
1. Description:

a. Standard: MSS SP-72.
b. CWP Rating: 200 psig.
c. Body Design: Split body.
d. Body Material: ASTM A 126, gray iron.
e. Ends: Flanged.
f. Seats: PTFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel.
i. Port: Full.

BUTTERFLY VALVES

2.7 DUCTILE-IRON, GROOVED-END BUTTERFLY VALVES

A. 175 CWP, Iron, Grooved-End Butterfly Valves:
1. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 175 psig.
c. Body Material: Coated, ductile iron.
d. Stem: Two-piece stainless steel.
e. Disc: Coated, ductile iron.
f. Seal: EPDM.

B. 300 CWP, Iron, Grooved-End Butterfly Valves:
1. Description:

a. Standard: MSS SP-67, Type I.
b. NPS 8 and Smaller CWP Rating: 300 psig.
c. NPS 10 and Larger CWP Rating: 200 psig.
d. Body Material: Coated, ductile iron.
e. Stem: Two-piece stainless steel.

f. Disc: Coated, ductile iron.
g. Seal: EPDM.

2.8 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance Butterfly Valves:
1. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 285 psig at 100 deg F.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: Carbon steel, **cast iron, ductile iron, or stainless steel. Match piping system**
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

B. Class 300, Single-Flange, High-Performance Butterfly Valves:
1. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 720 psig at 100 deg F.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material**: Carbon steel, cast iron, or ductile iron. Match piping system**
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

CHECK VALVES

2.9 BRONZE LIFT CHECK VALVES

A. Class 125 Lift Check Valves with Bronze Disc:
1. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Design: Vertical flow.
d. Body Material: ASTM B 61 or ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

B. Class 125 Lift Check Valves with Nonmetallic Disc:
1. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Design: Vertical flow.
d. Body Material: ASTM B 61 or ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: NBR or PTFE.

2.10 BRONZE SWING CHECK VALVES

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

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:
1. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: PTFE.

C. Class 150, Bronze Swing Check Valves with Bronze Disc:
1. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

D. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:
1. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: PTFE.

2.11 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:
   1. Description:

      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A 126, gray iron with bolted bonnet.
      f. Ends: Flanged.
      g. Trim: Bronze.
      h. Gasket: Asbestos free.

B. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:
   1. Description:

      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A 126, gray iron with bolted bonnet.
      f. Ends: Flanged.
      g. Trim: Composition.
      h. Seat Ring: Bronze.
      i. Disc Holder: Bronze.
      j. Disc: PTFE.
      k. Gasket: Asbestos free.

C. Class 250, Iron Swing Check Valves with Metal Seats:
   1. Description:

      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
      c. NPS 14 to NPS 24, CWP Rating: 300 psig.
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A 126, gray iron with bolted bonnet.
      f. Ends: Flanged.
      g. Trim: Bronze.
      h. Gasket: Asbestos free.

2.12 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
   1. Description:

      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Design: Clear or full waterway.

e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and spring.

2.13 IRON, CENTER-GUIDED CHECK VALVES

A. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron.
e. Style: Compact wafer.
f. Seat: NBR.

B. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
c. NPS 14 to NPS 24, CWP Rating: 250 psig.
d. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
e. Style: Compact wafer.
f. Seat: NBR.

C. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A 126, gray iron.
e. Style: Compact wafer, spring loaded.
f. Seat: [**EPDM**] [**or**] [**NBR**] <**Insert material**>.

GATE VALVES

A. Class 125, RS, Bronze Gate Valves:
1. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.

g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 150, RS, Bronze Gate Valves:
1. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

C. Class 125, OS&Y, Iron Gate Valves:
1. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

D. Class 250, OS&Y, Iron Gate Valves:
1. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

2.14 CHAINWHEELS

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

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to handwheels.

1. Sprocket Rim with Chain Guides: Ductile or cast iron Aluminum, of type and size required for valve.
2. Chain: Hot-dip-galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

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

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for valves NPS 6 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

G. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Throttling Service except Steam: Globe pattern valves.

B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.5 CHILLED-WATER VALVE SCHEDULE (shut off)

A. Pipe NPS 2 and Smaller: Bronze ball or globe valves, Class 150, bronze nonmetallic disc, with soldered or threaded ends.

B. Pipe NPS 2-1/2 and Larger: Iron globe valves, butterfly or gate valves Class 250 with flanged ends.

3.6 HEATING-WATER VALVE SCHEDULE (shut off)

A. Pipe NPS 2 and Smaller: Bronze ball or globe valves, Class 150, bronze nonmetallic disc, with soldered or threaded ends.

B. Pipe NPS 2-1/2 and Larger: Iron globe, butterfly or gate valves, Class 250 with flanged ends.

END OF SECTION 230523.11

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Fiberglass strut systems.
5. Thermal-hanger shield inserts.
6. Fastener systems.
7. Pipe stands.
8. Equipment supports.

B. Related Sections:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

3. Design seismic-restraint hangers and supports for piping and equipment.

1.5 ACTION SUBMITTALS

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

B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

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

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

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

    a. B-line, an Eaton business.
    b. Flex-Strut Inc.
    c. Thomas & Betts Corporation; A Member of the ABB Group.
    d. Unistrut; Part of Atkore International.
    e. Wesanco, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.

3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
7. Metallic Coating: Electroplated zinc, Hot-dipped galvanized, Mill galvanized, In-line, hot galvanized, or Mechanically-deposited zinc.
8. Paint Coating: Epoxy or Alkyd.
9. Plastic Coating: PVC or Polyurethane.
10. Combination Coating: .

B. Non-MFMA Manufacturer Metal Framing Systems:

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

    a. Anvil International.
    b. ERICO International Corporation.
    c. PHD Manufacturing, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.

3. Standard: Comply with MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
7. Coating: Zinc, Paint or PVC.

2.4 THERMAL-HANGER SHIELD INSERTS

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

1. Clement Support Services.
2. ERICO International Corporation.
3. National Pipe Hanger Corporation.
4. Pipe Shields Inc.
5. Piping Technology & Products, Inc.
6. Rilco Manufacturing Co., Inc.

B. Insulation-Insert Material for Hot and cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

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

2.6 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Stainless steel.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

C. Flashing;
Metal Flashing: 26gage galvanized steel.

1. Metal Counter-flashing: 22 gage thick galvanized steel.

2. Flexible Flashing: 47 mil thick sheet butyl or other material compatible with roofing. Verify with roofing manufacturer.

3. Caps: Steel, 22-gage minimum; 16 gage at fire resistant elements.

D. Sleeves:
1. Ductwork Sleeve 18 gauge Installation and Closure for Fire Rated Walls and Floors: Fire damper assembly with continuous angles on all sides as per NFPA-90A requirements.

2. Provide and install sleeves for all penetrations in accordance with Division 1.

E. Escutcheons;
1. Chrome plated cast brass escutcheons with set screws on all exposed piping at wall penetrations in finished spaces.

F. Hanger Rods:
1. Hanger Rods: Hot rolled steel threaded both ends, threaded one end, or continuous threaded. In accordance with the following schedule.

HANGER ROD SIZE SCHEDULE	
Pipe Size (in)	Min Rod Dia (in)
¾” to 2”	3/8”
½” to 3-1/2”	½”
4” to 5”	5/8”
6”	¾”
8” to 12”	7/8”
14”	1”
16” to 18”	1-1/8”
20”	1-1/4”
24”	1-1/2”
30”	1-7/8”

2. Hanger spacing shall be in accordance with the following schedule for maximum allowable distance. Provide hanger all changes in direction.

PIPE SUPPORT SPACING SCHEDULE		
Pipe Material/ Size (in)	Maximum Horizontal Spacing (ft)	Maximum Vertical Spacing (ft)
Steel		
Up to 1 ¼"	8	15
1 ½" to 2 ½"	10	15
3" and over	12	15
Copper Pipe	8	10
Copper Tubing		
Up to 1 ¼"	6	10
1 ½" and over	8	10
PVC / HDPE		
Up to 1"	3	10
1 1/4" and over	4	10

3. Fiberglass piping supports spacing shall be in accordance with the manufacture's guidelines.

2.9 VIBRATION ISOLATION HANGERS

A. Vibration isolation pipe hangers; pre-compressed and locked at the rated deflection by means of a resilient up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc.

2.10 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

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

F. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

G. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

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

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

J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

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

L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

O. Insulated Piping:

1. Attach clamps and spacers to piping.

a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.

b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles on all piping with roller hangers installed outside of insulation. Fill interior voids with insulation that matches adjoining insulation.

a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier not on roller hangers. Shields shall span an arc of 180 degrees.

a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
b. NPS 4: 12 inches long and 0.06 inch thick.
c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

2.11 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

2.12 METAL FABRICATIONS

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

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

2.13 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

2.14 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply cold galvanizing-repair paint to comply with ASTM A 780. ZRC cold galvanizing compound

2.15 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

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

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports or metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
5. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
6. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
7. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
8. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
9. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
10. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
11. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
12. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
13. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
14. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
15. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
9. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
10. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
11. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

12. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
13. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
9. Install vibration isolation hangers or supports on all piping connected to motor driven equipment for a distance of 20’ or the first two hangers.

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

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

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

2.16 MISCELLANEOUS:

A. Equipment bases and supports.
1. Provide housekeeping pads of concrete, minimum 4 inches thick and extending 6 inches beyond supported equipment. Champers edges all four side. Provide dowels into concrete floor for equipment that is seismically braced.
2. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment. Provide for all equipment, pumps, air handling units, etc.
3. Construct supports of steel members. Brace and fasten with flanges bolted to structure. Provide rigid anchors for pipes after vibration isolation components are installed.

B. Flashing;
   1. Provide flexible flashing and metal counter-flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
   2. Flash piping projecting above finished roof surface with prefabricated steel reinforced boot and counter flashing sleeve.

C. Sleeves;
   1. Sleeves are required for all piping passing through walls and/or slabs. Sleeve diameter to be large enough to accommodate insulated piping.
   2. Sleeves through interior non-fire rated walls are to have annular space between pipe and sleeve filled with materials specified in Division 1.
   3. Sleeves thru fire rated walls to have annular space filled with fire stopping wrapping strips and expanding caulking applied with a caulking gun for a minimum depth of 3" or in another manner suitable for the application as recommended by the manufacturer. See Division 1.

D. Escutcheons:
   1. Provide escutcheons on all wall pipe penetrations that are visible outside MER spaces. All escutcheons shall be chrome plated.

END OF SECTION 230529

SECTION 23 05 53 IDENTIFICATION FOR HVAC PIPING EQUIPMENT

PART 1 GENERAL

1.1 WORK INCLUDED

A. Identification of mechanical products installed under Division 23.

1.2 REFERENCES

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

1.3 SUBMITTALS

A. Submittals as per contract requirements.

B. See Division 1 list of wording, symbols, letter size, and color coding for mechanical identification.

C. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

D. Manufacturer's Instructions: Indicate installation instructions, special procedures, and installation.

E. Project Record Documents: Record actual locations of tagged valves; include valve tag numbers.

F. Valve Tag chart.

PART 2 PRODUCTS

2.1 NAMEPLATES, TAGS, MARKERS, ETC

A. Manufacturer: W.H. Brady Co., Signmark Div

B. Acceptable manufacturers offering equivalent products

1. Atlantic Engraving Company.
2. Seton Name Plate Co.
3. MSI Services
4. Substitutions as per Contract Requirements.

C. Description: Nameplates should be as specified in Division 1.

PART 3 EXECUTION

3.1 PREPARATION

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

B. Prepare surfaces in accordance with contract requirements.

3.2 INSTALLATION

A. Install tags, markers, etc. in conformance with Division 1.

B. Unless otherwise specified, color shall conform with ANSI/ASME A13.1

C. Install identifying devices after completion of coverings and painting.

D. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.

E. Install labels with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer. For unfinished cloth covering, apply paint primer before applying labels.

F. Install tags using corrosion resistant chain. Number tags consecutively by location.

G. Apply stencil painting in accordance with contract requirements.

H. Identify all equipment, including pumps, air handlers, air cooled condensers, boilers, chillers, pumps, packaged AC units, and hot water heater with nameplates. Small devices, such as in-line pumps, may be identified with metal tags. Identify service of all air handling units, ac units split and packaged units. I.E. Ground floor offices.

I. Identify control panels and major control components outside panels with nameplates.

J. Identify valves in main and branch piping with brass tags. Main shutoff valves for boiler shall be furnished with special wording as required by ASME IV HG 710.5 "Supply or Return Valve No. X - Do Not Close Without Also Closing Supply or Return Valve No. Y". Tags shall be provided for all new HVAC and related systems valves. Including; heating water, chilled water, CW make up, and drain.

K. Tag automatic controls, instruments, and relays. Key to control schematic.

L. Identify piping, concealed and exposed, with 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. Labeling shall be in conformance with OSHA and ANSI A13.1.

M. Identify all ductwork every 20’ with flow arrows and unit or air handler served as well as service, such as SUPPLY AIR, RETURN AIR, EXHAUST AIR. Etc

N. All smoke purge system components (including supply and exhaust ductwork) shall be clearly identified as such by stenciling the function and zone on the components, e.g. Smoke Purge Supply - Zone 2; Smoke Purge Exhaust - Zone 3; Smoke Damper No. 5;

etc. Stenciling shall be 6" high red letters located (every 10 feet along duct).

O. Identify all Smoke Dampers and Fire Dampers. All dampers shall be sequentially numbered by floor. For example, fire damper - FD-1-1 (Fire damper #1, floor 1) Tag shall be 1" high red letters located on damper. Provide red dot stencil on ceiling below damper.

P. Provide permanent labels for all controls and limits which state function of each control and control set-points.

3.3 SCHEDULE

A. Provide valve chart and schedule minimum of 8.5” x 11” in aluminum frame with clear laminate face. Install in the boiler room or at location as directed by the facilities. Indicate Valve #, size, Service and N.O. or N.C.

VALVE TAG SCHEDULE			
No.	size	Service	N.O./N.C.
1	2”	Hot water	NO
2			

END OF SECTION

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SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

a. Constant-volume air systems.
b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

a. Constant-flow hydronic systems.
b. Variable-flow hydronic systems.
c. Primary-secondary hydronic systems.

3. Testing, Adjusting, and Balancing Equipment:
a. Fans.
b. Air handling unit
c. Gas fired roof top units.
d. Supplemental AC units
e. Heating and ventilating units
f. Motors.
g. Chillers.
h. Boilers.
i. Pumps
j. Heat-transfer coils. Heating and cooling
k. VAV boxes
l. Diffusers, registers, and grilles
m. Louvers and dampers
n. Fin tube radiation
o. Air coils
p. Unit and cabinet heater, convectors
4. Duct leakage tests.
5. Control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

G. TDH: Total dynamic head.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: If requested by the engineer, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

a. The Contract Documents examination report.
b. The TAB plans.
c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.5 ACTION SUBMITTALS

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Certified TAB reports.

D. Sample report forms.

E. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.7 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by AABC or NEBB as a TAB technician.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

1.8 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with terminals installed.
c. Water treatment is complete.
d. Systems are flushed, filled, and air purged.
e. Strainers are pulled and cleaned.
f. Control valves are functioning per the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" ASHRAE 111 NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR ALL SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

M. Code requirements;

Each supply air outlet and zone terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the International Mechanical Code. Discharge dampers used for air-system balancing are prohibited on constant-volume fans and variable volume fans with motors 10 hp and larger. Air systems shall be balanced in a manner to first minimize throttling losses then, for fans with system power greater than 10 hp, fan speed shall be adjusted to meet design flow conditions.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.
    e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
    f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
    g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
    c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

6. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.

b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:

a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
b. Re-measure and confirm that total airflow is within design.
c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
d. Mark final settings.
e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
f. Verify tracking between supply and return fans.

3.7 GENERAL PROCEDURES FOR ALL HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

D. Code requirements;
1. Individual hydronic heating and cooling coils shall be equipped with means for balancing and measuring flow. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses, then the pump impeller shall be trimmed **or** pump speed shall be adjusted to meet design flow conditions. Each hydronic system shall have the capability to measure pressure across the pumps, and test ports at each side of each pump.

2. For systems 10 Hp and over, where triple duty valves are indicated on the discharge side of pumps, balancing shall be performed by adjusting pump speed at the variable frequency drive. The balance or throttle valves shall be used for positive shut off, check and as a means of reading flow across the ports.
3. Flow shall be balanced to total gpm given in the schedule for the pump and branch gpm as given on plan. Total dynamic head, (TDH), given in the plans and schedule or specifications is an estimate. The system shall be balanced such that the required flow is achieved by adjusting pump speed and branch balancing valves as well as terminal unit balancing valves. Upon balancing the actual required TDH can be established. This shall be used as the design set point used to modulate pump speed.

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.

1. Measure total water flow.

   a. Position valves for full flow through coils.
   b. Measure flow by main flow meter, if installed.
   c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

   a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
   b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
   c. Convert pressure to head and correct for differences in gage heights.
   d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
   e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.

4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no diversity:

1. Adjust pumps to deliver total design gpm.

a. Measure total water flow.

1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.

2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gage heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

a. Measure differential pressure and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system differential-pressure set point.
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:

a. Re-measure and confirm that total water flow is within design.
b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.

c. Mark final settings.

10. Verify that memory stops have been set.

D. For systems with diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
3. Adjust pumps to deliver total design gpm.

a. Measure total water flow.

1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gage heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

a. Measure differential pressure, and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

a. Re-measure and confirm that total water flow is within design.
b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
c. Mark final settings.

13. Verify that memory stops have been set.

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first.

B. Balance the secondary circuits after the primary circuits are complete.

C. Adjust pumps to deliver total design gpm.

1. Measure total water flow.

a. Position valves for full flow through coils.
b. Measure flow by main flow meter, if installed.
c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
c. Convert pressure to head and correct for differences in gage heights.

d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

D. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

E. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

F. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

G. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

H. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

I. Verify that memory stops have been set.

3.11 PROCEDURES FOR HEAT EXCHANGERS

A. Adjust water flow to within specified tolerances.

B. Measure inlet and outlet water temperatures.

C. Measure inlet steam pressure.

D. Check settings and operation of safety and relief valves. Record settings.

3.12 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.13 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
6. Capacity: Calculate in tons of cooling.
7. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.14 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record fan and motor operating data.

3.15 PROCEDURES FOR BOILERS

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Record relief valve pressure setting.

3.16 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.17 SOUND TESTS

A. After the systems are balanced and construction is Substantially Complete, measure and record sound levels at 5 locations as designated by the Architect.

B. Instrumentation:

1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (LEQ).
3. The sound-testing meter must be capable of using 1/3 octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
2. Equipment should be operating at design values.
3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) 31.5 Hz to 4000 Hz (RC) with the equipment off.
6. Take sound readings in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) 31.5 Hz to 4000 Hz (RC) with the equipment operating.
7. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 60 inches from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:

   a. Location.
   b. System tested.
   c. dBA reading.
   d. Sound pressure level in each octave band with equipment on and off.

2. Plot sound pressure levels on NC and RC worksheet with equipment on and off.

E. Equipment included for sound testing.
1. Chillers
2. All roof top air handling units and furnaces.

3.18 DUCT LEAKAGE TESTS

A. Ducts designed to operate at static pressures in excess of 3 inches w.g. shall be sealed in accordance with specifications Section 23 31 13 Metal Ducts. In addition, ducts and plenums shall be leak tested in accordance with the procedures given SMACNA ***HVAC Air Duct Leakage Test Manual.*** Air leakage rates must *(CL)* less than or equal to 4.0 as determined in accordance with Equations below
1. $CL=F/P^{0.65}$ where:

2. *F* -The measured leakage rate in cfm per 100 square feet of duct surface.
3. *P* -The static pressure of the test.

B. Documentation shall be furnished by the test and balancing contractor demonstrating that representative sections totaling at least 25 percent of the duct area have been tested and that all tested sections meet the requirements of this section.

C. Perform duct pressure testing in coordination with Installer.

D. Verify that proper test methods are used and that leakage rates are within specified tolerances.

E. Report; submit a report indicating which ductwork sections were tested. Provide single line or double line duct submittal drawing. The drawing shall indicate all systems in their entirety to 3/8' =1'-0" scale. Sections that air leakage tested shall be clearly indicated.

F. The report shall include full test procedure including how the ductwork was isolated for pressure testing, the pressure of the test and the duration of the test.

G. Submit duct pressure test procedures used for this project.

H. Submit summary of test results on a section by section basis, to include all CL, F,P and time.

I. Witness the duct pressure testing performed by Installer.

J. Verify that proper test methods are used and that leakage rates are within specified tolerances.

K. Report deficiencies observed.

3.19 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.20 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.21 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.22 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.

3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.

g. Discharge arrangement.
h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. Outdoor airflow in cfm.
j. Return airflow in cfm.
k. Outdoor-air damper position.
l. Return-air damper position.
m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.

d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. Gas- Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

    a. System identification.
    b. Location.
    c. Coil identification.
    d. Capacity in Btu/h.
    e. Number of stages.
    f. Connected volts, phase, and hertz.
    g. Rated amperage.
    h. Airflow rate in cfm.
    i. Face area in sq. ft..
    j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

    a. Heat output in Btu/h.
    b. Airflow rate in cfm.
    c. Air velocity in fpm.
    d. Entering-air temperature in deg F.
    e. Leaving-air temperature in deg F.
    f. Voltage at each connection.
    g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

    a. System identification.
    b. Location.
    c. Make and type.
    d. Model number and size.
    e. Manufacturer's serial number.
    f. Arrangement and class.
    g. Sheave make, size in inches, and bore.
    h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

    a. Motor make, and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
    g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

K. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

N. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.23 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of commissioning authority.

B. Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.

F. Prepare test and inspection reports.

3.24 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

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SECTION 23 07 13 - HVAC DUCTWORK INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Ductwork insulation.

B. Duct Liner.

C. Insulation jackets.

1.02 RELATED SECTIONS

A. Section 23 05 53 - Identification for HVAC Piping and Equipment.

B. Section 23 31 13 - Ductwork.

1.03 REFERENCES

A. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

B. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.

C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

D. NAIMA National Insulation Standards.

E. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.

F. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

G. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

H. ASHRAE 90-75 – Insulation Standards

1.04 SUBMITTALS

A. Division 1 - Submittals: Procedures for submittals.

B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

C. Submit manufacturers' insulation instructions under provisions of Division 1.

1.05 QUALITY ASSURANCE

A. Applicator Qualifications: Company specializing in performing the work of this section with minimum three years experience approved by manufacturer.

1.06 REGULATORY REQUIREMENTS

A. Materials: Flame spread/fuel contributed/smoke developed rating of 25/50/50 in accordance with NFPA 255.

B. Insulation thickness shall comply with all applicable energy conservation codes.

1.07 ENVIRONMENTAL REQUIREMENTS

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

2.01 ACCEPTABLE MANUFACTURERS - INSULATION

A. Owen Corning Fiberglass Corp.

B. Manville Industrial Products

C. Certain Teed Corporation

D. 3M Corporation “Firemaster” for Kitchen Exhaust

E. Substitutions: Under provisions of Division 1.

2.02 GLASS FIBER, RIGID

A. Type A: Flexible glass fiber duct insulation; ANSI/ASTM C612; commercial grade; “K” value of 0.25 at 75º F; minimum density of 1-1/2 pounds per cu. ft.; factory applied vapor barrier jacket of 0.7 mil minimum aluminum foil laminated to glass fiber reinforced Kraft paper. Similar to Owens-Corning type FRK-25-ED Type 150 commercial grade.

B. Type B: Rigid glass fiber board insulation with resin binder; ANSI/ASTM C612, Class 1; “K” value of 0.23 at 75º F minimum density of 6 pounds per cu. ft; factory applied white Kraft faced flame retardant vapor barrier jacket of aluminum laminated to heavy Kraft paper with a flame retardant snuffer type adhesive and reinforced with glass fibers; permeability of 0.2. Similar to Owens-Corning type 705 with AST jacket.

C. Type C: Molded block or board insulation made of asbestos free hydrous calcium silicate; “K” value of 0.42 at 200º F; minimum density of 14 pounds per cubic foot; temperature range up to 1200º F.

D. Type D1: **Flexible Glass Duct Liner:** (**For standard applications**)

ANSI/ASTM C553; “K” value of 0.23 at 75º F; minimum density of 1.5 pounds per cu. ft.; surface finish of black pigmented fire resistant resilient mastic coated on air side for maximum velocity of 4000 feet per minute.

a. Maximum Thermal Conductivity

1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

b. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

c. Solvent Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

E Type D2: **Flexible Elastomeric Duct Liner:** (**Wet Or Damp Applications Including Natatorium And Saunas**).

Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
2. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

F. Type “E” – Fire resistant duct wrap consisting of light weight, non-asbestos high temperature non-organic ceramic fiber blanket encapsulated in foil/scrim having a service temperature rating of 2300º F. Wrap shall be applied in two temperature layers to provide a two-hour rated enclosure assembly. Bonding material shall be 304 stainless steel, ¾” wide and .015” thick.

G Adhesives: Waterproof fire-retardant type. Smoke and flame spread rating less then 50.

H. Indoor Jacket: Pre-sized glass cloth, minimum 7.8 oz/sq. yd unless otherwise specified above.

I. Outdoor Jackets: All exterior ductwork shall be jacketed as per the specification and jacket with Alumaguard Cool Wrap by Polyguard. For watertight insulation jacket install as per manufacturers recommendations. Furnish all mastics and adhesives as per manufacture system.

PART 3 EXECUTION

3.01 EXAMINATION

A. Install insulation materials only after ductwork has been sealed, tested and approved.

B. All insulated surfaces are to be cleaned and dried of any foreign material. This includes but is not limited to oil, water, dirt, rust and scale. Completely cover the entire surface to present a tight, smooth appearance.

3.02 INSTALLATION

A. Division 1 - Quality Control: Install materials in accordance with manufacturer's instructions, specification requirements and in compliance with local code

B. Install in accordance with NAIMA National Insulation Standards.

C. Apply insulation in such a way as to permit expansion and/or contraction of metal without causing damage to insulation, joints, seams or finish.

D. Do not apply additional coats of mastic, adhesive, or sealers until previous coats have thoroughly dried.

E. Fill in all surface imperfections such as chipped edges, small joints, cracks, holes and small voids with materials o match insulation. Make smooth with a skim coat of insulation cement. Extend surface finish to protect all surfaces and leave no exposed edges.

F. Provide flashing for insulation installed outdoors to enclose all exposed edges or ends.

G. Repair existing insulation where damaged by new work. Use materials to match existing.

H. Cut, score or miter insulation to fit the slope and contour of surface to be covered. Insulation up to 3 inches thick to be applied in single layer. Over 3 inches apply in multiple layers, with joints staggered.

Service	**Type**	**Insulation Thickness**
[1]Interior H&V, AC systems; SA, RA & EA, ductwork that is exposed in equip rooms.	B	1-1/2"
[1]Interior H&V, AC systems; SA, RA & EA including flexible run outs, that is concealed.	A	2"
Outside air intake ductwork All	B	1 1/2"
[2]Exterior H&V, AC systems; SA, RA & RA, ductwork that that is exposed outdoors.	B	2”
Acoustically line all SA & RA ductwork For a distance of 20’ from fan inlet and outlet and 10’ downstream of all VAV boxes.	D1/D2	1/2”
[5]Interior exposed H&V, AC systems; SA, RA located in conditioned spaces rectangular, spiral round or oval ductwork;		
Located in conditioned space	D1/D2	1 "
Located in unconditioned space, plenum or equipment room.	D1/D2	11/2”

[4]Smoke purge exhaust and supply	E	2” (not used)
All Stair pressure ductwork	E	2” (not used)
Generator exhaust pipe and muffler	C	2” (not used)
Kitchen hood exhaust (grease duct)	E	2” applied in (2) 1” layers.

1. Reduce external insulation to 1” for internally lined ductwork except for outdoor installations. On outdoor installations insulation thickness shall be as scheduled but not less than the height of standing seams or angle bracing.
2. Insulation Thickness shall be no less than the size indicated or the height of standing seams or angle bracing.
3. Outside air intake and Kitchen exhaust ducts shall not be internally lined.
4. Smoke purge system supply and exhaust ducts passing through a rated Exit-way or within a fire-rated suspended ceiling assembly and all Kitchen Hood exhaust ducts shall be wrapped with thermal fiber - two (2) hour or encased in a two (2) hour rated enclosure. Trapeze hangers to be outside of thermal wrapping.
5. All square or rectangular ductwork that is exposed to view in finished spaces shall be internally insulated.
6. All exterior ductwork shall be insulated and jacketed.

END OF SECTION

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SECTION 23 07 16 HVAC EQUIPMENT INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Equipment insulation
B. Covering
C. Breeching insulation

1.02 RELATED SECTIONS

A. Section 23 05 53 – Identification for HVAC Piping and Equipment.

B. Section 23 21 13 - Hydronic Piping.

C. Section 23 23 00 - Refrigerant Piping and Specialties.

1.03 REFERENCES

A. ASHRAE 90-75 – Insulation Standards

B. ASTM C195 – Standard Specification for Mineral Fiber Thermal Insulation Cement.

C. ASTM C533 – Standard Specification for Calcium Silicate Block and Pipe Thermal

D. ASTM C552 – Standard Specification for Cellular Glass Thermal Insulation.

E. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

F. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.

G. ASTM C921 - Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.

H. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

I. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.

J. NAIMA National Insulation Standards.

K. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.

L. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.04 SUBMITTALS FOR REVIEW

A. Division 1 – Submittal Requirements.

B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for equipment scheduled.

C. Manufacturer's Instructions: Indicate installation procedures which ensure acceptable workmanship and installation standards will be achieved.

1.1 ACTION SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail removable insulation at equipment connections.
2. Detail application of field-applied jackets.
3. Detail application at linkages of control devices.
4. Detail field application for each equipment type.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.06 REGULATORY REQUIREMENTS

A. Materials: Flame spread/fuel contributed/smoke developed rating of 25/50/50 in accordance with NFPA 255.

B. Insulation thickness shall comply with applicable energy conservation codes.

1.07 DELIVERY, STORAGE, AND PROTECTION

A. Division 1 - Material and Equipment: Transport, handle, store, and protect products.

B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

C. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.08 ENVIRONMENTAL REQUIREMENTS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Owens Corning Fiberglass Corp.
B. Certain Teed Corporation
C. Manville Industrial Products.
D. Substitutions: Under provisions of Section 01630.

2.02 INSULATION

A. Type A: Flexible glass fiber blanket; ANSI/ASTM C553; ‘k’ value of 0.23 at 75º F, 3.5 lb/cu feet density. Temperature range - 35º F to 250º F.

B. Type B: Rigid glass fiber board; ANSI/ASTM C612; ‘k’ value of 0.24 at 75º F, 6.0 lb/cu feet. Temperature range - 35º F to 250º F.

C. Type C: Elastomeric insulation; ASTM C518, C177; 'K' Value of 0.27 at 75°F; non-combustible. Similar to Armstrong “AP Armaflex”; temperature range -40º F to 220º F.

2.03 ACCESSORIES

A. Bedding Compounds: Non-shrinking, permanently flexible, compatible with insulation

B. Vapor Barrier Coating: Non-flammable, fire resistant, polymeric resin, compatible with insulation.

C. Insulating Cement: ANSI/ASTM C195, hydraulic setting mineral wool

D. Wire Mesh: Corrosive-resistant metal; hexagonal pattern.

2.04 ADHESIVES

C. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

D. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F
1. Adhesive: As recommended by cellular glass manufacturer and with a VOC content of 80 g/L or less.
2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

E. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Adhesive: As recommended by Adhesive - PVC Jacket manufacturer and with a VOC content of 50 g/L or less.

2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.05 MASTICS AND COATINGS

F. Materials shall be compatible with insulation materials, jackets, and substrates.

1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.
2. Mastics shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.06 LAGGING ADHESIVES

G. Adhesives shall comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
1. Adhesive shall be as recommended by insulation manufacturer and shall have a VOC content of Insert value g/L or less.
2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
4. Service Temperature Range: 20 to plus 180 deg F Color: White.

2.07 SEALANTS

H. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

I. Joint Sealants:
1. Permanently flexible, elastomeric sealant.
2. Service Temperature Range: Minus 58 to plus 176 deg F.
3. Color: White or gray.
4. Sealant shall have a VOC content of 420 g/L or less.
5. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that equipment has been tested before applying insulation materials.

B. Clean and dry all surfaces to be insulated of all foreign material. This includes but is not limited to water, oil, dirt, rust, and scale.

3.02 INSTALLATION

A. Install materials in accordance with manufacturer's instruction, specification requirements and in compliance with local code.

B. Only insulation and finish materials including adhesives, cements, and mastics which conform to the requirements of all governing codes & ordinances shall be used.

C. Factory Insulated Equipment: Do not insulate.

D. Exposed Equipment: Locate insulation and cover seams in least visible locations. Insulate expansion tanks, pumps, pot feeders etc.

E. Apply insulation as close as possible to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands. Insulation shall be applied in single layers up to 3 inches thick; over 3 inches thick it shall be applied in multiple layers.

F. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement. The surface finish shall be extended to protect all insulation surfaces. No raw edges or ends shall be left exposed.

G. Insulated equipment containing fluids below ambient temperature: Insulate entire system.

H. Cover insulation with metal mesh and finish with heavy coat of insulating cement.

I. Insulation shall be applied in such a way as to permit expansion or contraction of metal without causing damage to insulation or surface finish. Seal or cement shall not be applied until all previous application of cements and adhesives have thoroughly dried.

J. Vapor barrier finishes shall not be stapled through.

K. Clean and dry all surfaces to be insulated of rust, scale, dirt, oil, water and other foreign matter. Apply insulation to completely cover metal surface. Surface finish shall be applied to present a tight, smooth appearance.

L. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.

M. Equipment Requiring Access for Maintenance, Repair, Cleaning: Install insulation so it can be easily removed and replaced without damage.

N. Insulate all pumps with type C insulation. Fabricate custom aluminum sheet metal enclosure around pump body and fittings. Cut and fit insulation to tightly fit the size and shape of the pump body parts including the volute and inlet and outlet piping and fittings. The enclosure shall be removable with out cutting or breaking the insulation. The enclosure shall be vapor tight to prevent condensation.

3.03 SCHEDULES

EQUIPMENT	INSULATION TYPE	THICKNESS
Air Handler Components and Fans, Not Factory insulated including coil & filter sections	B or C	1.5"
Return fans	B or C	1.5”
Expansion Tanks/Chemical Feed Tanks and heat exchangers All Specialties valves, air separators	C	1.5"
Boilers Factory Installed Jackets Factory Installed Jackets	B	2”
Pumps Body and Parts.	C	2”

END OF SECTION

SECTION 23 07 19 HVAC PIPING INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Piping insulation

B. Jackets and accessories

1.02 RELATED SECTIONS

A. Section 23 05 53 – Identification for HVAC Piping and Equipment.

B. Section 23 21 13 - Hydronic Piping.

1.03 REFERENCES

A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus

B. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.

C. ASTM C449/C449M - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement

D. ASTM C518 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

E. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.

F. ASTM C547 - Standard Specification for Mineral Fiber Preformed Pipe Insulation

G. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation.

H. ASTM C578 - Standard Specification for Preformed, Cellular Polystyrene Thermal Insulation

I. ASTM C610 - Standard Specification for Expanded Perlite Block and Pipe Thermal Insulation

J. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials

K. NAIMA National Insulation Standards

L. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials

M. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

N. ASHRAE 90-75 - Insulation Standards

1.04 SUBMITTALS FOR REVIEW

A. Division 1 – Submittal Requirements.

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.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years experience.

1.06 REGULATORY REQUIREMENTS

A. Conform to maximum flame spread/smoke developed rating of 25/50 in accordance with NFPA 255

B. Insulation thickness shall comply with applicable Energy Conservation Codes.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Pittsburgh Corning Corporation

B. Certainteed Corporation.

C. Armstrong Corporation.

D. Manville Industrial Products.

E. Owens-Corning Fiberglass Corporation

F. Polyguard

2.02 INSULATION

A. Type A: Molded glass fiber insulation; ANSI/ASTM C547; 'k' value of 0.23 at 75º F; noncombustible. Minimum density of 3.5 lbs./cu. Ft.; temperature range 35º F to 450º F.

B. Type B: Cellular glass insulation; ASTM C552; 'K' Value of 0.53 at 75°F; non-combustible. Minimum density of 8.0 lbs./cu. ft. similar to Pittsburgh Corning Foamglas.

C. Type C: Elastomeric insulation; ASTM C518, C177; 'K' Value of 0.27 at 75°F; non-combustible. Similar to Armstrong “AP Armaflex”; temperature range -40º F to 220º F

D. Type D; Underground engineered pipe insulation system shall be as follows;
Service pipe insulation shall be spray applied .16k-factor, R141B blowing agent, nominal 2 pound per cubic foot density, polyurethane foam for straight sections and preformed polyurethane foam for all fittings. Insulation shall not be less then 2" and shall be Perma-pipe polytherm

2.03 JACKETS

A. Interior Applications:

1. Insulation Type A - Factory applied, white, flame retardant, all service (ASJ) vapor barrier jacket of .001" aluminum foil laminated to Kraft paper with a flame retardant snuffer type adhesive reinforced with glass fibers and having a self sealing lap. Provide 2" longitudinal lap and 4" circumferential sealing strips. Permeability .02 perm.

B. Exterior Applications: Outdoor Jackets:

1. Insulation Type A thickness as scheduled with ASJ vapor barrior jacket - Cover factory interior jacket with Alumaguard Cool Wrap by Polyguard. Rubberized bitumen membrane designed specifically to be installed over insulation on exterior piping, tanks, vessels, and equipment. The membrane shall be 'peel and stick', self-healing if punctured, UV stable, and will expand and contract with the mechanical system. All seams shall be sealed water tight. Permeability .0053 perm

C. Piping exposed in Mechanical Rooms or any space:

1. All exposed piping and fittings shall be completely covered with white Zeston 2000 PVC insulated piping and fitting covers. Apply as per manufacturer with perma weld adhesive.

D. Underground applications: (not used)

All straight sections of the insulated piping system shall be filament wound, polyester resin/fiberglass reinforcement composite directly applied on the insulating foam. The jacket shall be either filament wind fiberglass directly onto the polyurethane foam or injected foam into a fiberglass outer casing.
Fiberglass outer casing shall be A.O. Smith Red Thread or Ameron Bondstrand 3000. Thermoplastic casing material that are not rated for temperatures above 140 degrees F will not be allowed, e.g., PVC or HDPE. The minimum thickness for FRP jacket shall be as 0.55"

2.04 ACCESSORIES

A. Insulation Bands: ¾" wide; 0.007-inch-thick aluminum.

B. Metal Jacket Bands: 3/8" wide; 0.015-inch-thick aluminum.

C. Insulating Cement: ANSI/ASTM C195; hydraulic setting mineral wool.

D. Finishing Cement: ASTM C449

E. Fibrous Glass Cloth: Untreated; 9 oz/sq. yd weight.

F. Adhesives: Compatible with insulation and fire retardant.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that piping has been tested before applying insulation materials.

B. Verify that surfaces are clean and dry, with all foreign material removed. This includes but is not limited to water, oil, dirt, scale and rust.

D. Only insulation and finish materials including adhesive cements and mastic which conform to the requirements of all-governing codes and ordinances shall be used.

3.02 INSTALLATION

A. Division 1 – Quality Control: Install materials in accordance with manufacturer's instructions and the best practice of the trade.

B. Install in accordance with NAIMA National Insulation Standards.

C. Insulation on all piping shall be vapor sealed. On insulated piping with vapor barrier, insulate all fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints. Vapor seal all exposed edges with jacket material and vapor barrier type adhesive.

D. Repair or replace any existing insulation and surface finish disturbed or damaged by installation of new work using materials to match existing.

E. Apply insulation to completely cover metal surface. Surface shall be applied to present a tight, smooth appearance.

F. Exposed Piping: Locate insulation and cover seams in least visible locations.

G. For hot piping conveying fluids 140 degrees F or less, and on insulated piping without vapor barrier, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

H. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.

I. Neatly finish insulation at supports, protrusions, and interruptions.

J. Do not use staples on vapor barrier insulation.

K. Jackets:

1. Indoor, Concealed Applications: Insulated pipes conveying fluids above ambient temperature shall have standard jackets, with vapor barrier, factory-applied or field-applied. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass cloth and adhesive. PVC jackets may be used
2. Indoor, Concealed Applications: Insulated dual-temperature pipes or pipes conveying fluids below ambient temperature shall have vapor barrier jackets, factory-applied. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe, and finish with glass cloth and vapor barrier adhesive.
3. Indoor, Exposed Applications: For pipe exposed in mechanical equipment rooms or in finished spaces, insulate and jacket as for concealed applications, and finish with PVC jackets.
4. Outdoor Applications: Cover with .016" aluminum jacket with 2" overlap at seams and joints. Lay joints downward to shed water. Secure with 3/8" seals and straps at joints and aluminum bands on 8" centers between joints.

L. Inserts and Shields:

1. Application: All insulated Piping 2 inches diameter or larger shall be installed with inserts and shields as follows.
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.

M. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions.

3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

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

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

1. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems."

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe

insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

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

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

3.05 INSULATION SCHEDULE

Refer to the insulation schedule below for pipe insulation thickness by system. Not all systems are necessarily included in this project

INSULATION SCHEDULE							
SERVICE	INSULATION TYPE	TEMPERATURE RANGE (F°)	NOMINAL PIPE SIZE				
			<1"	1" to< 1 1/2"	1 1/2" to< 4"	4" to< 8"	≥ 8"
			INSULATION THICKNESS				
Hot Water (HW)	A	> 350°	4 1/2	5	5	5	5
		251°-350°	3	4	4	4 1/2	4 1/2
		201°-250°	2 1/2	2 1/2	2 1/2	3	3
		141°-200°	1 1/2	1 1/2	2	2	2
		105°-140°	1	1	1 1/2	1 1/2	1 1/2
Buried (HW)	C	> 350°	4 1/2	5	5	5	5
		251°-350°	3	4	4	4 1/2	4 1/2
		201°-250°	2 1/2	2 1/2	2 1/2	3	3
		141°-200°	2	2	2 1/2	2 1/2	2 1/2
		105°-140°	1 1/2	1 1/2	2	2	2
Chilled Water (CHW)	A	40°- 60°	1/2	1/2	1	1	1
		< 40°	1/2	1	1	1	1
Buried (CHW)	C	40°- 60°	1	1 1/2	1 1/2	1 1/2	1 1/2
		< 40°	1	1 1/2	1 1/2	1 1/2	1 1/2
Steam & Condensate	A	Low Pressure	2 1/2	2 1/2	2 1/2	3	3
Steam Condensate	A	Low Pressure	2 1/2	2 1/2	2 1/2	3	3
Condensate Drains	A	All	1/2	1/2	1	1	1
Cold Water Make up	A	All	1/2	1/2	1	1	1
Refrigerant Hot Gas	C	All	1 1/2	1 1/2	2	2	2
Humidifier Steam	A	All	2 1/2	2 1/2	2 1/2	3	3
Refrigerant Suction	C	All	1/2	1/2	1	1	1

END OF SECTION

SECTION 23 09 01 – DIRECT DIGITAL CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. These basic Mechanical Requirements apply to all Division 23Sections.

B. 1.2 The work of this Section consists of providing of all materials, labor and equipment and the like necessary and/or required for the complete execution of all mechanical for this project, as required by the contract documents.

1.2 Qualifications of Bidder

A. All bidders must be building automation contractors in the business of installing direct digital control building automation systems for a minimum of 5 years.

B. All bidders must have a service and installation office in the Westchester area.

C. All bidders must be authorized distributors or branch offices of the manufacturers specified.

D. All bidders must have a trained staff of application engineers, who have been certified by the manufacturer in the configuration, programming and service of the automation system.

E. Manufacturers: Subject to compliance with requirements, provide products by the following pre-qualified manufacture:
   1. Andover Controls Corporation

1.3 Scope of Work

A. Except as otherwise noted, the control system shall consist of all Ethernet Network Controllers, Standalone Digital Control Units, software, sensors, transducers, relays, valves, dampers, valve and damper operators, control panels, and other accessory equipment, along with a complete system of electrical interlocking wiring to fill the intent of the specification and provide for a complete and operable system. Unless otherwise specified, provide operators for equipment such as dampers and valves if the equipment manufacturer does not provide these. Coordinate requirements with the mechanical contractors.

B. The Building Automation System (BAS) contractor shall review and study all HVAC drawings and the entire specification to familiarize himself with the equipment and system operation, and to verify the quantities and types of dampers, operators, alarms, controllers etc. to be provided. ALL NEW TEMPERATURE CONTROLS EQUIPMENT SHALL BE ANDOVER CONTINUUM SERIES VERSION 1.9. OR LATER.

C. All interlocking, wiring and installation of control devices associated with the equipment listed below shall be provided under this Contract. When the BAS system is fully installed and operational, the BAS Contractor and representatives of the Owner will review and check out the system. At that time, the BAS contractor shall demonstrate the operation of the system and prove that it complies with the intent of the drawings and specifications.

D. The Contractor shall furnish and install a complete building automation system including all necessary hardware, network wiring, all operating applications software, and all programming necessary to perform the control sequences of operation as called for in the specifications. The scope of work shall include control over and graphic representation all new mechanical and plumbing equipment installed as part of this project.

E. At a minimum, provide controls for the following:
1. Roof top H&V units
2. Roof top air conditioning units
3. Indoor H&V units
4. Unit heaters – gas and hot water
5. Convectors
6. Fin tube radiation
7. Indoor air handling units
8. CO detection system
9. VAV boxes
10. Chiller
11. New toilet, General Exhaust fan controls
12. Chilled water pumps. Primary and secondary
13. Hot water pumps primary and Secondary
14. Boilers
15. Domestic water mixing valves
16. Domestic water recirculation pumps
17. Frequency controllers, HOA's and starters
18. DDC devices, smoke control dampers and BAS panels.
19. Elevator sump pump alarm
20. Auxiliary high temp sensor and alarm for all data closets, elevator machine rooms.
21. High water alarm for all condensate drain pans with unit shut down
22. High water alarm for all condensate receiver tanks.
23. Auxiliary high temp and RH sensors and alarms for record storage room.
24. Auxiliary common alarm from the fuel tank inventory panel

F. Provide services and manpower necessary for commissioning of system in coordination with the HVAC Contractor, Balancing Contractor and Owner's representative.

G. All work performed under this section of the specifications will comply with all codes, laws and governing bodies. If this specification and associated drawings exceed governing code requirements, the specification will govern. The Contractor shall obtain and pay for all necessary construction permits and licenses.

H. Provide all labor and materials to perform all programming necessary at the owner's new operator work station to be located in the facilities managers office to graphically represent and control EACH AND EVERY PIECE OF EQUIPMENT IN THE LISTS ABOVE, ALL INPUT AND PUT STATUS POINTS, AND FUNCTIONAL POINTS. THIS SHALL INCLUDE BUT IS NOT LIMITED TO ALL EQUIPMENT LISTED IN SECTION E ABOVE.

1.4 System Description

A. The Building Automation System (BAS) shall consist of PC-based workstation and microcomputer controllers of modular design providing distributed processing capability, and

allowing future expansion of both input/output points and processing/control functions. For this project the system shall consist of the following components:

B. Operator Workstations.

The BAS Contractor shall furnish (1) Operator Workstation Computer and (1) printer as described in Part 2 of the specification. This workstation must be running the standard workstation software developed and tested by the manufacturer of the network controllers and the standalone controllers. No third-party front-end workstation software will be acceptable. Provide all necessary software and licensing as required

C. Ethernet-based Network Controllers.

1. The BAS Contractor shall furnish Ethernet-based network controllers as described in Part 2 of the specification. These controllers will connect directly to the Operator Workstation over Ethernet, provide communication to the Standalone Digital Control Units and/or other Input/Output Modules and serve as a gateway to equipment furnished by others (if applicable).

D. Standalone Digital Control Units (SDCUs).

1. Provide the necessary quantity and types of SDCUs to meet the requirements of the project for mechanical equipment control including air handlers, control, and terminal unit control. Each SDCU will operate completely standalone, containing all of the I/O and programs to control its associated equipment.

E. Service Tool.

1. Provide a portable service tool for monitoring and commissioning of the network and Standalone Digital Control Units. The tool shall have all the appropriate software for system access and have the same functionality as the main work station.

1.5 Work by Others

A. The BAS Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others' work.

B. The BAS Contractor shall furnish all control valves, sensor wells, flow meters and other similar equipment for installation by the Mechanical Contractor.

C. The BAS Contractor shall provide field supervision to the designated contractor for the installation of the following as required:

1. Automatic control dampers
2. Fire/smoke dampers
3. Sheet metal baffle plates to eliminate stratification.

D. The Electrical Contractor shall provide:

1. All power wiring to motors, heat trace, junction boxes for power to BAS panels.

2. Furnish smoke detectors and wire to the building fire alarm system. HVAC Contractor to mount devices. BAS Contractor to hardwire to fan shut down. BAS contractor to coordinate this with the electrical contractor.

E. The BAS Contractor shall provide:

1. All power wiring to all smoke damper actuators for smoke control sequence.

1.6 Code Compliance

A. Provide BAS components and ancillary equipment, which are UL-916 listed and labeled.

B. All equipment or piping used in conditioned air streams, spaces or return air plenums shall comply with NFPA 90A Flame/Smoke/Fuel contribution rating of 25/50/0 and all applicable building codes or requirements.

C. All wiring shall conform to the National Electrical Code.

D. All smoke dampers shall be rated in accordance with UL 555S.

E. Comply with FCC rules, Part 15 regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments.

F. Comply with FCC, Part 68 rules for telephone modems and data sets.

1.7 Submittals

A. All shop drawings shall be prepared in Visio Professional or AutoCAD software. In addition to the drawings, the Contractor shall furnish a diskette containing the identical information. Drawings shall be B size or larger.

B. Shop drawings shall include a riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typical will be allowed where appropriate.

C. Submittal data shall contain manufacturer's data on all hardware and software products required by the specification. Valve, damper and air flow station schedules shall indicate size, configuration, capacity and location of all equipment.

D. Software submittals shall contain narrative descriptions of sequences of operation, program listings, point lists, and a complete description of the graphics, reports, alarms and configuration to be furnished with the workstation software. Information shall be bound or in a three-ring binder with an index and tabs. All literature, descriptions, equipment spec sheets, sequences etc shall be on 8 1/2 x 11 or larger sized sheets. All details diagrams and schematics shall be on 11X17 sized sheets or larger.

E. Submit five (5) copies of submittal data and shop drawings to the Engineer for review prior to ordering or fabrication of the equipment. The Contractor prior to submitting shall check all documents for accuracy.

F. The Engineer will make corrections, if required, and return to the Contractor. The Contractor will then resubmit with the corrected or additional data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully approved.

G. Submit a training class syllabus and training manual for review with the temperature controls submittal. The training manual shall be custom made for this project. Manufactures brochures, and installation manuals will not be acceptable for this purpose. Submit a type written overview and a written summary of each topic to be covered. The document shall be suitable for a system operator to use as a quick reference guide to basic system operation as applicable for this project. Refer to section 1.9 paragraph B, for the minimum requirement of training to be included.

1.8 System Startup & Commissioning

A. Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS will be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A written report will be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.

B. The BAS contractor shall commission and set in operating condition all major equipment and systems, such as the chilled water, hot water and all air handling systems, in the presence of the equipment manufacturer's representatives, as applicable, and the Owner and Architect's representatives.

C. The BAS Contractor shall provide all manpower and engineering services required to assist the HVAC Contractor and Balancing Contractor in testing, adjusting, and balancing all systems in the building. The BAS Contractor shall have a trained technician available on request during the balancing of the systems. The BAS Contractor shall coordinate all requirements to provide a complete air balance with the Balancing Contractor and shall include all labor and materials in his contract.

1.9 Training

A. The BAS Contractor shall provide both on-site training to the Owner's representative and maintenance personnel per the following description:

B. On-site training shall consist of a minimum of (3) separate 4-hour sessions of hands-on instruction geared at the operation and maintenance of the systems. The sessions shall be scheduled at the beginning of substantial completion and spaced out over the first year of owner use. The first session curriculum shall include

1. System Overview
2. System Software and Operation

    a. System access
    b. Software features overview
    c. Changing set-points and other attributes
    d. Scheduling
    e. Editing programmed variables

f. Displaying color graphics
g. Running reports
h. Workstation maintenance
i. Application programming

3. Operational sequences including start-up, shutdown, adjusting and changing system variables. These items shall be reviewed for all equipment installed under this project and or connected to the BMS under this project.
4. Equipment and hardware overview and maintenance. This shall include:

a. Review of all hardware installed under this project
b. Review of a system schematic.
c. Review of where each controller is located in the building and what its function is. This shall include a walking, hands-on tour and demonstration of each and every controller.

1.10 Operating and Maintenance Manuals

A. The operation and maintenance manuals shall contain all information necessary for the operation, maintenance, replacement, installation, and parts procurement for the entire BAS. This documentation shall include specific part numbers and software versions and dates. A complete list of recommended spare parts shall be included with the lead-time and expected frequency of use of each part clearly identified.

B. Following project completion and testing, the BAS contractor will submit as-built drawings reflecting the exact installation of the system. The as-built documentation shall also include a copy of all application software both in written form and on diskette.

1.11 Warranty

A. The BAS contractor shall warrant the system for 12 months after system acceptance and beneficial use by the owner. During the warranty period, the BAS contractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with the letter and intent of the Sequence of Operation section of the specification.

B. Updates to the manufacturer's software shall be provided at no charge during the warranty period.

1.12 Programming

A. Sequence of operations: The controls contractor shall review the sequences of operation given in section 23 09 93 of this specification. "Canned", preprogrammed, or typical sequences by the manufacture may not be acceptable and shall only be used if accepted by the engineer. Otherwise the controls contractor shall be capable of and responsible for providing custom programming, hardware, software, and labor as required to achieve the sequences of operation as specified.

1.13 System Architecture

A. General

B. The Building Automation System (BAS) shall consist of all new Network Control Units (NCUs), a family of Standalone Digital Control Units (SDCUs), Input/Output Unit Modules (IOU Modules), Operator Workstations (OWs), and one File Server to support system configurations where more than one operator workstation is required. The BAS shall provide control, alarm detection, scheduling, reporting and information management for the entire class room building and all new and existing equipment in the building, and Wide Area Network (WAN) if applicable, from a single ODBC-compliant database

C. Level 1 Network Description

D. Level 1, the main backbone of the system, shall be an Ethernet LAN/WAN. Network Control Units, Operator Workstations, and the Central File Server shall connect directly to this network without the need for Gateway devices. The contractor shall visit the site and review the existing Andover temperature controls equipment installed in the building and in the physical plant. Certain of these controllers may be suitable for reuse. The network shall be an extension of the existing in the building as required to achieve a complete system,

E. Level 2 Network Description

F. Level 2 of the system shall consist of one or more field buses managed by the Network Control Units. The Level 2 field buses may consist of one or both of the following types:

G. An RS485, token passing bus that supports up to 127 Standalone Digital Control Units (SDCUs) for operation of HVAC equipment and lighting, or

H. An RS485 field bus that supports up to 32 devices from a family of plug-in, IOU modules.

I. These IOU modules may be mounted within the NCU enclosure or remotely mounted via a single, twisted, shielded pair of wires.

J. The BAS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN), sharing a single file server. This enables workstations to manage a single LAN (or building), and/or the entire system with all devices being assured of being updated by and sharing the most current database. In the case of a single workstation system, the workstation shall contain the entire database – with no need for a separate file server.

K. Standard Network Support

L. All NCUs, Workstation(s) and File Server shall be capable of residing directly on the owner's Ethernet TCP/IP LAN/WAN with no required gateways. Furthermore, the NCU's, Workstation(s) and File Server shall be capable of using standard, commercially available, off-the-shelf Ethernet infrastructure components such as routers, switches and hubs. With this design the owner may utilize the investment of an existing or new enterprise network or structured cabling system. This also allows the option of the maintenance of the LAN/WAN to be performed by the owner's Information Systems Department as all devices utilize standard TCP/IP components.

M. Remote Communications

N. In addition to the above LAN/WAN architecture support, the same workstation software (front end) must be capable of managing remote systems via standard dial-up phone lines as a standard component of the software. Front-end “add-on” software modules to perform remote site communication shall not be acceptable.

O. The remote system architecture shall consist of two levels providing control, alarm detection, reporting and information management for the remote facility. Level 1 shall contain the Remote Site Control Unit, communicating to the remotely located, Operator Workstation(s) through the use of a modem and a standard dial-up phone line. Level 2 shall consist of one or more field buses controlled by the RSCU. The field buses may consist of one or both of two types:

P. 1) An RS485, token passing bus that supports up to 127 Standalone Digital Control Units (SDCUs) for operation of HVAC equipment and lighting, or

Q. 2) An RS485 field bus that supports up to 32 devices from a family of plug-in, IOU modules that may be mounted within the RSCU enclosure or remotely mounted on a single, twisted, shielded pair of wires.

R. System Expansion

S. The BAS system shall be scalable and expandable at all levels of the system using the same software interface, and the same Level 1 and Level 2 controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the system shall not be acceptable.

T. The BAS shall be expandable to include Security and Access Control functions at any time in the future with no additional workstations, front-end software or Level 1 controllers required. Standalone Digital Control Units or IOU modules shall be able to be added to the existing Level 1 controller’s field bus(es), to perform security and card access applications. In this way, an owner’s existing investment in wiring infrastructure may be leveraged and the cost and inconvenience of adding new field bus wiring will be minimized.

U. Additionally, an integrated video badging option must be able to be included with no additional workstations required. This photo ID option must share the same database as the BAS in order to eliminate the need for updating multiple databases.

V. The system shall use the same application programming language for all levels: Operator Workstation, Network Control Unit, Remote Site Control Unit and Standalone Digital Control Unit. Furthermore, this single programming language shall be used for all applications: environmental control, card access control, intrusion detection and security, lighting control, leak detection / underground storage tank monitoring, and digital data communication interfaces to third party microprocessor-based devices.

W. Support For Open Systems Protocols

The BAS design must include solutions for the integration of the following “open systems” protocols: BACnet, LonTalk™, and digital data communication to third party microprocessors such as chiller controllers, fire panels and variable frequency drives (VFDs).

X. The system shall also provide the ability to program custom ASCII communication drivers, that will reside in the NCU, for communication to third party systems and devices. These drivers will provide real time monitoring and control of the third-party systems.

1.14 Network Control Units (NCUs)

A. Network Control Units shall be microprocessor based, multi-tasking, multi-user, and employ a real time operating system. Each NCU control panel shall consist of modular hardware including power supply, CPU board, and input/output modules. A sufficient number of NCUs shall be supplied to fully meet the requirements of this specification and the attached point list. NCUs for telephone dialup sites shall be of the same design as the Ethernet control units but without the plug-in Ethernet network interface card (NIC), i.e., NCUs, which include a NIC, shall be interchangeable whether used on a LAN/WAN or a dialup site.

B. Webserver Functionality

All NCUs on the Ethernet TCP/IP LAN/WAN shall be capable, out-of-the box, to be set up as a Web Server. The NCU shall have the ability to store HTML code and "serve" pages to a web browser. This provides the ability for any computing device utilizing a TCP/IP Ethernet connection and capable of running a standard Internet browser (Microsoft Internet Explorer™, Netscape Navigator™, etc.) to access real-time data from the entire BAS via any NCUs.

Graphics and text-based web pages shall be constructed using standard HTML code. The interface shall allow the user to choose any of the standard text or graphics-based HTML editors for page creation. It shall also allow the operator to generate custom graphical pages and forms.

The WEB server interface shall be capable of password security, including validation of the requesting PC's IP address. The WEB server interface shall allow the sharing of data or information between any controller, or process or network interface (BACnet, LonTalk and TCP/IP) that the BMS has knowledge of, regardless of where the point is connected on the BAS network or where it is acquired from.

The BAS network controller must act directly as the WEB server. It must directly generate the HTML code to the requesting user (i.e. WEB browser), eliminating the need for and reliance on any PC-based WEB server hardware or software. To simplify graphic image space allocation, HTML graphic images, if desired, shall be stored on any shared network device. The BAS WEB server shall have the ability to acquire any necessary graphics using standard pathing syntax within the HTML code mounted within the BAS WEB server. External WEB server hardware and software are not acceptable.

C. Hardware Specifications

1. Memory:

   A minimum of 64MB of RAM shall be provided for NCUs with expansion up to 128 MB. The 64 MB versions shall include a floating-point math co-processor.

2. Communication Ports:

   Each NCU shall provide communication to both the Workstation(s) and the field buses. In addition, each NCU must have at least 3 other communications ports that support a telephone modem, portable service tool, serial printer and connection to third party controllers such as a chiller control panel. On a LAN/WAN system the NCU shall be provided with a 10Mbps plug-in Ethernet TCP/IP network interface card (NIC).

3. Input/Output (I/O):

   Each NCU shall support the addition of the following types of inputs and outputs:

- Digital Inputs for status/alarm contacts
- Counter Inputs for summing pulses from meters.
- Thermistor inputs for measuring temperatures in space, ducts and thermowells.
- Analog inputs for pressure, humidity, flow and position measurements.
- Digital Outputs for on/off equipment control.
- Analog Outputs for valve and damper position control, and capacity control of primary equipment including all air handler and fan coil control valves

4. Modular Expandability:

   The system shall employ a modular I/O design to allow easy expansion. Input and output capacity is to be provided through plug-in modules of various types or DIN-mountable IOU modules. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.

5. Hardware Override Switches:

   All digital output units shall include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition, each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.

6. Local Status Indicator Lamps:

   Provide as a minimum LED indication of CPU status, Ethernet LAN status, and field bus status. For each output, provide LED indication of the value of the output (On/Off). For each output module provide an LED which gives a visual indication of whether any outputs on the module are manually overridden.

7. Real Time Clock (RTC):

   Each NCU shall include a battery-backed, real time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. In normal operation the system clock will be based on the frequency of the AC power. The system shall automatically correct for daylight savings time and leap years and be Year 2000 compliant.

8. Power Supply:

   The power supply for the NCUs shall be auto sensing, 120-220VAC, 60/50 Hz power, with a tolerance of +/- 20%. Line voltage below the operating range of the system shall be considered outages. The controller shall contain over voltage surge protection, and require no additional AC power signal conditioning. Optionally, if indicated on the drawings, the power supply shall accept an input voltage of (–48 VDC).

9. Automatic Restart After Power Failure:

   Upon restoration of power after an outage, the ECU shall automatically and without human intervention: update all monitored functions; resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

10. Battery backup:

    Each NCU with the standard 120-220VAC power supply shall include a programmable DC power backup system rated for a minimum of 72 hours of battery backup to maintain all volatile memory or, a minimum of 2 hours of full UPS including modem power. This power backup system shall be configurable such that at the end of a settable timeframe

(such as 1 hour) of running on full UPS, the unit will shut off full UPS and switch to memory retention-only mode for the remainder of the battery power. The system shall allow the simple addition of more batteries to extend the above minimum battery backup times.

D. Software Specifications

1. General.

   The NCU shall contain flash ROM as the resident operating system. Application software will be RAM resident. Application software will only be limited by the amount of RAM memory. There will be no restrictions placed on the type of application programs in the system. Each NCU shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.

2. User Programming Language:
   The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be English language-based and programmable by the user. The language shall be structured to allow for the easy configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, passwords, and histories. The language shall be self-documenting. Users shall be able to place comments anywhere in the body of a program. Program listings shall be configurable by the user in logical groupings.

E. Control Software:

1. The NCU shall have the ability to perform the following pre-tested control algorithms:

   a. Proportional, Integral plus Derivative Control (PID)
   b. Self Tuning PID
   c. Two Position Control
   d. Digital Filter
   e. Ratio Calculator
   f. Equipment Cycling Protection

2. Mathematical Functions:

   a. Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These must be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.

3. Energy Management Applications:

a. NCUs shall have the ability to perform any or all of the following energy management routines:
b. Time of Day Scheduling
c. Calendar Based Scheduling
d. Holiday Scheduling
e. Temporary Schedule Overrides
f. Optimal Start
g. Optimal Stop
h. Night Setback Control
i. Enthalpy Switchover (Economizer)
j. Peak Demand Limiting
k. Temperature Compensated Duty Cycling
l. CFM Tracking
m. Heating/Cooling Interlock
n. Free Cooling
o. Hot Water Reset
p. Chilled Water / HW water Reset
q. Chiller / boiler Sequencing

4. History Logging:
   a. Each controller shall be capable of logging any system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system variables (inputs, outputs, math calculations, flags, etc.) can be logged in history. A maximum of 32767 values can be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logs can be automatic or manual. Logged data shall be downloadable to the Operator Workstation for long term archiving based upon user-defined time intervals, or manual command.

5. Alarm Management:

   a. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan of the NCU and can result in the display of one or more alarm messages or reports. Up to 8 alarms can be configured for each point in the controller. Messages and reports can be sent to a local terminal, to the front-end workstation(s), or via modem to a remote-computing device. Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided. If communication with the Operator Workstation is temporarily interrupted, the alarm will be buffered in the NCU. When communications return, the alarm will be transmitted to the Operator Workstation if the point is still in the alarm condition.

6. Reporting.

   a. The NCU shall be able to generate user-definable reports to a locally connected printer or terminal. The reports shall contain any combination of text and system variables. Report templates shall be able to be created by users in a word processing environment. Reports can be displayed based on any logical condition or through a user command.

1.15 Standalone Digital Control Units (SDCUs)

A. General:

1. Standalone Digital Control Units shall provide control of HVAC and lighting. Each controller shall have its own control programs and will continue to operate in the event of a failure or communication loss to its associated NCU.

B. Memory:

1. Control programs shall be stored in battery backed-up RAM and EPROM. Each controller shall have a minimum of 32K bytes of user RAM memory and 128K bytes of EPROM.

C. Communication Ports:

1. SDCUs shall provide a communication port to the field bus. In addition, a port shall be provided for connection of a portable service tool to support local commissioning and parameter changes with or without the NCU online. It shall be possible from a service port on any SDCU to view, enable/disable, and modify values of any point or program on any controller on the local field bus, any NCU or any SDCU on a different field bus.

D. Input/Output:

1. Each SDCU shall support the addition of the following types of inputs and outputs:

   a. Digital Inputs for status/alarm contacts
   b. Counter Inputs for summing pulses from meters.
   c. Thermistor Inputs for measuring temperatures in space, ducts and thermowells.
   d. Analog inputs for pressure, humidity, flow and position measurements.
   e. Digital Outputs for on/off equipment control.
   f. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

E. Expandability:

1. Input and output capacity shall be expandable through the use of plug-in modules. A minimum of two modules shall be added to the base SDCU before additional power is required.

F. Networking:

1. Each SDCU will be able to exchange information on a peer to peer basis with other Standalone Digital Control Units during each field bus scan. Each SDCU shall be capable of storing and referencing global variables (on the LAN) with or without any workstations online. Each SDCU shall be able to have its program viewed and/or enabled/disabled either locally through a portable service tool or through a workstation connected to an NCU.

G. Indicator Lamps:

1. SDCUs will have as a minimum, LED indication of CPU status, and field bus status.

H. Real Time Clock (RTC):

1. An SDCU shall have a real time clock in either hardware or software. The accuracy shall be within 10 seconds per day. The RTC shall provide the following information: time of day, day, month, year, and day of week. Each SDCU shall receive a signal, every hour, over the network from the NCU which synchronizes all SDCU real time clocks.

I. Automatic Restart After Power Failure:

1. Upon restoration of power, the SDCU shall automatically and without human intervention, update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

J. Battery Back Up:

1. Each SDCU shall have at least 3 years of battery back up to maintain all volatile memory.

K. Alarm Management:

1. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan of the SDCU and can result in the display of one or more alarm messages or reports. Up to 8 alarms can be configured for each point in the controller enabling the escalation of the alarm priority (urgency) based upon which alarm(s) is/are triggered. Alarm messages can be sent to a local terminal or modem connected to an NCU or to the Operator's Workstation(s). Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided. If communication with the NCU is temporarily interrupted, the alarm will be buffered in the SDCU. When communications return, the alarm will be transmitted to the NCU if the point is still in the alarm condition.

L. Air Handler Controllers

1. AHU Controllers shall be capable of meeting the requirements of the sequence of operation found in the Execution portion of this specification and for future expansion.
2. AHU Controllers shall support all the necessary point inputs and outputs as required by the sequence and operate in a standalone fashion.
3. AHU Controllers shall be fully user programmable to allow for modification of the application software.
4. An LCD display shall be optionally available for readout of point values and to allow operators to change setpoints and system parameters.
5. A manual override switch shall be provided for all digital and analog outputs on the AHU Controller. The position of the switch shall be monitored in software and available for operator displays and alarm notification.

M. VAV Terminal Unit Controllers

1. VAV Terminal Unit Controllers shall support, but not be limited to the control of the following configurations of VAV boxes to address current requirements as described in the Execution portion of this specification, and for future expansion:

    a. Single Duct Cooling Only

b. Single Duct Cooling with Reheat (Electric or Hot Water)
c. Fan Powered (Parallel or Series)
d. Dual Duct (Constant or Variable Volume)
e. Supply/Exhaust

2. VAV Controllers for single duct applications will come equipped with a built-in actuator for modulation of the air damper. The actuator shall have a minimum torque rating of 35 in.-lb., and contain an override mechanism for manual positioning of the damper during startup and service. VAV Controllers shall contain an integral velocity sensor accurate to +/- 5% of the full range of the box's CFM rating. Each controller shall perform the sequence of operation described in Part 3 of this specification, and have the capability for time of day scheduling, occupancy mode control, after hours operation, lighting control, alarming, and trending. VAV Controllers shall be able to communicate with any other Standalone Digital Control Unit on the same field bus with or without communication to the NCU managing the field bus. Systems that fail to provide this (true peer-to-peer) capability will be limited to a maximum of 32 VAV controllers per field bus.

3. Unitary Controllers

a. Unitary Controllers shall support, but not be limited to, the control of the following systems as described in the Execution portion of this specification, and for future expansion:

1) Cabinet heater and convectors
2) Rooftop top air handling units
3) Fan Coils
4) Unit and cabinet heaters

b. The I/O of each Unitary Controller shall contain the sufficient quantity and types as required to meet the sequence of operation found in the Execution portion of this specification. In addition, each controller shall have the capability for time of day scheduling, occupancy mode control, after hour operation, lighting control, alarming, and trending.

N. Lighting Controllers (Not Used)

1. Lighting controllers shall provide direct control of 20 Amp, 277 VAC lighting circuits using mechanically held, latching relays. Controllers will contain from 8 to 48 circuits per enclosure. Each controller shall also contain inputs for direct connection to light switches and motion detectors. Each controller shall have the capability for time of day scheduling, occupancy mode control, after hour operation, alarming, and trending.

O. Display Controllers

1. Display controllers are standalone, touch screen based operator interfaces. The controller shall be designed for flush mounting in a finished space, with a minimum display size of 9 x 9 inches. Software shall be user programmable allowing for custom graphical images that simulate floor plans, menus, equipment schematics along with associated real time point values coming from any NCU on the network. The touch screen display shall contain a minimum of 64 possible touch cells that permit user interaction for changing screens, modifying set-points or operating equipment. Systems that do not offer a display

controller as specified must provide a panel mounted computer with touch screen capability as an alternative. All air handling units shall use display controllers.

1.16 Operator Workstation Requirements

A. General.

The BAS workstation software shall be configurable as a multi-workstation system where the database is located on a central file server in the physical plant. The client software on multi-workstation system shall access the file server database program via an Ethernet TCP/IP network running at either 10MBPS or 100MBPS. All Workstations shall be Pentium II based personal computers operating under the Microsoft NT operating system. The application software shall be capable of communication to all Network Control Units and Standalone Digital Control Units, feature high-resolution color graphics, alarming, reporting, and be user configurable for all data collection and data presentation functions.

For multi-workstation systems, a minimum of 256 workstations shall be allowed on the Ethernet network along with the central file server. In this client/server configuration, any changes or additions made from one workstation will automatically appear on all other workstations without the requirement for manual copying of files. Multi-workstation systems with no central database will not be acceptable. Multi-workstation systems with distributed/tiered file servers and a central (master) database will not be acceptable.

B. Workstation Requirements

The workstation shall consist of the following:

3.6 GHz Intel Core i7 processor with 64GB of RAM

Microsoft Windows operating system (latest version compatible with BMS software)

Serial port, parallel port

10/100MBPS Ethernet NIC

500 GB hard disk

CD-ROM drive

High resolution (minimum 1080 x 1920), 17” flat panel display

Mouse

Full function keyboard

Audio sound card and speakers

License agreement for all applicable software.

C. File Server Hardware Requirements.

The file server computer shall contain of the following:

3.6 GHz Intel Core 2 Duo processor with 64GB of RAM

Microsoft Windows operating system (latest version compatible with BMS software)

10/100MBPS Ethernet NIC

500 GB hard disk

CD-ROM drive

Mouse

Full function keyboard

License agreement for all applicable software.

Provide one Windows 2000-compatible 56 Kbaud modem.

D. Printer

Provide an alarm and report printer. Printer shall be a HP LaserJet.

E. Monitor;

1. The monitor shall be flat screen minimum of 22" (16"x20"), LED type, 1920x1080 resolution, 16:9 aspect ratio, VGA.

F. Workstation Software

1. General Description

The software architecture must be object-oriented in design, a true 32-bit application suite utilizing Microsoft's OLE, COM, DCOM and ODBC technologies. These technologies make it easy to fully utilize the power of the operating system to share, among applications (and therefore to the users of those applications), the wealth of data available from the BAS.

The workstation functions shall include monitoring and programming of all DDC controllers. Monitoring consists of alarming, reporting, graphic displays, long term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments.

Programming of controllers shall be capable of being done either off-line or on-line from any operator workstation. All information will be available in graphic or text displays. Graphic displays will feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location of information throughout the DDC system. All operator functions shall be selectable through a mouse.

2. System Database

The files server database engine must be Microsoft SQL Server, or another ODBC-compliant, relational database program. This ODBC (Open Database Connectivity)-compliant database engine allows for an owner to utilize "their" choice of database and due to it's "open" architecture, allows an owner to write custom applications and/or reports which communicate directly with the database avoiding data transfer routines to update other applications. The system database shall contain all point configurations and programs in each of the controllers that have been assigned to the network. In addition, the database will contain all workstation files including color graphic, alarm reports, text reports, historical data logs, schedules, and polling records.

3. User Interface

The BAS workstation software shall allow the creation of a custom, browser-style interface linked to the user that has logged into the workstation software. This interface shall support the creation of "hot-spots" that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface must be able to be configured to become a user's "PC Desktop" – with all the links that a user needs to run other applications. This, along with the Windows 10 user security capabilities, will enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BAS software but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shutdown the active alarm viewer and/or unable to load software onto the PC.

4. User Security

The software shall be designed so that each user of the software can have a unique username and password. This username/password combination shall be linked to a set of capabilities within the software, set by and editable only by, a system administrator. The sets of capabilities shall range from View only, acknowledge alarms, Enable/disable and change values, Program, and Administer. The system shall allow the above capabilities to be applied independently to each and every class of object in the system. The system must allow a minimum of 256 users to be configured per workstation. There shall be an inactivity timer adjustable in software that automatically logs off the current operator after the timer has expired.

5. Configuration Interface

The workstation software shall use a familiar Windows Explorer™-style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a "network map" of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure. All object names shall be alphanumeric and use Windows long filename conventions. Object names shall not be required to be unique throughout the system. This allows consistency in point naming. For example, each fan coil unit controller can have an input called Space Temperature and a setpoint called CFM Setpoint. The FCU controller name shall be unique such as FCU for LAB101. Systems requiring unique object names throughout the system will not be acceptable.

The configuration interface shall also include support for template objects. These template objects shall be used as building blocks for the creation of the BAS database. The types of template objects supported shall include all data point types (input, output, string variables, setpoints, etc.), alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of template object types shall be able to be set up as template subsystems and systems. The template system shall prompt for data entry if necessary. The template system shall maintain a link to all "child" objects created by each template. If a user wishes to make a change to a template object, the software shall ask the user if he/she wants to update all of child objects with the change. This template system shall facilitate configuration and programming consistency and afford the user a fast and simple method to make global changes to the BAS.

6. Color Graphic Displays

The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse. Requirements of the color graphic subsystem include:

a. SVGA, bit-mapped displays. The user shall have the ability to import AutoCAD generated picture files as background displays.
b. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, ad graphs which can be "dropped" on a graphic through the use of a software configuration "wizard". These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.

c. Status changes or alarm conditions must be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.

d. Graphic panel objects shall be able to be configured with multiple “tabbed” pages allowing an operator to quickly view individual graphics of equipment, which make up a subsystem or system.

e. Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression. Operators must be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.

f. Automatic monitoring

The software shall allow for the automatic collection of data and reports from any controller through either a hardwire or modem communication link. The frequency of data collection shall be completely user-configurable.

g. Alarm Management

The software shall be capable of accepting alarms directly from controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations configured through the software. Any alarm (regardless of its origination) will be integrated into the overall alarm management system and will appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, or reports.

Alarm management features shall include:

1) A minimum of 255 alarm notification levels. Each notification level will establish a unique set of parameters for controlling alarm display, acknowledgment, keyboard annunciation, alarm printout and record keeping.
2) Automatic logging in the database of the alarm message, point name, point value, connected controller, timestamp, username and time of acknowledgement, username and time of alarm silence (soft acknowledgement)
3) Automatic printing of the alarm information or alarm report to an alarm printer or report printer.
4) Playing an audible beep or audio (wav) file on alarm initiation or return to normal.
5) Sending an email or alphanumeric page to anyone listed in a workstation’s email account address list on either the initial occurrence of an alarm and/or if the alarm is repeated because an operator has not acknowledged the alarm within a user-configurable timeframe. The ability to utilize email and alphanumeric paging of alarms shall be a standard feature of the software integrated with the operating system’s mail application interface (MAPI). No special software interfaces shall be required.
6) Individual alarms shall be able to be re-routed to a workstation or workstations at user-specified times and dates. For example, a critical high temp alarm can be configured to be routed to a Facilities Dept. workstation during normal working hours (7am-6pm, Mon-Fri) and to a Central Alarming workstation at all other times.
7) An active alarm viewer shall be included which can be customized for each user or user type to hide or display any alarm attributes.

8) The font type and color, and background color for each alarm notification level as seen in the active alarm viewer shall be customizable to allow easy identification of certain alarm types or alarm states.
9) The active alarm viewer can be configured such that an operator must type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.

h. Custom Report Generation

The software will contain a built-in custom report generator, featuring word processing tools for the creation of custom reports. These custom reports shall be able to be set up to automatically run or be generated on demand. Each workstation shall be able to associate reports with any word processing or spreadsheet program loaded on the machine. When the report is displayed, it will automatically spawn the associated report editor such as MS Word™.

1) Reports can be of any length and contain any point attributes from any controller on the network.
2) The report generator will have access to the user programming language in order to perform mathematical calculations inside the body of the report, control the display output of the report, or prompt the user for additional information needed by the report.
3) It shall be possible to run other executable programs whenever a report is initiated.
4) Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.
5) Standard reports shall include:

a) Points in each controller.
b) Points in alarm
c) Disabled points
d) Overridden points
e) Operator activity report
f) Alarm history log.
g) Program listing by controller with status.
h) Network status of each controller

i. Spreadsheet-style reports

The software shall allow the simple configuration of row/column (spreadsheet-style) reports on any class of object in the system. These reports shall be user-configurable and shall be able to extract live (controller) data and/or data from the database. The user shall be able to set up each report to display in any text font, color and background color. In addition, the report shall be able to be configured to filter data, sort data and highlight data which meets user-defined criteria.

j. HTML Reporting

The above spreadsheet-style reports shall be able to be run to an HTML template file. This feature will create an HTML “results” file in the directory of the HTML template. This directory can be shared with other computer users, which will allow those users with access to the directory to “point” their web browser at the file and view the report.

k. Scheduling- It shall be possible to configure and download from the workstation schedules for any of the controllers on the network.

1) Time of day schedules shall be in a calendar style and shall be programmable for a minimum of one year in advance. Each standard day of the week and user-defined day types shall be able to be associated with a color so that when the schedule is viewed it is very easy, at-a-glance, to determine the schedule for a particular day even from the yearly view. To change the schedule for a particular day, a user shall simply click on the day and then click on the day type.
2) Each schedule will appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.
3) Schedules will be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation will be automatically updated to the corresponding schedule in the controller.

l. Programmer's Environment

The programmer's environment will include access to a superset of the same programming language supported in the controllers. Here the programmer will be able to configure application software off-line (if desired) for custom program development, write global control programs, system reports, wide area networking data collection routines, and custom alarm management software. On the same screen as the program editor, the programming environment shall include dockable debug and watch bars for program debugging and viewing updated values and point attributes during programming. In addition, a wizard tool shall be available for loading programs from a library file in the program editor.

m. Saving/Reloading

The workstation software shall have an application to save and restore field controller memory files. This application shall not be limited to saving and reloading an entire controller – it must also be able to save/reload individual objects in the controller. This allows off-line debugging of control programs, for example, and then reloading of just the modified information.

n. Data Logging

The workstation software shall have the capability to easily configure groups of data points with trend logs and display the trend log data. A group of data points shall be created by drag-and-drop method of the points into a folder. The trend log data shall be displayed through a simply menu selection. This data shall be able to be saved to file and/or printed.

o. Audit Trail

The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.

p. Fault Tolerant File Server Operation

The system shall provide the option to provide fault tolerant operation in the event of the loss of the CPU, disk drives, or other hardware required to maintain the operational

integrity of the system. Operational integrity includes all user interfaces, monitoring of alarm points and access points, and executing access control functions.

The switchover mechanism provided shall be automatic. Should the failure be caused by hardware, then the system shall immediately switch to the Backup computer. Should the system failure be caused by software (instruction or data), the system shall not pass the faulted code to the Backup computer, otherwise the Backup shall fail in the same manner of the Primary computer.

Switchover to the Backup computer shall be initiated and effective (complete) in a manner and time frame that precludes the loss of event data, and shall be transparent to the system users, except for an advisory alarm message indicating that the switchover has occurred.

When the system fails-over from the Primary to the Backup computer, no alarm or other event shall be lost, and the Backup computer shall take control of all system functions.

A single component failure in the system shall not cause the entire system to fail. All system users shall be informed of any detectable component failure via an alarm event. System users shall not be logged off as a result of a system failure or switchover.

The Primary computer shall provide continual indication that the Backup computer is unavailable until such time that the fault has been purged.

1.17 **Portable Operator's Terminal** (NOT USED)

A. Provide one 15" full screen, laptop portable operator terminal shall communicate directly to all controllers. The laptop software shall enable users to monitor both instantaneous and historical point data, modify control parameters, and enable/disable any point or program in any controller on the network.

1. The laptop computer will be a Intel Core 2 Duo-based portable computer with a minimum of 4GB of RAM memory, and a 160GB hard disk drive, running Windows ver 7 or Windows XP.
2. The laptop service tool will connect to any Ethernet controller or standalone controller via a dedicated service port. From this single connection, the user shall be able to communicate with any other controller on the LAN.
3. The laptop service tool will limit operator access by passwords. The service tool must support, at a minimum, the following password-protected user types: Administrator, Modify Parameters, View Only.
4. The laptop software shall include built-in menus for viewing points by controller, enabling, disabling and viewing programs, configuring controllers, and communicating to other controllers on the network.

1.18 **DDC Sensors and Point Hardware**

A. Temperature Sensors

1. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of –30 to 230 degrees F. Space temperature sensors shall be accurate to +/- .5 degrees F over a range of 40 to 100 degrees F.

2. Space sensors shall be have off white enclosure and shall be mounted on a standard electrical box. Space sensors shall use surface mounted finished cast electrical box for surface mounting with metal “wire-mold” to conceal wiring for all solid masonry partitions. For space sensors located on gypsum board partitions, wiring shall be concealed inside the walls with recessed flush mounted electrical boxes. In general, control wiring shall run from the ceiling plenum to the box which shall be wall mounted next to the door or as shown on plan. (This shall be the standard for this project)

3. The space sensor housing shall utilize buttons for adjusting the space temperature set-point, as well as a push button for selecting after hours operation, fan speed and all and other operator selectable parameters. Operators shall be able to adjust set points directly from the sensor. All space sensors, (located in public location, office, conference room or support space), shall incorporate either an LED or LCD display for viewing the space temperature, set-point and other operator selectable parameters. Space sensors located in store rooms, MER, and unoccupied space are not required have LED or LCD display.

4. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless-steel tube. Probe style duct sensors are useable in air handling applications where the coil or duct area is less than 14 square feet.
5. Averaging sensors shall be employed in ducts which are larger than 14 square feet. The averaging sensor tube must contain at least one thermistor for every 3 feet, with a minimum tube length of 12 feet.
6. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications.
7. A pneumatic signal shall not be allowed for sensing temperature.

B. Humidity Sensors

1. Humidity devices shall be accurate to +/- 5% at full scale for space and +/- 3% for duct and outside air applications. Suppliers shall be able to demonstrate that accuracy is NIST traceable.
2. Provide a hand-held field calibration tool that both reads the output of the sensor and contains a reference sensor for ongoing calibration.

C. Pressure Sensors

1. Air pressure measurements in the range of 0 to 10” water column will be accurate to +/- 1% using a solid-state sensing element. Acceptable manufacturers include Modus Instruments and Mamac.
2. Differential pressure measurements of liquids or gases shall be accurate to =/- 0.5% of range. The housing shall be Nema 4 rated.

D. Current and KW Sensors

1. Current status switches shall be used to monitor fans, pumps, motors and electrical loads. Current switches shall be available in solid and split core models, and offer either a

digital or an analog signal to the automation system. Acceptable manufacturer is Veris or approved equal.

2. Measurement of three phase power shall be accomplished with a kW/kWH transducer. This device shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy usage (kWH). Provide Veris Model 6000 Power Transducer or approved equal.

E. Flow Sensors

1. Provide an insertion vortex flowmeter for measurement of liquid, gas or steam flows in pipe sizes above 3 inches.
2. Install the flow meter on an isolation valve to permit removal without process shutdown.
3. Sensors shall be manufactured by EMCO or approved equal.

F. Electric/Pneumatic Transducers

1. Electric to pneumatic transducers shall operate from either a PWM or analog signal. E/P transducers shall be rated for 0 - 20 psi operation and accurate to 2% of full scale. E/P transducers shall have a maximum air consumption of 100 SCIM.
2. E/P transducers may be installed at the end device (damper or valve), or mounted separately in a field interface panel, or as part of the controller. All transducers will be calibrated. Panel mounted transducers shall be Sensycon or approved equal.

1.19 Control Valves

A. Provide automatic control valves suitable for the specified controlled media (water or glycol). Provide valves which mate and match the material of the connected piping. Equip control valves with the actuators of required input power type and control signal type to accurately position the flow control element and provide sufficient force to achieve required leakage specification.

B. Control valves shall meet the heating and cooling loads specified, and close off against the differential pressure conditions within the application. Valves should be sized to operate accurately and with stability from 10 to 100% of the maximum design flow.

C. Trim material shall be stainless steel for steam and high differential pressure applications.

D. Electric actuation should be provided on all terminal unit reheat applications.

1.20 Dampers

A. Automatic dampers, furnished by the Building Automation Contractor shall be single or multiple blade as required. Dampers are to be installed by the HVAC Contractor under the supervision of the BAS Contractor. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the Sheet Metal Contractor.

B. Damper frames are to be constructed of 13 gauge galvanized sheet steel mechanically joined with linkage concealed in the side channel to eliminate noise as friction. Compressible spring stainless steel side seals, and acetal or bronze bearings shall also be provided.

C. Damper blade width shall not exceed eight inches. Seals and 3/8 inch square steel zinc plated pins are required. Blade rotation is to be parallel or opposed as shown on the schedules.

D. For high performance applications, control dampers will meet or exceed the UL Class I leakage rating.

E. Control and smoke dampers shall be Ruskin, or approved equal.

F. Provide opposed blade dampers for modulating applications and parallel blade for two position control.

1.21 Damper Actuators

A. Electronic Actuators – the actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The actuator shall have electronic overload circuitry to prevent damage. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-spring return actuators shall have an external manual gear release to allow positioning of the damper when the actuator is not powered.

B. Pneumatic Actuators - shall be of the synthetic elastomer diaphragm piston type and shall be fully proportioning unless otherwise specified. They shall have full metal bodies and utilize replaceable diaphragms. Damper actuators on large sections of modulating dampers (>25 sq.ft.) or high face velocity applications (such as fan inlet vanes) shall be equipped with pilot positioners to provide repeatability and quick response. Also provide pilot positioners on steam valves requiring 1/3 – 2/3 operation. (Not used)

1.22 Smoke Detectors

A. Air duct smoke detectors shall be by Air Products & Controls or approved equal. The detectors shall operate at air velocities from 300 feet per minute to 4000 feet per minute.

B. The smoke detector shall utilize a photoelectric detector head.

C. The housing shall permit mechanical installation without removal of the detector cover.

D. The detectors shall be listed by Underwrites Laboratories and meet the requirements of UL 268A.

1.23 Airflow Measuring Stations

A. Provide a thermal anemometer using instrument grade self heated thermistor sensors with thermistor temperature sensors.

B. The flow station shall operate over a range of 0 to 5,000 feet/min with an accuracy of +/- 2% over 500 feet/min and +/- 10 ft/min for reading less than 500 feet/min.

C. The output signal shall be linear with field selectable ranges including 0-5 VDC, 0-10VDC and 4-20 mA.

D. Furnish Ebtron Series 3000 airflow stations or approved equal.

PART 2 - EXECUTION

2.1 Contractor Responsibilities

A. General

Installation of the building automation system shall be performed by the Contractor or a subcontractor. However, all installation shall be under the personal supervision of the Contractor. The Contractor shall certify all work as proper and complete. Under no circumstances shall the design, scheduling, coordination, programming, training, and warranty requirements for the project be delegated to a subcontractor.

B. Demolition

1. Remove controls which do not remain as part of the building automation system, all associated abandoned wiring and conduit, and all associated pneumatic tubing and or wiring. The Owner will inform the Contractor of any equipment which is to be removed that will remain the property of the Owner. All other equipment which is removed will be disposed of by the Contractor.

C. Access to Site

1. Unless notified otherwise, entrance to building is restricted. No one will be permitted to enter the building unless their names have been cleared with the Owner or the Owner's Representative.

D. Code Compliance

1. All wiring shall be installed in accordance with all applicable electrical codes and will comply with equipment manufacturer's recommendations. Should any discrepancy be found between wiring specifications in Division 17 and Division 16, wiring requirements of Division 17 will prevail for work specified in Division 17.

E. Cleanup

1. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this contract.

2.2 Wiring, Conduit, and Cable

A. All wire will be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Std.	600 Volt
Class Two	18 Gauge Std.	300 Volt
Class Three	18 Gauge Std.	300 volt
Communications	Per Mfr.	Per Mfr.

B. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.

C. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.

D. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum 1/2 inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit seal-off fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.

E. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.

F. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

G. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit.

H. Coaxial cable shall conform to RG62 or RG59 rating. Provide plenum rated coaxial cable when running in return air plenums.

I. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140.

J. Only glass fiber is acceptable, no plastic.

K. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

L. Hardware Installation

2.3 Installation Practices for Wiring

A. All controllers are to be mounted vertically and per the manufacturer's installation documentation.

B. The 120VAC power wiring to each Ethernet or Remote Site controller shall be a dedicated run, with a separate breaker. Each run will include a separate hot, neutral and ground wire. The ground wire will terminate at the breaker panel ground. This circuit will not feed any other circuit or device.

C. A true earth ground must be available in the building. Do not use a corroded or galvanized pipe, or structural steel.

D. Wires are to be attached to the building proper at regular intervals such that wiring does not droop. Wires are not to be affixed to or supported by pipes, conduit, etc.

E. Conduit in finished areas, will be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction. Exception; metallic surface raceway may be used in finished areas on

masonry walls. All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors.

F. Conduit, in non-finished areas where possible, will be concealed in ceiling cavity spaces, plenums, furred spaces, and wall construction. Exposed conduit will run parallel to or at right angles to the building structure.

G. Wires are to be kept a minimum of three (3) inches from hot water, steam, or condensate piping.

H. Where sensor wires leave the conduit system, they are to be protected by a plastic insert.

I. Wire will not be allowed to run across telephone equipment areas.

2.4 Installation Practices for Field Devices

A. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.

B. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100 percent of the stroke.

C. Relay outputs will include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.

D. Water line mounted sensors shall be removable without shutting down the system in which they are installed.

E. For duct static pressure sensors, the high pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low pressure port shall be left open to the plenum area at the point that the high pressure port is tapped into the ductwork.

F. For building static pressure sensors, the high pressure port shall be inserted into the space via a metal tube. Pipe the low pressure port to the outside of the building.

2.5 Enclosures

A. For all I/O requiring field interface devices, these devices where practical will be mounted in a field interface panel (FIP). The Contractor shall provide an enclosure which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.

B. FIPs shall contain power supplies for sensors, interface relays and contactors, safety circuits, and I/P transducers.

C. The FIP enclosure shall be of steel construction with baked enamel finish, NEMA 1 rated with a hinged door and keyed lock. The enclosure will be sized for twenty percent spare mounting space. All locks will be keyed identically.

D. All wiring to and from the FIP will be to screw type terminals. Analog or communications wiring may use the FIP as a raceway without terminating. The use of wire nuts within the FIP is prohibited.

E. All outside mounted enclosures shall meet the NEMA-4 rating.

F. The wiring within all enclosures shall be run in plastic track. Wiring within controllers shall be wrapped and secured.

2.6 Identification

A. Identify all control wires with labeling tape or sleeves using either words, letters, or numbers that can be exactly cross-referenced with as-built drawings.

B. All field enclosures, other than controllers, shall be identified with a bakelite nameplate. The lettering shall be in white against a black or blue background.

C. Junction box covers will be marked to indicate that they are a part of the BAS system.

D. All I/O field devices (except space sensors) that are not mounted within FIP's shall be identified with name plates.

E. All I/O field devices inside FIP's shall be labeled.

2.7 Location

A. The location of sensors is per mechanical and architectural drawings.

B. Space humidity or temperature sensors will be mounted away from machinery generating heat, direct light and diffuser air streams.

C. Outdoor air sensors will be mounted on the north building face directly in the outside air. Install these sensors such that the effects of heat radiated from the building or sunlight is minimized.

D. Field enclosures shall be located immediately adjacent to the controller panel(s) to which it is being interfaced.

2.8 Software Installation

A. General.

The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third party software necessary for successful operation of the system.

B. Database Configuration.

The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.

C. Color Graphic Slides.

Unless otherwise directed by the owner, the Contractor will provide color graphic displays as depicted in the mechanical drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the owner. Graphically represent each and every piece of equipment in the class room building, new and existing, all input and put status point, and functional points. This shall include the new fans, chillers, and convectors, existing boilers, water, fuel, and ejection pumps, fan coil units, convectors, air handlers and fans.

D. Reports.

The Contractor will configure a minimum of 6 reports for the owner as listed below:

1. Central chiller Status Report
2. Hot water and chilled pump report
3. Domestic HW pump status
4. All exhaust fans, including general, toilet and stair ventilators
5. Air Handler Status Report
6. VAV Status Report
7. boiler Report
8. Space Temperature Report

E. Documentation

As built software documentation will include the following:

1. Descriptive point lists
2. Application program listing
3. Application programs with comments.
4. Printouts of all reports.
5. Alarm list.
6. Printouts of all graphics

F. Commissioning and System Startup

G. Point to Point Checkout.

Each I/O device (both field mounted as well as those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the Project Manager for submission to the owner or owner's representative.

H. Controller and Workstation Checkout.

A field checkout of all controllers and front end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the owner or owner's representative by the completion of the project.

I. System Acceptance Testing

All application software will be verified and compared against the sequences of operation. Control loops will be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.

J. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the owner.

K. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the owner.

L. Perform an operational test of each third party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

END OF SECTION 23 09 01.11

SECTION 230923.11 - CONTROL VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes control valves and actuators for DDC systems.

1.3 DEFINITIONS

A. Cv: Design valve coefficient.

B. DDC: Direct-digital control.

C. NBR: Nitrile butadiene rubber.

D. PTFE: Polytetrafluoroethylene

E. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.

2. Include details of product assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for pneumatic signal and main air tubing.

C. Delegated-Design Submittal:

1. Schedule and design calculations for control valves and actuators, including the following:

a. Flow at project design and minimum flow conditions.
b. Pressure differential drop across valve at project design flow condition.
c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.
e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Control valve installation location shown in relationship to room, duct, pipe, and equipment.
2. Size and location of wall access panels for control valves installed behind walls.
3. Size and location of ceiling access panels for control valves installed above inaccessible ceilings.

1.6 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Delegated Design: Engage a qualified professional, to size products where indicated as delegated design.

D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

E. Backup Power Source: Systems and equipment served by a backup power source shall have associated control valve actuators served from a backup power source.

F. Environmental Conditions:

1. Provide electric control valve actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control valve actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.

    a. Hazardous Locations: Explosion-proof rating for condition.

G. Body & Trim. Body and trim style and materials shall be in accordance with the manufacturer's recommendations for design conditions and service shown in compliance with the following at a minimum:
1. Valve pattern, three-way or straight through, shall be as indicated on Drawings.
2. Modulating two-way pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
3. Modulating three-way pattern water valves shall have linear flow-throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position
4. **Valve bodies shall meet or exceed pressure and temperature class rating based upon design operating temperature and 150% design operating pressure. Unless otherwise specified or scheduled, minimum body rating for any valve is 125 psi and a maximum fluid temperature of 350˚F.**
5. Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation.
6. Globe valves shall have replaceable seats.

H. Determine control valve sizes and flow coefficients by ISA 75.01.01.
1. Water Valves. Unless otherwise specified or scheduled, water valves shall follow the following criteria:
    a. Two-position service: Line size.
    b. Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through the heat exchanger (coil, load, etc.), 50% of the pressure difference between the supply and return mains, or 5 psi (Maximum).
    c. Three-way modulating service: Pressure drop shall be equal to twice the pressure drop through the heat exchanger (coil, load, etc.), (5 psi) maximum.
    d. Valves 1/2" through 2" shall be bronze or cast brass body ANSI Class 250, spring-loaded, PTFE packing quick opening for two-position service.
    e. Valves larger than 2 ½" and shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
    f. Valves 1/2" through 2" shall be ANSI/ASME B1.20.1 (NPT) threaded connections.
    g. Valves 2 ½"to 3" shall use flanged connections.

2. Steam Valves. Body and trim style and materials shall be in accordance with the manufacturer's recommendations for design conditions and service shown in compliance with the following at a minimum:
    a. Linear percentage ports for modulating service.
    b. Two-position service: Pressure drop 10% to 20% of inlet pressure.
    c. Modulating service: 15 psig or less; pressure drop 80% of inlet pressure.
    d. Modulating service: 16-50 psig or less; pressure drop 50% of inlet pressure.
    e. Modulating service: Greater than 50 psig; pressure drop as scheduled

I. Control valve characteristics and rangeability of 50;1 and shall comply with ISA 75.11.01.

J. Control valve shutoff classifications shall be FCI 70-2, Class IV. Close-Off/Differential Pressure Rating. All valves shall be guaranteed to have not more than 1% leakage of design flow rate at the pump shut-off pressure. All valve actuators and trim shall be furnished to provide the following minimum close-off pressure ratings unless otherwise specified or scheduled:
    1. Two-way water valves: 150% of total system (pump) head.
    2. Three-way water valves: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head (whichever is greater).
    3. Steam valves: 150% of operating (inlet) pressure.

K. Fail positions unless otherwise indicated:
    1. Chilled Water: close
    2. Condenser Water: close
    3. Heating Hot Water: Open.
    4. Steam: Open. n/a

L. General Characteristics:

    1. In water systems, use ball- or globe-style control valves for two-position control for valves NPS 2 and smaller and butterfly style for valves larger than NPS 2. Butterfly valves shall be for open close service only.
    2. In steam systems, use ball- or globe-style control valves regardless of size.
    3. Pneumatic, two-position control valves shall provide a smooth opening and closing characteristic slow enough to avoid water hammer. Valves with pneumatic actuators shall have an adjustable opening time (valve full closed to full open) and an adjustable closing time (valve full open to full closed) ranging from zero to 10 seconds. Opening and closing times shall be independently adjustable. (Not Used This Project)
    4. Control valve, pneumatic-control signal shall not exceed 200 feet. For longer distances, provide an electric/electronic control signal to the valve and an electric solenoid valve or electro-pneumatic transducer at the valve to convert the control signal to pneumatic. (Not Used This Project).
    5. Valves for chilled water shall use all internal trim,(including seats, rings, modulating plugs and springs), of 316 stainless steel, regardless of body style.
    6. Valves for hot water service between 210F and 250F shall have all internal trim (including seats, rings, modulating plugs and springs) of Type 316 Stainless Steel
    7. Valves for hot water service below 210F shall have all internal trim (including seats, rings, modulating plugs and springs) of Brass, Bronze or Type 316 Stainless Steel

2.2 BALL-STYLE CONTROL VALVES

A. General:
1. All control ball valves shall feature characterized flow guides when used for modulating applications.

B. Ball Valves with Single Port and Characterized Disk:

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

a. Belimo Aircontrols (USA), Inc

2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temperature Range: Zero to 212 deg F.
6. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: Chrome-plated brass or bronze or 300 series stainless steel.
9. Stem and Stem Extension:

a. Material to match ball.
b. Blowout-proof design.
c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

10. Ball Seats: Reinforced PTFE.
11. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
12. Flow Characteristic: Equal percentage.

C. Ball Valves with Two Ports and Characterized Disk:

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

a. Belimo Aircontrols (USA), Inc.

2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temperature Range: Zero to 212 deg F.
6. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: Chrome-plated brass or bronze or 300 series stainless steel].
9. Stem and Stem Extension:

a. Material to match ball.
b. Blowout-proof design.
c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

10. Ball Seats: Reinforced PTFE.
11. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
12. Flow Characteristics for A-Port: Equal percentage.
13. Flow Characteristics for B-Port: Modified for constant common port flow.

D. Ball Valves with Single Port and Segmented Ball:

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

a. Valve Solutions, Inc.

2. ASME B16.10 face-to-face dimensions.
3. Valves NPS 2 and Smaller: Threaded (NPT) ends.
4. Valves NPS 2-1/2 through NPS 6: Flanged ends suitable for mating to ASME B16.5 flanges.
5. Body: Carbon or stainless steel.
6. Ball and Shaft: Stainless steel.
7. Shaft and Segmented Ball: Pinned and welded.
8. Ball Seat: Graphite.
9. Packing: PTFE V-rings and graphite packing follower.
10. Replaceable seat, ball, and shaft packing.
11. Label each valve with following:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Flow directional arrow.

E. Ball Valves with Segmented Ball, Three-Way Pattern:

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

a. Valve Solutions, Inc.

2. Arrangement: Two single-port valves mated to a fabricated tee with interconnecting mechanical linkage.
3. Performance:

a. Process Temperature Rating: Minus 20 to plus 450 deg F.
b. ASME B16.34, Class 300.
c. Leakage: FCI 70-2, Class IV.
d. Rangeability: 300 to 1.

e. Rotation: Zero to 90 degrees.
f. Equal percentage flow characteristic.

4. Face-to-Face Dimensions: ASME B16.10.
5. Valves NPS 3through NPS 6: Flanged ends suitable for mating to ASME B16.5 flanges.
6. Body: Carbon or stainless steel.
7. Ball and Shaft: Stainless steel.
8. Shaft and Segmented Ball: Pinned and welded.
9. Ball Seat: Graphite.
10. Packing: PTFE V-rings and graphite packing follower.
11. Replaceable seat, ball, and shaft packing.
12. Label each valve with following:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Flow directional arrow.

F. Ball Valves with Full Ball and Characterized V-Notch:

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

a. Flow-Tek, Inc.

2. Performance:

a. Process Temperature Rating: Minus 20 to plus 500 deg F.
b. ASME B16.34, Class 600 for NPS 2 and smaller; Class 150 or Class 300 for larger than NPS 2.
c. Leakage: FCI 70-2, Class VI, bi-directional.
d. Rangeability: Varies from 200 to 1 up to 800 to 1 based on notch pattern of ball.
e. Rotation: Zero to 90 degrees.
f. Equal percentage flow characteristic.
g. Full port.

3. Face-to-Face Dimension: ASME B16.10 long pattern.
4. Valves NPS 2 and Smaller: ASME B1.20.1 threaded (NPT) ends and three-piece body.
5. Valves NPS 2-1/2 through NPS 12: Flanged ends suitable for mating to ASME B16.5 flanges and two-piece body.
6. Hole in the stem slot of each ball equalizes pressure between the body cavity and the line media flow.
7. Replaceable seat, ball, and shaft packing.
8. Body: Carbon or stainless steel.
9. Ball and Shaft: Stainless steel.
10. Ball Seat: RPTFE.
11. Stem Seals for Valves NPS 2 and Smaller: Live-loaded, self-adjusting, primary and secondary sealing using belleville washers.

a. Primary Seal: Combination of thrust washer and thrust washer protector.
b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.

12. Stem Seals for Valves Larger than NPS 2: Independent packing gland, adjusted without removing mounting hardware or operator, and contoured to uniformly distribute load across packing.

    a. Primary Seal: Combination of thrust washer and thrust washer protector.
    b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.

13. Label each valve with following:

    a. Manufacturer's name, model number, and serial number.
    b. Body size.
    c. Flow directional arrow.

G. Pressure-Independent Ball Valves NPS 2 and Smaller:

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

    a. Belimo Aircontrols (USA), Inc.
    b. HCI; Hydronics Components Inc.

2. Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.
3. Body: Forged brass, nickel plated, and with threaded ends.
4. Ball: Chrome-plated brass.
5. Stem and Stem Extension: Chrome-plated brass, blowout-proof design.
6. Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
7. Ball Seats: Reinforced PTFE.
8. Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.
9. Flow Characteristic: Equal percentage.

2.3 BUTTERFLY-STYLE CONTROL VALVES

A. General:
1. Unless otherwise indicated, butterfly valves shall have a minimum range ability of 10:1. All valves shall be guaranteed to have not more than 1% leakage of design flow rate at the pump shut-off pressure
2. Flanges shall meet all ANSI 125 and ANSI 150 standards.
3. Valve shall have a long stem design to accommodate 2 inches insulation.
4.

B. Two-Way Butterfly Valves:

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

a. Keystone; Tyco Flow Control.

2. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
3. Disc: 316 stainless steel.
4. Shaft: 316 or 17-4 PH stainless steel.
5. Seat: Reinforced EPDM or reinforced PTFE with retaining ring.
6. Shaft Bushings: Reinforced PTFE or stainless steel.
7. Replaceable seat, disc, and shaft bushings.
8. Corrosion-resistant nameplate indicating:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Body and trim materials.
d. Flow arrow.

C. Three-Way Butterfly Valves:

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

a. Keystone; Tyco Flow Control.

2. Arrangement: Two valves mated to a fabricated tee with interconnecting mechanical linkage.
3. Performance:

a. Bi-directional bubble tight shutoff at 250 psig.
b. Comply with MSS SP-67 or MSS SP-68.
c. Rotation: Zero to 90 degrees.
d. Linear or modified equal percentage flow characteristic.

4. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
5. Disc: 316 stainless steel.
6. Shaft: 316 or 17-4 PH stainless steel.
7. Seat: Reinforced EPDM or reinforced PTFE seat with retaining ring.
8. Shaft Bushings: Reinforced PTFE or stainless steel.
9. Replaceable seat, disc, and shaft bushings.
10. Corrosion-resistant nameplate indicating:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Body and trim materials.
d. Flow arrow.

2.4 GLOBE-STYLE CONTROL VALVES

A. General Globe-Style Valve Requirements:

1. Globe-style control valve body dimensions shall comply with ISA 75.08.01.
2. Construct the valves to be serviceable from the top.
3. For cage guided valves, trim shall be field interchangeable for different valve flow characteristics, such as equal percentage, linear, and quick opening.
4. Reduced trim for one nominal size smaller shall be available for industrial valves NPS 1 and larger.
5. Replaceable seats and plugs.
6. Furnish each control valve with a corrosion-resistant nameplate indicating the following:

    a. Manufacturer's name, model number, and serial number.
    b. Body and trim size.
    c. Arrow indicating direction of flow.

B. Two-Way Globe Valves NPS 2 and Smaller:

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

    a. Johnson Controls, Inc.

2. Globe Style: Single port.
3. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
4. End Connections: Threaded.
5. Bonnet: Screwed.
6. Packing: PTFE V-ring.
7. Plug: Top guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Range: 35 to 248 deg F.
10. Ambient Operating Temperature: 35 to 150 deg F.
11. Leakage: FCI 70-2, Class IV.
12. Rangeability: 25 to 1.
13. Equal percentage flow characteristic.

C. Three-Way Globe Valves NPS 2 and Smaller:

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

    a. Johnson Controls, Inc.

2. Globe Style: Mix flow pattern.
3. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
4. End Connections: Threaded.
5. Bonnet: Screwed.
6. Packing: PTFE V-ring.
7. Plug: Top guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Range: 35 to 248 deg F.
10. Ambient Operating Temperature: 35 to 150 deg F.
11. Leakage: FCI 70-2, Class IV.
12. Rangeability: 25 to 1.

13. Linear flow characteristic.

D. Two-Way Globe Valves NPS 2-1/2 to NPS 6:

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

a. Johnson Controls, Inc.

2. Globe Style: Single port.
3. Body: Cast iron complying with ASME B61.1, Class 125.
4. End Connections: Flanged, suitable for mating to ASME B16.5, Class 150 flanges.
5. Bonnet: Bolted.
6. Packing: PTFE cone-ring.
7. Plug: Top or bottom guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Rating: 35 to 281 deg F.
10. Leakage: 0.1 percent of maximum flow.
11. Rangeability: Varies with valve size between 6 and 10 to 1.
12. Modified linear flow characteristic.

E. Three-Way Globe Valves NPS 2-1/2 to NPS 6:

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

a. Johnson Controls, Inc.

2. Globe Style: Mix flow pattern.
3. Body: Cast iron complying with ASME B61.1, Class 125.
4. End Connections: Flanged suitable for mating to ASME B16.5, Class 150 flanges.
5. Bonnet: Bolted.
6. Packing: PTFE cone-ring.
7. Plug: Top or bottom guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Rating: 35 to 281 deg F.
10. Leakage: 0.1 percent of maximum flow.
11. Rangeability: Varies with valve size between 6 and 10 to 1.
12. Modified linear flow characteristic.

2.5 SOLENOID VALVES

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

1. ASCO Valve, Inc.

B. Description:

1. Action: Either normally open or normally closed in the event of electrical power failure as required by the application.

2. Size to close against the system pressure.
3. Manual override capable.
4. Heavy-duty assembly.
5. Body: Brass or stainless steel.
6. Seats and Discs: NBR or PTFE.
7. Solenoid Enclosure: NEMA 250, Type 4.

2.6 SELF-CONTAINED TEMPERATURE REGULATING VALVE

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

1. Jordan Valve; Richards Industries Company.

B. Description:

1. Self-contained and self-operated temperature regulating valve. Direct acting or reverse acting as required by application.
2. Direct Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn closing the valve. The valve shall fail open.
3. Reverse Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn opening the valve. The valve shall fail close.
4. Body: Carbon steel.
5. Trim and Seats: 300 series stainless steel.
6. Yoke: Cast iron.
7. Actuator: 300 series stainless steel.
8. End Connections: Threaded.
9. Capillary, Bulb, and Armor: 300 series stainless steel.
10. Thermal Fill Material: Match to the temperature range.
11. Thermowell: Type 316 stainless-steel thermowell sized to fit the bulb and pipe.

C. Operational Characteristics: Control flow from between 5 to 100 percent of rated capacity.

D. Interchangeable trim for one size smaller.

E. Valve Leakage: Comply with FCI 70-2, Class IV.

F. Temperature Range: Match application.

1. Drains from Hot Equipment to Sanitary Sewer System: 105 to 165 deg F.

G. Valve Size: Size to pass the design flow required with not more than 95 percent of the stem lift while operating at design pressure.

2.7 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.

B. Actuators for Steam Control Valves: Shutoff against 1.5 times steam design pressure.

C. Position indicator and graduated scale on each actuator.

D. Type: Motor operated, with or without gears, electric and electronic.

E. Voltage: 24-V ac.

F. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

G. Function properly within a range of 85 to 120 percent of nameplate voltage.

H. Construction:

1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
4. All control valves shall have a visual position indicator.
5. All non-spring return actuators shall have an external clutch/manual gear release to allow manual positioning of the valve when the actuator is not powered. Spring return actuators with more than 60-in-LB torque capacity shall have a manual crank for this purpose. In lieu of a manual positioning device, it will be acceptable for the contractor to provide a full line size bypass around the control valve. Three bypass shut off valves shall be provided to allow the control valve to be isolated while the open stop valve in the bypass allows flow around the control valve.

I. Field Adjustment:

1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

J. Two-Position Actuators: Single direction, spring return or reversing type.

K. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc 4- to 20-mA signals.
c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
d. Programmable Multi-Function:

1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

3. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation

L. Position Feedback:

1. Equip where indicated two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Equip where indicated, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

M. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.
4. Any mechanical equipment with direct introduction of outside air shall require fail-safe spring return valve actuators. Terminal equipment (VAV ATU, &c.) without direct introduction of outside air are permitted to have actuators that maintain their last commanded position when power is lost to the actuator. Equipment isolation and differential or temperature pressure bypass valves shall not be required to be provided with a spring return actuator provided that a failure of the valve to return to its “fail-safe” position will not incur damage to property or the system it serves.

N. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

O. Valve Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

P. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

Q. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.
5. Actuators used in wet conditions and/or in or near outdoor air streams shall have NEMA 2 housings.

R. Stroke Time:

1. Operate valve from fully closed to fully open within 60 75 90 150 Insert number seconds.
2. Operate valve from fully open to fully closed within 60 seconds.
3. Move valve to failed position within 15 seconds.
4. Select operating speed to be compatible with equipment and system operation.

S. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

2.8 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies & Control Transformers. Control transformers and power supplies shall be UL-Listed. Provide Class 2 current-limiting type or over-current protection in both primary and secondary circuits for Class 2 service not to exceed 100 VA in accordance with the applicable following requirements or as directed by the AHJ.
1. NEC 2011 (NFPA 70) Chapter 7 Article 725 – Class 1, Class 2 and Class 3 Remote-Control, Signaling and Power-Limited Circuits.
2. NEC 2011 (NFPA 70) Chapter 9 Table 11(A) and Table 11(B).
3. Canadian Electrical Code, Part 1 (CSA C22.1-12) Rule 16-200.

B. DC Power Supplies. DC power supply output shall match output current and voltage requirements. Power supply shall be half-wave rectified type with the following minimum specifications:
1. Output ripple: 5.0 mV maximum peak-to-peak.

2. Regulation: 1.0% line and load combined.
3. Response: 100 ms for 50% load changes.
4. Built-in overvoltage and overcurrent protection and able to withstand a 150% current overload for a minimum of three (3) seconds without tripping or failure.

C. Power Line Filtering. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component.

D. Valve Actuators shall be modulating, floating (tri-state) with feedback signal, two-position and spring return fail safe as called out in the control sequence of operation or indicated on the drawings. All modulating valves shall be positive positioning, and respond to a [0-10VDC] [2-10 VDC] [4-20 mA with a load resistor] with the exception that terminal unit zone valves may use an actuator that responds to a floating or tri-state with feedback signal.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 CONTROL VALVE APPLICATIONS

A. Unless otherwise noted, controls valves shall be globe pattern.

B. Do not use butterfly valves for steam service or modulating applications.

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.

F. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including. but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring, as per electrical specifications

D. Furnish and install raceways as per electrical specifications.

E. Electrical subcontractor shall provide all required line voltage. The mechanical subcontractor shall provide all low voltage wiring and power supply transformers in coordination with the controls subcontractor and control actuator requirements.

3.5 CONTROL VALVES

A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Where indicated, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing manual throttling valve in bypass pipe.

D. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold and for each control valve larger than NPS 4.

E. Install pressure temperature taps in piping upstream and downstream of each control valve larger than NPS 2.

F. Valve Orientation:

1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

G. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

H. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

I. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

3.6 CONNECTIONS

A. Connect electrical devices and components to electrical grounding system. Comply with electrical specifications

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 230553.

B. Install engraved phenolic nameplate with valve identification on valve.

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.9 CHECKOUT PROCEDURES

A. Control Valve Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check valves for proper location and accessibility.
3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic valves, verify that pressure gauges are provided in each air line to valve actuator and positioner.
6. Verify that control valves are installed correctly for flow direction.
7. Verify that valve body attachment is properly secured and sealed.
8. Verify that valve actuator and linkage attachment are secure.
9. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
10. Verify that valve ball, disc, and plug travel are unobstructed.
11. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.11

SECTION 230923.12 - CONTROL DAMPERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes the following types of control dampers and actuators for DDC systems:

1. Rectangular control dampers.
2. General control-damper actuator requirements.
3. Pneumatic actuators.
4. Electric and electronic actuators.

1.3 DEFINITIONS

A. DDC: Direct-digital control.

B. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.
5. Include diagrams for pneumatic signal and main air tubing.

C. Delegated-Design Submittal:

1. Schedule and design calculations for control dampers and actuators, including the following.

a. Flow at project design and minimum flow conditions.
b. Face velocity at project design and minimum airflow conditions.
c. Pressure drop across damper at project design and minimum airflow conditions.
d. AMCA 500D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
e. Maximum close-off pressure.
f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Product installation location shown in relationship to room, duct, and equipment.
2. Size and location of wall access panels for control dampers and actuators installed behind walls.
3. Size and location of ceiling access panels for control dampers and actuators installed above inaccessible ceilings.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE AND GENERAL REQUIREMENTS

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

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Backup Power Source: Systems and equipment served by a backup power source shall have associated control damper actuators served from a backup power source.

E. All Automatic Control Dampers provided as a part of this Specification shall bear the AMCA Seal as an indication that they comply with all requirements of the AMCA Certified Ratings Programs.

F. Maximum leakage rate through any 48 inches by 48 inches closed damper in any application shall not exceed 10.0 cfm per sq. ft. of damper face area at 4 inches of water pressure differential and a maximum closing torque of 4 inch-lbs./sq. ft. of damper face area. Damper leakage ratings shall be certified in accordance with AMCA Standard 500-D.

G. Environmental Conditions:

1. Provide electric control-damper actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control-damper actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.

    a. Hazardous Locations: Explosion-proof rating for condition.
    b. All outdoor air damper components shall be suitable for applications operating in the temperature range of -40F to 167F.

H. Selection Criteria:

1. Fail positions unless otherwise indicated:

    a. Supply Air: Open.
    b. Return Air: Open.
    c. Outdoor Air: Close.
    d. Mixed Air: Open.
    e. Exhaust Air: Close.

2. Dampers shall have stable operation throughout full range of operation, from design to minimum airflow over varying pressures and temperatures encountered.
3. Select modulating dampers for a pressure drop of 5 percent of fan total static pressure unless otherwise indicated.
4. Two-position dampers shall be full size of duct or equipment connection unless otherwise indicated.
5. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service. Use opposed blade configuration for modulating, mixing and any application of upstream critical components.
6. Pneumatic, two-position control dampers shall provide a smooth opening and closing characteristic slow enough to avoid excessive pressure. Dampers with pneumatic actuators shall have an adjustable opening time (valve full closed to full open) and an adjustable closing time (valve full open to full closed) ranging from zero to 10 seconds. Opening and closing times shall be independently adjustable. (Not Used For This Project)

2.2 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.

B. Rectangular Dampers with Aluminum Airfoil Blades:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
    1) Ruskin Company.
    2) Arrow
    3) Nailer Hart
    4) Green heck

2. Performance:

    a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
    b. Pressure Drop: 0.05-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
    c. Velocity: Up to 6000 fpm.
    d. Temperature: Minus 40 to plus 185 deg F.
    e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
    f. Damper shall have AMCA seal for both air leakage and air performance.

3. Construction:

    a. Frame:

        1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.
        2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
        3) Width not less than 5 inches.

    b. Blades:

        1) Hollow, airfoil, extruded aluminum.
        2) Parallel or opposed blade configuration as required by application.
        3) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.07 inch thick.
        4) Width not to exceed 6 inches.
        5) Length as required by close-off pressure, not to exceed 48 inches.

    c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch- diameter stainless steel, mechanically attached to blades.
e. Bearings:

1) Molded synthetic or stainless-steel sleeve mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and galvanized plated or stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments: **(Not Used)**

1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

4. Airflow Measurement:

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

1) Ruskin Company.
2) Arrow
3) Nailer Hart
4) Green heck

b. Where indicated, provide damper assembly with integral airflow monitoring.
c. Zero- to 10-V dc or 4- to 20-mA scaled output signal for remote monitoring of actual airflow.
d. Accuracy shall be within 5 percent of the actual flow rate between the range of minimum and design airflow. For applications with a large variation in range between the minimum and design airflow, configure the damper sections and flow measurement assembly as required to comply with the stated accuracy over the entire modulating range.

e. Provide a straightening device as part of the flow measurement assembly to achieve the specified accuracy with configuration indicated.
f. Suitable for operation in untreated and unfiltered air.
g. Provide temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
h. Provide automatic zeroing feature.

5. Airflow Control:

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1) Ruskin Company.
2) Arrow
3) Nailer Hart
4) Green heck

b. Where indicated, provide damper assembly with integral airflow measurement and control.
c. A factory-furnished and -calibrated controller shall be programmed, in nonvolatile EPROM, with application-specific airflow set point and range.
d. The controller and actuator shall communicate to control the desired airflow.
e. The controller shall receive a zero- to 10-V dc input signal and report a zero- to 20-mA output signal that is proportional to the airflow.
f. Airflow measurement and control range shall be suitable for operation between 150 to 2000 fpm.
g. Ambient Operating Temperature Range: Minus 40 to plus 140 deg F.
h. Ambient Operating Humidity Range: 5 to 95 percent relative humidity, non-condensing.
i. Provide unit with control transformer rated for not less than 85 VA. Provide transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.
j. Provide screw terminals for interface to field wiring.
k. Factory mount electronics within a NEMA 250, Type 1 painted steel enclosure.

C. Industrial-Duty Rectangular Dampers with Steel Airfoil Blades:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
1) Ruskin Company.
2) Arrow
3) Nailer Hart
4) Green heck

2. Performance:

a. Leakage: Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
b. Pressure Drop: 0.06-in. wg at 2000 fpm across a 48-by-48-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 40 to plus 250 deg F.

e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, minimum 10-in. wg.

3. Construction:

a. Frame:

1) Material: Galvanized or stainless steel, 0.11 inch thick.
2) C-shaped channel. Mating face shall be a minimum of 1 inch.
3) Width not less than 3 inches.

b. Blades:

1) Hollow, airfoil, galvanized or stainless steel.
2) Parallel or opposed blade configuration as required by application.
3) Material: Galvanized or stainless steel, 0.06 inch thick.
4) Width not to exceed 6 inches.
5) Length not to exceed 48 inches.

c. Seals:

1) Blades: Replaceable, mechanically attached EPDM or extruded silicone.
2) Jambs: Stainless steel, double compression type.

d. Axles: 0.5- or 0.75-inch- diameter stainless steel, mechanically attached to blades and continuous from end to end.

e. Bearings:

1) Stainless-steel sleeve type mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Face linkage exposed to airstream.
2) Constructed of plated or stainless steel.
3) Hardware: Stainless steel.

D. Insulated Rectangular Dampers:

1. Performance:

a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure and shall not exceed 4.9 cfm/sq. ft. against 4-in. wg differential static pressure at minus 40 deg F.
b. Pressure Drop: 0.1-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 100 to plus 185 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles, 0.08 inch thick.
2) C-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
3) Width not less than 4 inches.
4) Entire frame shall be thermally broken by means of polyurethane resin pockets, complete with thermal cuts.
5) Damper frame shall be insulated with polystyrofoam on four sides.

b. Blades:

1) Hollow shaped, extruded aluminum.
2) Blades shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.
3) Parallel or opposed blade configuration as required by application.
4) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.08 inch thick.
5) Width not to exceed 6 inches.
6) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals: Blade and frame seals shall be of flexible silicone and secured in an integral slot within the aluminum extrusions.
d. Axles: 0.44-inch- diameter plated or stainless steel, mechanically attached to blades.
e. Bearings:

1) Bearings shall be composed of a Celcon inner bearing fixed to axle, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and plated or stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

2.3 GENERAL, OPERATING LINKAGES AND DAMPER ACCESSORIES

A. All operating linkages and/or damper accessories required for installation and application in accordance with specification design intent and manufacturer's installation procedures shall be provided

B. Operating linkages provided external to dampers (crank arms, connecting rods, shaft extensions, &c.) for transmitting motion from the actuator/operator to dampers shall be designed as to functionally operate a load equal to or in excess of 300% of the maximum required operating force for the damper.

C. Crank arms and connecting rods shall be adjustable. Linkages shall be brass, bronze, zinc-coated steel, or stainless steel.

D. Adjustments of Crank Arms shall control the position of the damper

E. Use of Operating Linkages external to damper drive shaft shall neither delay nor impede operation of the damper in a manner of performance less than a direct-coupled damper actuator. Operating linkages shall not under any circumstances be permitted to flex, warp, shift &c. under normal operation of connected damper sections.

2.4 GENERAL, CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Control damper actuators shall be electronic direct-coupled type. Actuators shall have a means for reversing drive direction and a manual override accessible at the front cover

B. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

C. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

D. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

E. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

F. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

G. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

H. Provide mounting hardware and linkages for connecting actuator to damper. Single bolt or setscrew type fasteners are not acceptable.

I. Select actuators to fail in desired position in the event of a power failure. For spring return fail-safe applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.

J. Actuator Fail Positions: As indicated below refer to sequence of operations for additional information regarding specific equipment:

1. Exhaust Air: Close.
2. Outdoor Air: Close.
3. Supply Air: Open.
4. Return Air: Open.

K. All non-spring return actuators shall have an external manual clutch/gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-LB torque capacity shall have a manual crank for this purpose.

2.5 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage:

1. 24 V.
2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

D. Field Adjustment:

1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. Modulating Actuators:

1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.
c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink or source controller.
d. Programmable Multi-Function: (Not Used)

1) Control input, position feedback, and running time shall be factory or field programmable.
2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
3) Service data, including at a minimum, number of hours powered and number of hours in motion.

G. Position Feedback:

1. Equip where indicated, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Equip where indicated, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

H. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

I. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

J. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

K. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

L. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

M. Stroke Time:

1. Operate damper from fully closed to fully open within 60 75 90 150
2. Operate damper from fully open to fully closed within 60 75 90 150
3. Move damper to failed position within 15 30 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

N. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

2.6 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies & Control Transformers. Control transformers and power supplies shall be UL-Listed. Provide Class 2 current-limiting type or over-current protection in both primary and secondary circuits for Class 2 service not to exceed 100 VA in accordance with the applicable following requirements or as directed by the AHJ.
1. NEC 2011 (NFPA 70) Chapter 7 Article 725 – Class 1, Class 2 and Class 3 Remote-Control, Signaling and Power-Limited Circuits.
2. NEC 2011 (NFPA 70) Chapter 9 Table 11(A) and Table 11(B).
3. Canadian Electrical Code, Part 1 (CSA C22.1-12) Rule 16-200.

B. DC Power Supplies. DC power supply output shall match output current and voltage requirements. Power supply shall be half-wave rectified type with the following minimum specifications:
1. Output ripple: 5.0 mV maximum peak-to-peak.

2. Regulation: 1.0% line and load combined.
3. Response: 100 ms for 50% load changes.
4. Built-in overvoltage and overcurrent protection and able to withstand a 150% current overload for a minimum of three (3) seconds without tripping or failure.

C. Power Line Filtering. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 CONTROL-DAMPER APPLICATIONS

A. Control Dampers:
   a. Use opposed blade type dampers for all modulating damper applications
   b. Use parallel blade type damper for all open closed applications.
   c. Damper actuation stroke time shall be adjustable
   d. Damper position feedback is required for all dampers that are part of a smoke purge or smoke control system.

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.

C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:

1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

G. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.
    c. Natatorium supply, return or exhaust air

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Electrical subcontractor shall provide all required line voltage. The mechanical subcontractor shall provide all low voltage wiring and power supply transformers in coordination with the control’s subcontractor and control actuator requirements.
1. Furnish and install electrical power to products requiring electrical connections.
2. Furnish and install circuit breakers. Comply with requirements of the electrical specifications.
3. Furnish and install power wiring. Comply with requirements of the electrical specifications.
4. Furnish and install raceways. Comply with requirements of the electrical specifications.

3.5 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 30 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.6 CONNECTIONS

A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 230553.

B. Install engraved phenolic nameplate with damper identification on damper.

3.8 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic dampers, verify that pressure gages are provided in each airline to damper actuator and positioner.
6. Verify that control dampers are installed correctly for flow direction.
7. Verify that proper blade alignment, either parallel or opposed, has been provided.
8. Verify that damper frame attachment is properly secured and sealed.
9. Verify that damper actuator and linkage attachment are secure.

10. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
11. Verify that damper blade travel is unobstructed.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.12

SECTION 230923.16 - GAS INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes the Following Gas Instruments:

1. Carbon-monoxide sensors and transmitters. CO
2. Nitrogen-dioxide sensors and transmitters. NO2
3. VOC sensors and transmitters.
4. Multipoint monitoring system.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.16.

1.3 DEFINITIONS

A. NDIR: Nondispersive infrared.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Installation instructions, including factor affecting performance.
3. Product description with complete technical data, performance curves, product specification sheets.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.

2. Include diagrams for power, signal, and control wiring.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Samples: For each exposed product installed in finished space.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which wall-mounted instruments located in finished space are shown and coordinated with each other, showing relationship to light switches, fire alarm devices, and other installed devices using input from installers of the items involved.

B. Product Test Reports: For each product, for tests performed by a qualified testing agency.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 CARBON-MONOXIDE AND NITROGEN DIOXIDE SENSORS AND TRANSMITTERS

A. Manufactures
1. Sierra monitoring and controls
2. Honeywell analytical
3. Armstrong Monitoring

B. Description:

1. NDIR technology or equivalent technology providing long-term stability and reliability.
2. Two-wire, 4-20 mA output signal, linearized to gas concentration in ppm.

C. Construction:

1. House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 1 enclosure for wall-mounted space applications and NEMA 250, Type 4 for duct-mounted applications.
2. Equip with digital display for continuous indication of gas concentration.

D. Performance:

1. Measurement Range: Zero to 2000 ppm.
2. Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
3. Repeatability: Within 1 percent of full scale.
4. Temperature Dependence: Within 0.05 percent of full scale over an operating range of 25 to 110 deg F

5. Long-Term Stability: Within 5 percent of full scale after more than five years.
6. Response Time: Within 60 seconds.
7. Warm-up Time: Within five minutes.

E. Provide calibration kit. Turn over to Owner at start of warranty period.

2.2 MULTIPOINT CARBON-MONOXIDE and NITROGEN DIOXIDE MONITORING SYSTEM

A. Manufactures
1. Sierra monitoring and controls
2. Honeywell analytical
3. Armstrong Monitoring

B. Description:

1. Each sampling point shall monitor any variation in the carbon-monoxide and NO2 concentration level.
2. Each sampling point shall be individually piped to the monitoring system.
3. Provide each sampling point with a 0.3-micron filter.
4. Each sampling point shall be an alarm point.
5. A dual-head diaphragm pump shall draw an air sample through piping system and through a microprocessor-controlled sequencer feeding an analyzer with a new sample every 15 seconds.
6. Sample time shall be adjustable in 1 second increments from zero to 60 minutes.
7. Span and zero calibration gas shall be automatically initiated by the microprocessor. System shall also provide manual initiation of span and zero calibration gas.
8. Analyzer output shall be corrected by the microprocessor.
9. Monitoring system shall have minimum 32 sample points.
10. System shall operate on 120-V ac, single-phase, 60-Hz power.
11. Final adjustment; calibration, testing, and startup of the system shall be performed by a trained representative of manufacturer.

C. Analyzer:

1. Analyzer shall operate using principle of nondispersive infrared absorption.
2. Sampling response time shall be within 10 seconds.
3. Zero drift and span drift shall be less than 1 percent of full scale within a 24-hour period.
4. Repeatability shall be within 1 percent of full scale.
5. Accuracy shall be within 1 percent of full scale.
6. Calibration range shall be zero to 500 ppm.
7. Digital display on analyzer face with scale shall be in ppm.
8. Temperature shall be compensated from 30 to 120 deg F ambient temperature.

D. Control and Display:

1. Each sample shall send a 4-20 mA output signal proportional to the highest concentration.
2. Alphanumeric visual display of current analyzer concentration reading shall be in ppm or another industry-accepted measurement.

3. Visual indication for sample analyzing, sample high-concentration alarm, analyzer malfunction, and calibration.
4. Any number and configuration of sample points shall be capable of being bypassed.
5. Each sample point shall be capable of being manually sampled through an override feature.
6. System parameters shall be stored in nonvolatile memory.
7. Provide at least an eight-hour battery backup of current alarm status. Battery shall be rechargeable.

E. Enclosure:

1. NEMA 250, Type 1 or Type 12.
2. Hinged and locking door, full size of face.
3. House all system components. Multiple adjoining enclosures are acceptable if joined to a common support structure.

F. Calibration Equipment:

1. Provide equipment necessary to automatically and manually calibrate the system, including, but not be limited to, the following:

a. Regular assembly.
b. Zero cap.
c. Calibration cap.
d. Two cylinders filled with calibration gas.
e. Instruction book.
f. Carrying case.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

G. PROTECTION
1. Provide steel protection guards for all sensors located in the garage area. Guards are to factor or field fabricated out of heavy gauge galvanized steel.

3.3 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Install transmitters for gas associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
2. Install space sensors in location where they are least likely to be damaged. Plans indicate general locations. Final locations shall be coordinated in the field with other trades. In general, where located in traffic areas install on the back of columns where damage is least likely.
3. Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
5. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches.

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.5 CARBON-MONOXIDE and NITROGEN DIOXIDE MONITORING SYSTEM

A. Install sample points in monitored area to provide accurate measurement of gas concentration.

B. Install exposed sampling points with a finished appearance consistent with other materials in space. Submit proposed products to be installed for review and approval.

C. Individually install each sample point to the carbon-monoxide monitoring system.

D. Install tubing in a minimum size of NPS 3/8.

E. Use compression fittings at connections to equipment.

F. If not indicated on Drawings, locate carbon-monoxide monitoring system in a secured and serviceable location accessible to authorized personnel.

G. Support carbon-monoxide monitoring system from floor or wall. Support floor-mounted systems using a structural channel frame. Provide mounting brackets.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 23 05 53 "Identification for HVAC Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.7 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have an accuracy of at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.

9. Comply with field-testing requirements and procedures in ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

E. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

F. Switches: Calibrate switches to make or break contact at set points indicated.

G. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.9 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of gas system and equipment Installer. Include annual preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.10 DEMONSTRATION

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

B. Coordinate gas instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.16

SECTION 230993 SEQUENCE OF OPERATION (FROM CMSV)

PART 1 GENERAL

1.01 SECTION INCLUDES

1. Summer Winter Change Over
2. Boiler Plant
3. Chiller plant
4. Variable Speed Hot/Chilled Water Pumping System Control
5. VAV Air Conditioning Units: AC-1 And AC-2
6. Constant Volume Packaged Rooftop Units. RTU2-1 RTU2-2
7. Supplemental Air Conditioning Units AC-1
8. Supplemental Air Conditioning Units AC-2 AC-3
9. Air Conditioning Condensate pumps
10. Unit Heaters
11. Cabinet convectors
12. Finned tube radiation
13. Radiant Heat systems
14. Constant volume air handling units HV-2-1 through HV-4-4
15. Vehicle Exhaust System
16. Constant volume air handling units HV-4-1 through HV-4-6
17. Miscellaneous:

1.02 RELATED SECTIONS

A. Section 23 0901 - Digital Control Equipment.

B. Section 230900 - Instruments and Control for HVAC.

1.03 SYSTEM DESCRIPTION

A. This Section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other Sections.

B. Provide DDC based electronic controls, panels, wiring and all accessories required to achieve the specified control sequences and establish a complete independent system for all new equipment and existing equipment. In general, the equipment shall be controlled through Standalone Digital Control Units (SDCUs).

Provide the necessary quantity and types of SDCUs to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each SDCU will operate completely standalone, containing all of the I/O and programs to control its associated equipment.

Certain controls are specified to be furnished with the equipment. This contractor shall provide all components to communicate with factory furnished controls and

connect them to the building automation control system. The contractor shall also provide all controls, wiring and auxiliaries required to operate equipment not furnished with factory controls. Work required includes, but is not limited to the following:

1. Control wiring between factory mounted unit panels and factory supplied remote panels.
2. Installation and wiring for factory supplied devices requiring field installation.
3. Panel mounted transformers and control power wiring for all controllers and control devices.
4. Control wiring to each remote device (room thermostats, outdoor air sensors, static pressure controllers, control actuators, control panels, etc.).
6. All control valves, motorized dampers thermostats, relays, sensors, etc. unless furnished as an integral part of the equipment.
7. All interlock control wiring (24 volt and 120 volt) between units, fans, etc.

C. All control and interlock wiring shall be run in EMT for indoor locations and in galvanized conduit for outdoor locations.

D. **All new controllers, hardware and accessories shall be ANDOVER CONTINUUM SERIES VERSION 1.9. OR LATER all new hardware, software and programming shall be compatible with the existing campus system.**

1.04 SUBMITTALS FOR REVIEW

A. Division 1 - Submittals: Procedures for submittals.

B. Shop Drawings: Indicate mechanical system controlled and control system components.

1. Label with settings, adjustable range of control and limits. Include written description of control sequence.
2. Include flow diagrams for each control system, graphically depicting control logic.
3. Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.
4. Submit a complete written sequence of operation for each and every controlled piece of equipment.

1.05 SUBMITTALS AT PROJECT CLOSEOUT

A. Operation and Maintenance Data.

B. Project Record Documents: Record actual locations of components and set-points of controls, including changes to sequences made after submission of shop drawings.

1.06 QUALITY ASSURANCE

A. Design system under direct supervision of a Professional Engineer experienced in design of this Work and licensed in the State of New York.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION

3.01 Summer/Winter Change Over

The Building Automation System Building Management System (BMS) shall index the heating and cooling system equipment into either summer or winter control based upon outdoor air temperature. Below 65 F, (adjustable), outside air temperature, the cooling systems shall be disabled. Above 55F, (adjustable), outside air temperature the hot water and gas heating system shall disabled. The system operator shall have capacity of overriding the system for manual change over. During heating mode, the chiller and condensers shall be locked out.

3.02 Boiler Plant:

Boilers shall be operated through the manufactures application specific unitary controller built in to the boilers. Refer to section 235216 for all safeties and combustion control sequences. The controller shall be microprocessor-based system engineered and programmed exclusively for the operation of multiple hot water boilers. Safety and firing controls, and hot water reset shall be done by each boiler built-in microprocessor. The Andover “boiler room” controller shall start and stop the boiler, rotate the lead and lag boiler for equal running time, reset hot water temperature, and interlock pumps with boiler controls.

The communications protocol for the burner controls shall be based on ASHRA/ANSI BACNET Standard 135-1995. Provide required modules to allow open communication, integration and interoperability with other BMS system. The ATC contractor and boiler manufacturer shall coordinate their work to insure compatibility prior to installation.

When the heating plant is enabled to run the building lead secondary pump shall run (HWP-3 and HWP-4) shall run continuously. Each boiler’s primary pump, (HWP-1 and HWP-2) shall be enabled to start when the respective boiler is enabled to fire. Provide a flow switch in each boiler’s primary pipe sub header to determine flow. If flow is not proven the boiler shall be disabled and the standby boiler shall be enabled to run. The boiler plant controller or the boiler manufacturers built in controller shall be arranged to rotate the boilers for equal running time. After proof of flow, the boiler’s packaged safety and operating controls shall be enable the boilers to maintain their individual supply water set-point as set through the BMS system. The BMS shall monitor and alarm primary hot water supply and return temperatures in addition to primary pump status.

The BMS system shall sequence the hot water boilers to maintain the secondary hot water loop temperature set-point. The set-point shall be reset by the outdoor air temperature sensor. Reset schedule to be 180 F to 120 F hot water supply temperature as outside air varies from 10 F to 55 F. adjustable). Lead boiler selection shall be made by the BMS system according to a rotating seven day schedule.

BMS BOILER ROOM ALARMS;

Boiler room alarms;
Common failure alarm for each boiler.
High temperature
Low temperature
Primary pump failure
Secondary pump failure
Low water level
High / pressure
High / low gas pressure
Temperature out of bounds

3.03 Chiller Plant;

The cooling plant shall be manually or automatically started through the DDC system.
The DDC system change the system from heating to cooling operation based on outdoor air temperature. Set point shall be 70 degrees or above, for cooling and 55° or lower for heating. The chiller shall be arranged to automatically start and stop through the digital control module (DCM) furnished with the chiller. It shall be enabled through the DDC system. The DCM shall be arranged to "soft start" the chiller bringing on one compressor at a time as applicable.
the Chilled water primary circulation pump furnished with the chiller shall be interlocked to run continuously when the chiller is started. Furnish a flow switch in the primary supply water header arranged to prevent chiller operation if flow is not proved.
After proof of flow, the chiller's packaged safety and operating controls shall be enabled to maintain supply water set-point as set through the DDC system. The DDC shall monitor and alarm primary chilled water supply and return temperatures in addition to primary pump status.
The BMS shall sequence compressors to maintain the chilled water secondary loop temperature set-point. On a call for cooling the DCM shall modulate chiller capacity until it is fully loaded. A decrease in chilled water demand shall cause the reverse operating sequence.
The set-point shall be reset by the outdoor air temperature sensor. Refer to the reset schedule given below.

Once enabled, the DDC system chiller sequencing software shall perform the following control strategies and support their specified monitoring and diagnostics.

System Scheduling - The chiller sequencing software will start the chiller system based upon an 8 day (7 + Holiday) time of day schedule. The chiller plant shall start in response to the optimum start, night setback or timed override operation of any system air handler.

Chilled Water Reset - Provide reset of the chilled water supply temperature set point based on return chilled water temperature. The reset parameters shall be user selectable.
Chiller Status Report - Provide an operating status report for each chiller. The report(s) shall provide the present status of all binary information and for analog information present value, today's average, and the month to date average for the following information to provide the operator with critical chiller operating data.

Chiller On/Off Status.

Chiller Starts/Run Hours - Compressor A, B.
Phase 1/2/3 Percent RLA - Compressor A,B.
Active Chiller Diagnostics or Alarms.
Leaving Chilled Water Temperature.
Entering Chilled Water Temperature.
Chilled Water Set point.
Entering condenser water temperature
Leaving Condenser water temperature.
Refrigerant Temperature Evaporator/Condenser - Circuit 1, 2.
Operating Mode.
Chiller Model and Serial Number.
Percent RLA/Percent Current Limit.
Outside Air Temperature.

Chilled Water Reset - Provide reset of the chilled water supply temperature set point based on return chilled water temperature or outdoor air temperature. The reset parameters shall be user selectable. The reset schedule shall be as follow:

Chilled water reset schedule	
CWST (F)	OAT(F)
44	92
45	90
46	88
47	86
48	84
49	82
50	80
51	78
52	76
53	74
54	72
55	70
56	68

3.04 Variable Speed Hot Water/Chilled Water Pumping System Control (Secondary Pumps)

Typical for heating and cooling plant. When the plant is enabled, the lead, variable speed pump will be enabled to operate at its lowest speed setting, (30% of maximum flow). If the lead variable speed drive pump fails to operate the standby variable speed pump will start and an alarm will be generated at the pump control panel and the BMS. Furnish a flow switch in the header of each pump with adjustable time delay. The BMS system shall rotate the lead and lag pumps for equal running time on a weekly or daily basis, (adjustable).

Differential pressure, shall be measured across the supply and return of the two-pipe system using a five-point manifold differential pressure sensor. The differential pressure

will be measured at the ends of the piping run in building #3. The speed of the pump will be controlled to maintain the differential pressure at (28 psi adjustable). If the differential pressure drops below set point, the pump speed shall increase proportionately, if differential pressure rises above set point, the pump speed shall be decreased proportionately. The minimum speed set point shall be determined such that the speed corresponds to 30% of the maximum flow at 28 psi differential. The actual DP set point shall be determined in the field when all water balancing has been completed. DP set point shall be determined when design flow is achieved at the lowest available pump speed. Furnish and install a differential by pass valve on the hot water system arranged to open and allow minimum flow through the pumps should the pumps slow to minimum speed and DP is still above 28psi. (set point)

3.05 VAV Air conditioning Units: AC-1 and AC-2

The units shall be supplied with, and operated through a unit mounted or remote DDC unitary control panel, capable of providing set-point adjustments and all programming control sequences. Controls shall include all motorized dampers and valves, damper motors, motor starters, wiring, sensors and all hardware accessories for a complete system. Furnish wall mounted room thermostats with automatic summer/winter change over, and temperature adjustments.

Units Off: The outside air intake and relief air dampers shall be closed, and the return air damper shall be full open. The automatic 2-way valve on the heating coil shall be open to the coil.

Summer Operation: Upon start up, the control circuits energized. The supply fan and return fan (RF-1 and RF-2) shall run continuously. The outside air intake, and relief air dampers shall open to minimum position the return damper shall open to the maximum position. A temperature sensor in the unit discharge duct shall be reset by a return air temperature sensor, (master-sub-master), arranged to modulate the cooing coil capacity to maintain a constant discharge air temperature in the range of 55°F - 60°F. As return air temperature drops, (decreased load), discharge air temperature shall increase. As return air temperature increases, (increased load), discharge air temperature shall drop proportionality. The discharge air temperature set-point shall be determined through a comparison of the return air temperature and SA set-point, and shall be reset according or cooling demand. Hot water heating coil control valve shall be closed. VAV boxes shall operate in the summer mode.

Winter Operation: Upon start up, the control circuits shall be energized. The supply fan and return fan (RF-1 and RF-2) shall run continuously. The outside air intake, and relief air dampers shall open to minimum position the return damper shall open to the maximum position. The heating coil valve shall be arranged to maintain a discharge temperature at 65°F to 75°F range (adjustable). VAV boxes shall operate in the winter mode.

Economizer Operation: On a call for cooling when outdoor air conditions permit, (56 deg adjustable), and below an **enthalpy control** shall modulate the outside air intake, exhaust and return air dampers, to maintain SA temp set point. Override DCV as required. Heating coil control valve shall be closed. Control action shall be that an increase in SA temperature will cause the outside air and exhaust air dampers to modulate towards the

open position and the return air damper to modulate towards the closed position. A drop in below set point temperature will cause the reverse to take place. When the outdoor air damper reaches the full open position a further call for cooling shall cause chilled system to operate. When ambient conditions are no longer suitable for economizer operation the unit controls shall revert to normal summer operation. The return and supply fans shall run continuously.

Morning Warm-up Operation: Unit shall start and operate for a predetermined period as programmed into the unit controllers. During this cycle outside intake and exhaust air dampers shall remain closed, and return air damper shall be full open. The heating valve shall modulate to maintain set point. When the zone temperature(s) comes to within 2 degrees of set point the unit shall operate in occupied mode.

Morning Cool-Down Operation: Unit shall start and operate for a predetermined period as programmed into the unit controllers. During this cycle outside intake and spill air dampers shall remain closed, and return air damper shall remain open. The cooling coil shall modulate to maintain discharge air temperature set point. When the zone temperature comes to within 2 degrees of set point the unit shall operate in occupied mode.

Unoccupied Operation: Unit supply/return fans and heating/cooling coil control valves shall cycle on a call for cooling or heating. During this cycle the unit shall operate with 100% re-circulated air. Unit controls shall allow complete shutdown if desired. Set point shall be 68˚ in the heating season and 80 in the cooling season.

Limit Controls: Provide a High/low limit control(s) in the supply fan discharge arranged to override temperature controls and prevent discharge temperature from dropping below 50°F and rising above 110°F(adjustable).

Freezestat: Provide each air handling unit with a manual reset type freezestat,(set at 35° adjustable),arranged to shut down the unit and sound an audio and visual alarm at the BAS operator station should the set point be reached. The freezestat element shall be the capillary type with lowest point temperature sensing. The manual reset shall be capable of being reset from the operator work station.

Static Pressure Controls: Provide static pressure sensors in the supply ductwork for each AC unit located approximately two-thirds downstream of the unit in the SA duct.. Sensors shall be arranged to vary the speed of the supply in response to supply duct static pressure. An increase in static pressure shall cause the fans to slow down a decrease shall cause the fans to speed up. The outside air dampers shall be arranged to modulate open proportionately from the minimum position as fan speed decreases. This shall be done through an air flow measuring station located in the outside air intake plenum to insure constant ventilation air rate (CFM) through the range of fan speeds. For those units that operate DCV mode during normal occupied hours this function shall be overridden by DCV control. Corresponding return air fans for each air handling unit shall be arranged to maintain a positive pressure of .1" sp in their respective zones. On a drop-in zone pressure the fan shall be arranged to slow down, on a rise in SP above set point the fan shall be arranged to speed up.

VAV Boxes: Furnish and install electronic controllers for pressure independent operation. Room thermostats / sensors shall be heating / cooling automatic change over type with dual maximum proportional control. Winter operation; on a drop-in space temperature below set point the VAV box shall modulate towards the open position, the VAV box heating coil control valve shall modulate open proportionately to maintain set space point. On a rise in space temperature the opposite shall take place. Summer operation, the VAV box shall modulate open to increase airflow on a rise in space temperature above set point. On a drop in space temperature the box shall modulate toward the minimum position.

BMS Alarms:

- Low mixed air temperature detection (freezestat)
- Return/exhaust fan failure
- Supply fan failure (current relay or sail switch)
- Hi discharge air temperature (temperature sensor)
- Low discharge air temperature (temperature sensor)
- Dirty filter
- Smoke detection

Building #1 Exhaust Fans:
TX-1-1, TX-1-2, TX-1-3 – Toilet Rooms – automatic start/stop - As scheduled through the DDC system.
EX-1-1, – Electric Room – automatic start/stop - As scheduled through the DDC system, and room thermostat
RF-1 Return Fan – automatic start/stop – interlocked with AHU-1

Building #3 Exhaust Fans:
TX-3-1 – Locker Rooms – automatic start/stop - As scheduled through the DDC system.
EX-3-1, – Electric Room – automatic start/stop - As scheduled through the DDC system, and room thermostat.
EX-3-2, – Paint Storage Room – automatic start/stop - As scheduled through the DDC system.
EX-3-3 – Sign Shop – automatic start/stop - As scheduled through the DDC system.
RF-2 Return Fan – automatic start/stop – interlocked with AHU-2

Building #5 Exhaust Fans:
TX-5-1 – Toilet Room – automatic start/stop - As scheduled through the DDC system.

3.06 CONSTANT VOLUME PACKAGED ROOFTOP UNITS. (RTU-2-1)

General: The unit shall be supplied with, and operated through a unit mounted or remote DDC unitary control panel, capable of providing set-point adjustments and all programming control sequences. Controls shall include all motorized dampers and valves, damper motors, motor starters, wiring, sensors and all hardware accessories for a complete system. The unitary control panel shall be provided by the unit manufacturer or provided by the BMS controls contractor, and shall use native BACnet as the operating communications protocol. Furnish wall mounted room thermostats with automatic

summer/winter change over, and temperature adjustments. Space temperature shall be measured by averaging multiple zone sensors. (one on each floor)

Units Off: The outside air intake and relief air dampers shall be closed, and the return air damper shall be full open. Refrigeration system shall be off. Gas heating shall be off.

Summer Operation Occupied: Upon start up, the control circuits shall be energized. The supply fan shall run continuously. The outside air intake, and relief air dampers shall open to minimum position the return damper shall open to the maximum position. Zone temperature sensor arranged to modulate the unit capacity to maintain zone set point. The gas control valve closed.

Winter Operation Occupied; Upon start up, the control circuits shall be energized. The supply fan shall run continuously the outside air intake, and relief air dampers shall open to minimum position, the return air damper shall open to the maximum position. The gas control valve shall be arranged to modulate to maintain furnace capacity and space temperature set point in the range of 70° range (adjustable)

Economizer Operation: On a call for cooling when outdoor air conditions permit, a **enthalpy controller** shall modulate the outside air intake, exhaust and return air dampers, to maintain SA temp set point. The gas furnace shall be off. Control action shall be that an increase in space temperature will cause the outside air and exhaust air dampers to modulate towards the open position and the return air damper to modulate towards the closed position. A drop in below set point temperature will cause the reverse to take place. When the outdoor air damper reaches the full open position a further call for cooling shall cause DX system to operate. When ambient conditions are no longer suitable for economizer operation the unit controls shall revert to normal summer operation. The barometric damper shall be balanced to maintain building zone positive pressure no greater than +.1" wc.

Unoccupied Operation: Unit supply, furnace and DX cooling system shall cycle on a call for heating or cooling. During this cycle the unit shall operate with 100% re-circulated air. Unit controls shall allow complete shutdown if desired. Set point shall be 70˚ (set back) in the heating season and 80, (set up) in the cooling season.

Limit Controls: Provide a High/low limit control(s) in the supply fan discharge arranged to override temperature controls and prevent discharge temperature from dropping below 50°F and rising above 110°F(adjustable).

Freezestat: Provide a manual reset type freezestat,(set at 35° adjustable),arranged to shut down the unit and sound an audio and visual alarm at the BAS operator station should the set point be reached. The freezestat element shall be the capillary type with lowest point temperature sensing.

3.07 Supplemental Air Conditioning (AC-1) Short Term Storage Archives 126

The units shall be supplied with, and operated through a unit mounted or remote DDC unitary control panel, provided by the unit manufacture capable of providing set-point adjustments and all programming control sequences. Controls shall include all motorized dampers and valves, damper motors, motor starters, wiring, sensors and all hardware accessories for a complete system. Furnish wall mounted room thermostat and humidistat

with automatic summer/winter change over, and temperature and humidity set point adjustments. Temperature set point for this space shall be constant with no set back and no set up. Therefore no morning warm up or cool down is required.

Units Off: The outside air intake damper shall be closed, and the return air damper shall be full open. Supply and return fans shall be off. The electric heating coil shall be de-energized.

Cooling Operation: Upon start up, the control circuits energized. The supply fan shall run continuously. The outside air intake, damper shall open to minimum position the return damper shall open to the maximum position. A space mounted temperature sensor shall be arranged to modulate the DX system capacity to maintain space temperature set point. Set the space temperature set point at 76°F to 70°F range (adjustable).
The electric heating coil shall be de-energized.

Humidity Controls; Space humidity shall be measured by a space-mounted humidistat. The set point shall be in the 45% RH +- 2 % RH. (adjustable) When space RH drops below set point, the unit supplied humidifier shall be energized to provide steam. When RH set point is met the humidifier shall be de-energized. When space RH rises above set point, the unit shall perform dehumidification by sub-cooling and using hot gas reheat to reheat SA to maintain room temperature set-point.

Winter Operation: Upon start up, the control circuits shall be energized. The supply and return fans shall run continuously. The outside air intake, air dampers shall open to minimum position the return damper shall open to the maximum position. The electric heating coil shall be arranged to maintain a space temperature set point between 70°F to 75°F range (adjustable).

Economizer Operation: No economizer due to reheat and humidification requirements.

Morning Warm-up Operation: Not required.

Morning Cool-Down Operation: Not required.

Unoccupied Operation: Unit supply and return fans and heating coils or DX cooling shall cycle on a call for cooling or heating. During this cycle, the unit shall operate with 100% re-circulated air. Unit controls shall allow complete shutdown if desired. Limit winter night set back or summer night set up to 2 degrees.

Limit Controls: Provide a High/low limit control(s) in the supply fan discharge arranged to override temperature controls and prevent discharge temperature from dropping below 50°F and rising more than 15 degrees above space set point.

Freezestat: Provide each air handling unit with a manual reset type freezestat,(set at 35° adjustable),arranged to shut down the unit and sound an audio and visual alarm at the BAS operator station should the set point be reached. The freezestat element shall be the capillary type with lowest point temperature sensing.

Miscellaneous:

- Low temperature detection (freezestat)
- Return/spill fan failure
- Supply fan failure (current relay or sail switch)
- Hi discharge air temperature (temperature sensor)
- Low discharge air temperature (temperature sensor)
- Dirty filter
- Smoke detection
- Limit winter night set back or summer night set up to 2 degrees.

3.08 Supplemental Air Conditioning Ductless split system: (AC-2 and AC-3)

Shall be started and stopped through a space mounted electronic microcomputer-based room thermostat, by the equipment manufacture. The room thermostat shall be capable of providing set-point adjustments and all programming control sequences. Each evaporator shall have a separate thermostat. Each evaporator's fan and compressors shall cycle to maintain room temperature set point 75˚ when indexed to the auto mode. All condenser, and compressor operations shall be controlled by the AC unit's built in unitary controller. Provide a separate room temperature sensor provided by the BMS contractor for each evaporator. The sensor shall be report room high and low temperatures and enable an alarm at the BMS work station.

3.09 Air condition condensate pumps: (All systems)

Provide connection to the overflow switch in each condensate pump tank arranged to annunciate an alarm at the BMS and shut down the respective AHU/AC unit.
Provide a secondary high-level float switch in each AC unit's condensate pan and each split system air handling unit condensate pan arranged to annunciate an alarm at the BMS and shut down the respective AHU/AC unit.

3.10 Unit heaters: Hanging and Cabinet Type.

Hot Water: Provide a space thermostat set at 72°F adjustable for each hot water cabinet and unit heater. Upon a drop in space temperature below set-point the unit fan shall cycle on and the hot water control valve shall open. On a rise in space temperature above set point the reverse shall take place. Provide a strap-on-aquastat to prevent fan and valve operation when hot water is not detected. In summer mode the control valve shall be closed. All control valves positions and space temperatures shall be monitored and indicated on the BMS.

Electric: Provide a space thermostat set at 72°F adjustable for each electric cabinet and unit heater. Upon a drop in space temperature below set-point the unit fan shall cycle on and the electric heating shall be energized. On a rise in space temperature above set point the reverse shall take place. Controls shall be arranged to prevent fan operation when the heating element is not energized. In summer mode the heating element shall be deenergized.

Gas: Provide a space thermostat set at 72°F adjustable for each unit heater. Upon a drop in space temperature below set-point the unit fan shall cycle on and the gas control valve shall open. On a rise in space temperature above set point the reverse shall take place. The gas burner shall modulate to maintain space temperature. Unit status shall be monitored on the BMS.

3.11 Cabinet Convectors:

Provide a control valve for all units and room thermostats where indicated on plan set at 72°F for each convector. Upon a drop in space temperature below set-point the CV valve shall cycle open. On a rise in space temperature above set point the reverse shall take place. All control valves positions and space temperatures shall be monitored and indicated on the BMS.

3.12 Finned Tube Radiation: Provide a control valve (CV) and room thermostats where indicated on plan set at 72°F for each zone of hot water fin tube radiation, upon a drop in space temperature below set-point the CV valve shall cycle open. On a rise in space temperature above set point the reverse shall take place. For those zones served by VAV boxes and FTR controls shall be arranged to operate the VAV box and FTR in sequence off the same thermostat. All control valves positions shall be monitored and indicated on the BMS.

3.13 Radiant Heating Systems

When the DDC system is indexed to the heating mode the radiant floor heating system shall be enabled to operate. Provide temperature sensors in the concreate floor in accordance with the radiant manufacture's recommendations. Provide a temperature sensor in the hot water supply line to or header downstream of the mixing valve. The mixing valve shall be arranged to modulate hot water temperature in relation to outdoor air temperature.

- Reset schedule to be 110° F to 75° F hot water supply temperature as outside air varies from 10° F to 55° F. (adjustable).
- Set supply water temperature to 75 deg F for the first three heating days.
- Increase supply water temperature to the set point in gradual increments for the next 4 days. Maximum of a 50 deg F increase in a period of 24 hour).
- After initial heating the floor slab shall be maintained at 80° F.
- On a call for heating the zone pump(s) shall be started and circulation shall be commence through the radiant system. When set point is met the opposite shall take place.

3.14 Constant Volume Air Handling Units (HV-2-2, HV-2-3, HV-2-4)

General: The units shall be supplied with, and operated through a unit mounted or remote DDC unitary control panel, capable of providing set-point adjustments and all programming control sequences. Controls shall include all motorized dampers and valves, damper motors, motor starters, wiring, sensors and all hardware accessories for a complete system. The unitary control panel shall be provided by the unit manufacturer or provided by the BMS controls contractor, and shall use native BACnet as the operating communications protocol. Furnish wall mounted room thermostats with automatic summer/winter change over, and temperature adjustments. Space temperature shall be measured by averaging multiple zone sensors. (one on each floor)

Units Off: The outside air intake dampers shall be closed, and the return air damper shall be full open. Gas heating shall be off.

Summer Operation Occupied: Upon start up, the control circuits shall be energized. The supply fan shall run continuously. The outside air intake damper shall open, the return damper shall open **(HV-2 -2 only)**. The gas control valve closed.
Exhaust fans shall be on.

Winter Operation Occupied; Upon start up, the control circuits shall be energized. The supply fan shall run continuously. The outside air intake damper shall open, the return damper shall open **(HV-2 -2 only)**. The gas control valve shall be arranged to modulate to maintain furnace capacity and space temperature set point in the range of 70° range (adjustable).
Exhaust fans shall be on.

Economizer Operation: Not required

Unoccupied Operation: Upon start up, the control circuits shall be energized. The supply fan shall cycle the outside air intake damper shall be closed, the return air damper shall be full open. **(HV-2-2 only)**. On a call for heat the fan shall start, the gas control valve shall be arranged to modulate to maintain furnace capacity and space temperature set point in the range of 65° (setback temperature) (adjustable). When set point is satisfied the fan shall cycle off and the gas valve shall close OAI damper shall close.
Exhaust fans shall be off.

Limit Controls: Provide a High/low limit control(s) in the supply fan discharge arranged to override temperature controls and prevent discharge temperature from dropping below 50°F and rising above 110°F(adjustable).

Building #2 Exhaust Fans:

TX-2-1 – toilet room-automatic start/stop-runs continuously or as scheduled through BMS

EX-2-1- battery room – automatic start/stop - runs continuously. Provide hydrogen detector in the room arranged to annunciate at the BMS in case of high level.

EX-2-2 – welding area – manual start/stop

EX-2-3 – Lube room – automatic start/stop – interlock with HV-2-3

GX-2-1, GX-2-2 – garage exhaust – automatic start/stop interlock with HV-2-4 – runs during occupied hours.

GX-2-3, GX -2-4, GX -2-5 – garage exhaust – automatic start/stop interlock with HV-2-3 – runs during occupied hours.

3.15 Vehicle Exhaust System (VEX-1 VEX-2)

Each system shall be started and stopped manually from wireless remote stations located in the zone served. Refer to the plans for locations. The wireless remote starters shall communicate with each system's fan variable frequency drive (VFD). The fan shall be arranged to modulate based on static pressure in the ductwork. Provide duct static pressure sensor arranged to maintain static pressure setpoint. As vehicles are connected to the hose reals and the exhaust system demand increases, fan speed shall increase. As hose reals are disconnected and demand decreases, fan speed shall decrease.

3.16 Constant Volume Air Handling Units (HV-4-1, HV-4-2, HV-4-3, HV-4-4, HV-4-5, HV-4-6)

General: The units shall be supplied with, and operated through a unit mounted or remote DDC unitary control panel, capable of providing set-point adjustments and all programming control sequences. Controls shall include all motorized dampers and valves, damper motors, motor starters, wiring, sensors and all hardware accessories for a complete system. The unitary control panel shall be provided by the unit manufacturer or provided by the BMS controls contractor, and shall use native BACnet as the operating communications protocol. Furnish wall mounted room thermostats with automatic summer/winter change over, and temperature adjustments. Space temperature shall be measured by averaging multiple zone sensors. (one on each floor)

Units Off: The outside air intake dampers shall be closed, and the return air damper shall be full open. Gas heating shall be off.
Exhaust fans off.

Summer Normal Operation Occupied: Upon start up, the control circuits shall be energized. The supply fan shall run continuously. The outside air intake damper shall open to minimum position, and the return damper shall open to the maximum position. The gas control valve closed.
Exhaust fans shall be off.

Provide a room thermostat with set point adjustment. When the space temperature rises above set point. (78 deg adjustable) the units operate at maximum ventilation air.
The outside air intake damper shall open to maximum position, and the return damper shall open to the minimum position. The gas control valve closed.
Exhaust fans shall be on full speed.

Winter Normal Operation Occupied; Upon start up, the control circuits shall be energized. The supply fan shall run continuously the outside air intake shall open to the minimum position, the return air damper shall open to the maximum position. The gas control valve shall be arranged to modulate to maintain furnace capacity and space temperature set point in the range of 70° range (adjustable.)
Exhaust fans shall be off.

Economizer Operation: Not required

Unoccupied Operation: Upon start up, the control circuits shall be energized. The supply fan shall cycle, the outside air intake damper shall be closed, the return air damper shall be full open. On a call for heat the fan shall start, the gas control valve shall be arranged to modulate to maintain furnace capacity and space temperature set point in the range of 65° (setback temperature) (adjustable). When set point is satisfied the fan shall cycle off and the gas valve shall close OAI damper shall close.
Exhaust fans shall be off.

Building #4 Exhaust Fans:

GX-4-1, through GX-4-12 – garage exhaust – automatic start/stop interlock with HV- 4-1 – through HV- 4 – 6. Refer to plans for zoning.

EX-4-1- parts Storage Room – automatic start/stop - runs based on room thermostat or as scheduled through the DDC system.

Gas detection: There shall six zones of CO and NO2 detection in building #4. Refer to the floor plans. There shall be two levels of gas detection for each of the six zones. The following sequence shall be typical for each of the six air handling units and the associated exhaust fans.
Level 1 detection - 25ppm CO, 50ppm NO2– HV unit fan on, OAI damper 50% open, RA damper 50% open, exhaust fans 50% speed.

Level 2 detection - 50ppm CO, 100ppm NO2– HV unit fan on, OAI damper 100% open, RA damper 100% open, exhaust fans 100% speed.

Limit Controls: Provide a High/low limit control(s) in the supply fan discharge arranged to override temperature controls and prevent discharge temperature from dropping below 50°F and rising above 110°F(adjustable).

3.17 Miscellaneous:

Motor starters shall be supplied for each Air Handler, Fan, pump, etc. When starters are located at the unit, (factory or field installed), or within line of site of the unit combination Starters/disconnects shall be used. All starters shall be equipped with H-O-A switches and pilot lights in cover. For units with remote mounted starters,(i.e. roof-top exhaust fans), furnish disconnects at the unit.

All safety devices shall be interlocked with “hand” and “Automatic” positions in series with motor controller holding coil circuit. Interlocking with other fans and equipment of system shall be through “Automatic” position “Hand” position shall be for maintenance only. Remote starting shall be from through “automatic” position only.

All air handling units 2,000 cfm or greater shall have a duct mounted smoke detector arranged to stop the unit and position all dampers and valves in the “unit off” sequence as described in this section, upon detecting smoke.
All air handling units, unit ventilators, cabinet unit heaters, unit heaters, fans, and fan coil units, shall be interlocked to the building fire alarm system. Upon building fire alarm all units shall shut down and damper and valves shall go to “unit off” positions.

END OF SECTION 230993

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Hot-water heating piping.
2. Chilled-water piping.
3. Glycol cooling-water piping.
4. Makeup-water piping.
5. Condensate-drain piping.
6. Blowdown-drain piping.
7. Air-vent piping.
8. Safety-valve-inlet and -outlet piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Plastic pipe and fittings with solvent cement.
2. RTRP and RTRF with adhesive.
3. Pressure-seal fittings.
4. Chemical treatment.

B. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.
5. For underground piping provide size and quantity of pipe expansion loops and thrust blocks.

1.4 INFORMATIONAL SUBMITTALS

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

1. Suspended ceiling components.
2. Other building services.
3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

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

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 150 psig at 200 deg F.

2. Chilled-Water Piping: 150 psig at 200 deg F.
3. Makeup-Water Piping: 80 psig at 150 deg F.
4. Condensate-Drain Piping: 150 deg F.
5. Blowdown-Drain Piping: 200 deg F.
6. Air-Vent Piping: 200 deg F.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Copper or Bronze Pressure-Seal Fittings:
1. Pro-press should be reviewed

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

a. Elkhart Products Corporation.
b. Mueller Industries, Inc.
c. NIBCO INC.
d. Viega LLC.

3. Housing: Copper.
4. O-Rings and Pipe Stops: EPDM.
5. Tools: Manufacturer's special tools.
6. Minimum 200-psig working-pressure rating at 250 deg F.

E. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Grooved Mechanical-Joint Fittings and Couplings:

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

   a. Anvil International.
   b. Grinnell G-Fire by Johnson Controls Company.
   c. Star Pipe Products.
   d. Victaulic Company.

2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
4. Gaskets; gaskets shall be compatible with the fluid in the system. Glycol or water as required.

I. Steel Pressure-Seal Fittings:

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

   a. Victaulic Company.
   b. Viega LLC.
   c. Watts.

2. Housing: Steel.
3. O-Rings and Pipe Stop: EPDM.
4. Tools: Manufacturer's special tool.
5. Minimum 300-psig working-pressure rating at 230 deg F.

J. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 PLASTIC PIPE AND FITTINGS; (CONDENSATE DRAIN ONLY)

A. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.

1. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.5 JOINING MATERIALS

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

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

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

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

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

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

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

G. Solvent Cements for Joining Plastic Piping:

1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

a. PVC solvent cement shall have a VOC content of 510 g/L or less.
b. Adhesive primer shall have a VOC content of 550 g/L or less.
c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

H. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:

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

a. Charlotte Pipe and Foundry Company.
b. IPEX USA LLC.
c. KBI (King Bros. Industries).
d. Viega LLC.

2. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

B. Plastic-to-Metal Transition Unions:

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

a. Charlotte Pipe and Foundry Company.
b. IPEX USA LLC.
c. KBI (King Bros. Industries).
d. NIBCO INC.

2. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.7 DIELECTRIC FITTINGS

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

B. Dielectric Unions:

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

a. WATTS.
b. Wilkins.
c. Zurn Industries, LLC.

2. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 150 psig 250 psig.
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

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

    a. WATTS.
    b. Wilkins.
    c. Zurn Industries, LLC.

2. Description:

    a. Standard: ASSE 1079.
    b. Factory-fabricated, bolted, companion-flange assembly.
    c. Pressure Rating: 150 psig minimum at 250 deg F.
    d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

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

    a. Advance Products & Systems, Inc.
    b. Calpico, Inc.
    c. Central Plastics Company.
    d. Pipeline Seal and Insulator, Inc.

2. Description:

    a. Nonconducting materials for field assembly of companion flanges.
    b. Pressure Rating: 150 psig.
    c. Gasket: Neoprene or phenolic.
    d. Bolt Sleeves: Phenolic or polyethylene.
    e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

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

    a. Grinnell G-Fire by Johnson Controls Company.
    b. Matco-Norca.
    c. Victaulic Company.

2. Description:

    a. Standard: IAPMO PS 66.
    b. Electroplated steel nipple, complying with ASTM F 1545.
    c. Pressure Rating: 300 psig at 225 deg F.
    d. End Connections: Male threaded or grooved.
    e. Lining: Inert and noncorrosive, propylene.

2.8 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity minimum; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. **Hot-water heating, Chilled Water, Dual Temperature, Glycol cooling-water, piping aboveground**; NPS 2 1/2 and smaller, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed, pressure-seal joints.
2. Schedule 40, Grade B, Type 96 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. **Hot-water heating, Chilled Water, Dual Temperature, Glycol cooling-water, piping, Aboveground;** NPS 3 and larger, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. **Alternative for use outside of machine rooms only;** Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

C. **Chilled Water Piping: below ground;** shall be either of the following:

1. Pre-insulated PEX piping

D. Hot-water heating Piping; Below ground and under slabs; shall be the following:

1. Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

E. Makeup-water piping installed aboveground shall be either of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

F. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

G. Condensate-Drain Piping: Type M, Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

H. Boiler Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

I. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

J. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

K. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

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

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 230523.10 " Valves for HVAC Piping,"

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs and escutcheons on all exposed piping. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and escutcheons for HVAC Piping." install

W. Install escutcheons for exposed piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230517.5 "Sleeves and Escutcheons for HVAC Piping."

X. For piping passing through equipment room walls to occupied spaces provide split seals for sound and vibration attenuation between rooms. Comply with section 23 21 16.

Y. Install packless expansion fitting in all hydronic piping sections that are 75’ long or over.

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples, or unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges, or nipples.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports and hanger rod size.

B.]Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

C. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 6 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

D. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

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

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

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

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

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

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

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

H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.

I. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

J. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

K. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

1. pH: 9.0 to 10.5.
2. "P" Alkalinity: 100 to 500 ppm.
3. Boron: 100 to 200 ppm.
4. Chemical Oxygen Demand: Maximum of 100 ppm. Revise this value if closed system contains glycol.
5. Corrosion Inhibitor:

    a. Sodium Nitrate: 1000 to 1500 ppm.
    b. Molybdate: 200 to 300 ppm.
    c. Chromate: 200 to 300 ppm.
    d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
    e. Chromate Plus Molybdate: 50 to 100 ppm each.

6. Soluble Copper: Maximum of 0.20 ppm.
7. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of 10 ppm.
8. Total Suspended Solids: Maximum of 10 ppm.
9. Ammonia: Maximum of 20 ppm.
10. Free Caustic Alkalinity: Maximum of 20 ppm.
11. Microbiological Limits:

    a. Total Aerobic Plate Count: Maximum of 1000 organisms/mL.
    b. Total Anaerobic Plate Count: Maximum of 100 organisms/mL.
    c. Nitrate Reducers: 100 organisms/mL.
    d. Sulfate Reducers: Maximum of zero organisms/mL.
    e. Iron Bacteria: Maximum of zero organisms/mL.

B. Install bypass chemical feeders in each hydronic system where indicated.

1. Install in upright position with top of funnel not more than 48 inches above the floor.
2. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
3. Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.

C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

1. Fill systems that have antifreeze or glycol solutions with the following concentrations:
2. Chilled-Water Piping: Minimum of 35% percent ethylene propylene glycol.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232113.13 - UNDERGROUND HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. PEX pipe and fittings.
3. Cased piping systems

1.3 REFERENCES

A. ASTM International (ASTM):

B. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

C. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

D. American National Standards Institute (ANSI)/American Water Works Association (AWWA)

E. ANSI/AWWA C901 AWWA Standard for Polyethylene (PE) Pressure Pipe and Tubing, 1/2 inch Through 3 inches, for Water Service

F. ANSI/AWWA C906 AWWA Standard for Polyethylene (PE) Pressure Pipe and Fittings, 4 inch Through 63 inches, for Water Distribution.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Conduit piping.
2. Cased piping.

B. Shop Drawings: For underground hydronic piping. Signed and sealed by a professional engineer representing the product manufacturer. Submittals shall contain the following information for review and comment and approval by the engineer or architect.

1. Calculate requirements for expansion compensation for underground piping.

2. Show expansion compensators, offsets, and loops with appropriate materials to allow piping movement in the required locations. Show anchors and guides that restrain piping movement with calculated loads, and show concrete thrust block dimensions.
3. Show pipe sizes, locations, and elevations. Show piping in trench, conduit, and cased pipe with details showing clearances between piping, and show insulation thickness.

1.5 INFORMATIONAL SUBMITTALS

A. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet and at vertical scale of not less than 1 inch equals 5 feet. Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing hydronic piping.

B. Qualification Data: For qualified Installer.

C. Welding certificates.

D. Material Test Reports: For cased piping.

E. Source quality-control reports.

F. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

B. Installer Qualifications: Use an installer with demonstrated experience on projects of similar size and complexity and possessing documentation proving familiarization training by the tubing manufacturer.
1. Regulatory Requirements and Approvals: Ensure the piping distribution system complies with all applicable codes and regulations.
2. Certifications: Provide letters of certification indicating: Installer uses skilled workers holding a trade qualification license or equivalent, or apprentices under the supervision of a licensed trades person.
3. Pre-installation Meetings:
    a. Verify project requirements, excavation conditions, system performance requirements, manufacturer's installation instructions and warranty requirements.
    b. Review project construction timeline to ensure compliance or discuss modifications as required.
    c. Interface with other trade representatives to verify areas of responsibility.
    d. Establish the frequency and construction phase the project engineer intends for site visits and inspections by the tubing manufacturer's representative.

1.7 WARRANTY

A. Manufacturer's Warranty for Hydronic Piping: Manufacturer's standard 25 year warranty for PEX-a piping and ASTM F 1960 fittings.

B. Manufacturer's Warranty for Pre-Insulated Pipe Distribution Systems: Submit, for owner's acceptance, USA manufacturer's standard 5-year 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 most recent limited warranty published by the manufacturer takes precedence at the time of installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:

   1. Hot-Water Piping: 150 psig at 200 deg F.
   2. Chilled-Water Piping: 150 psig at 200 deg F.

2.2 COPPER TUBE AND FITTINGS (NOT USED)

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L. or K

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

2.3 PREINSULATED PEX PIPE AND FITTINGS (CHILLED WATER)

A. Manufacturers: Subject to compliance with requirements, provide products Uponor or one of the following, subject to compliance with the requirements of the contract documents.

   1. UPonor
   2. IPEX USA LLC.
   3. Viega LLC.
   4. Watts - a Watts Water Technologies company.

B. Design Requirements: The PEX-a service tubing is USA manufactured and tested in accordance with ASTM F876, ASTM F877, ASTM F1960, CSA B137.5 and NSF-rfh. The PEX service tubing has hydrostatic ratings in accordance with the temperatures and pressures listed in the ASTM standard. The hydrostatic ratings are:
   1. 200 degrees F at 80 PSI
   2. 180 degrees F at 100 PSI.
   3. 73.4 degrees F at 160 psi .

C. Performance Requirements: Provide a pre-insulated distribution system that is USA manufactured, fabricated and installed to comply with regulatory agencies and authorities with jurisdiction, and that maintains performance criteria stated by the tubing manufacturer without defects, damage or failure.
   1. Show compliance with ASTM F876 regarding Crosslinked Polyethylene (PEX) Tubing.
   2. Show compliance with ASTM F877 regarding Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems.
   3. Show compliance with DIN 4726 regarding Oxygen Diffusion.
   4. Show compliance with ASTM F1960 regarding Cold Expansion Fittings with PEX Reinforcing Rings for Use with Crosslinked Polyethylene (PEX) Tubing.
   5. Show compliance with CSA B137.5 regarding Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications.
   6. Show compliance with NSF-rfh regarding Radiant Floor Heating Applications

D. Service Tubing:
   1. Material: Crosslinked polyethylene (PEX) manufactured to PEX-a or Engel-method standard
   2. Material Standard: Manufactured in accordance with ASTM F876 and F877
   3. Pressure Ratings: Hydrostatic design and pressure ratings are in accordance with the ASTM standard. Operating limits are as follows.
   4. -58 degrees F to 203 degrees F at 80 psi
   5. The PEX service tubing in the Ecoflex Thermal Single pipe has an oxygen diffusion barrier that does not exceed an oxygen diffusion rate of 0.10 grams per cubic meter per day at 104 degrees F water temperature.
   6. Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated.

E. Outer Jacket:
   1. Material: Corrugated seamless high-density polyethylene (HDPE)
   2. The HDPE jacket completely encompasses and protects the insulation from moisture and damage.
   3. Outer jacket shall be extruded directly over the insulation and is flexible.
   4. The outer jacket shall contain 2 percent carbon black, finely divided and thoroughly dispersed to provide protection from UV degradation.
   5. Minimum Bend Radius:
      a. 1-inch pre-insulated tubing with 5.5-inch jacket has a bend radius of 10 inches
      b. 1-1/4-inch pre-insulated tubing with 5.5-inch jacket has a bend radius of 12 inches
      c. 1-1/2-inch pre-insulated tubing with 6.9-inch jacket has a bend radius of 16 inches.
      d. 2-inch pre-insulated tubing with 6.9-inch jacket has a bend radius of 18 inches
      e. 2-1/2-inch pre-insulated tubing with 6.9-inch jacket has a bend radius of 30 inches
      f. 3-inch pre-insulated tubing with 7.9-inch jacket has a bend radius of 32 inches
      g. 3-1/2 inch pre-insulated tubing with 7.9-inch jacket has a bend radius of 44 inches
      h. 4 inch pre-insulated tubing with 7.9-inch jacket has a bend radius of 48 inches

F. Insulation:
   1. The insulation shall be layered expanded crosslinked water-resistant polyethylene closed-cell foam.
   2. All seams of the insulation shall be sealed.
   3. Insulation shall not be bonded to the service tubing.
   4. Density; 2.0 lb/ft^3
   5. Thermal conductivity; 0.26 BTU/ft^2H
   6. Absorption: 2.0%
   7. Vapor permeability;$0.1g/100in^2d$
   8. Thickness
      a. 1" pipe – 1.85" – R6.85
      b. 11/4" pipe – 1.73" – R6.42
      c. 11/2" pipe – 2.13" – 7.89
      d. 2" pipe – 1.93" – 7.15
      e. 2 1/2" pipe – 1.65" R 6.11
      f. 3" pipe – 1.93" R7.15
      g. 3 1/2" pipe 1.65" R6.11
      h. 4" pipe – 1.42 – 3.26

G. Cold Expansion Fittings for PEX-a Service Tubing:
   1. For system compatibility, use fittings offered by the tubing manufacturer.
   2. Fittings must comply with the performance requirements of ASTM F877.
   3. Fittings are to be manufactured in accordance with ASTM F1960.
   4. The fitting assembly consists of a barbed adapter and an applicable-sized PEX ring.
   5. All buried fittings will be installed, insulated, and sealed in accordance with the instructions of the piping manufacturer.

H. Compression Fittings for PEX-a Service Tubing:
   1. For system compatibility, use fittings offered by the tubing manufacturer.
   2. Fittings are to be manufactured from dezincification-resistant brass and lead-free brass.
   3. The fitting assembly must comply with performance requirements of ASTM F877 AND astm 1807
   4. Fittings will consist of a compression fitting with a coupling sleeve, a fitting body insert with o-ring(s) and a bolt and nut.
   5. All buried fittings will be installed, insulated, and sealed in accordance with the piping manufacturer's instructions.
   6. Male NPT thread for each compression fitting is shown below.
      a. 1-inch PEX compression fitting has 1-inch male NPT thread.
      b. 1-1/4-inch PEX compression fitting has 1-1/4-inch male NPT thread.
      c. 1-1/2-inch PEX compression fitting has 1-1/2-inch male NPT thread.
      d. 2-inch PEX compression fitting has 2-inch male NPT thread.
      e. 2-1/2-inch PEX compression fitting has 2-inch male NPT thread.
      f. 3-inch PEX compression fitting has 2-1/2-inch male NPT thread.
      g. 3-1/2-inch PEX compression fitting has 3-inch male NPT thread.
      h. 4-inch PEX compression fitting has 4-inch male NPT thread.
   7. All transition fittings connecting to the compression fittings will be manufactured of dezincification-resistant brass.

I. Pipe and Fitting Identification: The pipe shall be marked in accordance with the standards to which it is manufactured.

1. Color identification by the use of stripes on pipe to identify pipe service shall be optional. If used, stripes or colored exterior pipe product shall be blue for potable water, green for wastewater/sewage, or purple for reclaimed water.
2. Tracing wire shall be placed parallel and 18 inches above, but separate from, the pipe and shall be 10 AWG.
3. Marking tape shall be approved by the engineer and placed between 12 and 18 inches above the crown of the pipe.

J. Accessories: Use accessories associated with the installation of the piping system as recommended by or available from the manufacturer.

K. Insulation Kits: Insulation kits will be manufactured of ABS shells or HDPE sleeves, will feature equal thickness of closed-cell PEX insulation as the pipe, and sealed watertight.

L. Connection Vaults:
   a. The piping manufacturer will provide the connection vaults when required by the project construction.
   b. Connection vaults shall be constructed of rotationally molded composite polyethylene and PE foam, providing a structurally sound and thermally insulated chamber.
   c. Heat shrink seals as provided by the tubing manufacturer shall be installed to prevent introduction of water into the vault.

M. Anchors: The project engineer will determine the use of anchors, if required, within the distribution system.

N. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.

O. Pressure/Temperature Rating: Minimum 100 psig and 180 deg F.

2.4 CASED PIPING SYSTEM (HOT WATER)

A. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.

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

   a. Perma-Pipe, Inc.
   b. Rovanco Piping Systems, Inc.
   c. Thermacor Process, L.P.
   d. TRICON
   e. Insul-TEK

B. The service or carrier pipe shall be Type “K”, or Type “L” hard drawn seamless copper tubing to ASTM B-88 and WWT-799.

C. Carrier Pipe Insulation: The insulation shall be a foamed in place closed cell polyurethane which is injected between the carrier pipe and jacket and completely fills the annular

space between the carrier pipe and the exterior casing. The insulation shall have the following physical properties:

1. Minimum Density (lb./cu. ft.) 2.0 ASTM D-1621,
2. 90-95 % Closed Cell, ASTM D-2856
3. Comply with ASTM C 591; thermal conductivity (k-value) shall not exceed 0.14 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
4. Insulation thickness;

Pipe Size	Minimum Insulation Thickness	PVC Jacket O.D.	PVC Jacket Wall
½"	1.88"	4.50"	.070"
¾"	1.74"	4.50"	.070"
1"	1.62"	4.50"	.070"
1¼"	1.50"	4.50"	.070"
1½"	1.37"	4.50"	.070"
2"	1.94"	6.14"	.070"
2½"	1.69"	6.14"	.070"
3"	1.44"	6.14"	.070"
4"	1.94"	8.16"	.080"
6"	1.94"	10.20"	.100"

D. Casing:

1. The exterior casing shall be Seamless, extruded white PVC Type 1, Grade 1,
2. Class 12454-B per ASTM D-1784 or
3. High Density Polyethylene (H.D.P.E.) with the following physical properties: (NOT USED)
4. ASTM D-3350…Resin Type III, Grade P34 ASTM D-633…Ultimate Elongation 850% ASTM D-633…Tensile Yield Strength 3300 psi
5. ASTM D-790…Tangent Flexural Modules 175,000 psi
6. No polyethylene tape casings will be allowed.

E. Casing accessories include the following:

1. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
2. Expansion Blanket: Elastomeric foam, formed to fit over piping.
3. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.

F. All fittings, anchors, end seals, other sub-assemblies shall be prefabricated

G. Field Joints: After soldering and hydrostatic testing, PVC jacketed straight field joints shall be insulated with polyurethane foam to the thickness specified, PVC sleeve and pressure sensitive tape. HDPE jackets will use polyurethane foam and a heat shrinkable sleeve.

H. Expansion/Contraction Compensation: Expansion and contraction within the piping system shall be accommodated with factory prefabricated internal expansion elbows, z-bends, expansion loops, and anchors specifically designed for each application. External expansion compensation can be provided with the use of flexible foam bolsters.

I. Source Quality Control: Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

PART 3 - EXECUTION

3.1 EARTHWORK

A. See Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATION

A. Hot-Water Heating Piping:

1. All:

a. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.

b. Preinsulated with PVC jacket

B. Chilled-Water Piping:

1. ALL:

a. Crosslinked PEX. Underground piping shall be installed with no joint.

b. Brass pressure seal fitting at the point of connection to indoor building piping.

c. Pre-insulated with HDPE jacket.

3.3 PIPING INSTALLATION

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

B. Remove standing water in the bottom of trench. No Piping shall be installed in standing water. Trenches shall be maintained dry until final field closure is complete.

C. Do not backfill piping trench until field quality-control testing has been completed and results approved.

D. Install piping at uniform grade of 0.2 percent. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points and elsewhere as required for system drainage. Install manual air vents at high points.

E. In conduits, install drain valves at low points and manual air vents at high points.

F. Install components with pressure rating equal to or greater than system operating pressure.

G. Install piping free of sags and bends.

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

I. See Section 230517 "Sleeves and Sleeve Seals for HVAC Piping" for sleeves and mechanical sleeve seals through exterior building walls.

J. Secure anchors with concrete thrust blocks. Concrete is specified in Section 033000 "Cast-in-Place Concrete."

K. See Section 134700 "Cathodic Protection" for cathodic devices and connections to piping and conduit systems.

L. Pre-insulated PEX pipe shall be installed with attention to the minimum bending radius as recommended by the manufacture.

3.4 JOINT CONSTRUCTION

A. See Section 330500 "Common Work Results for Utilities" for basic piping joint construction.

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

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

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Ch. 35, "Pipe and Tubing," using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

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

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

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

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

I. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.

2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.

J. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

K. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

L. Conduit and Cased Piping Joints: Assemble sections and finish joints with pourable or split insulation and exterior jacket sleeve, and apply shrink-wrap seals.

3.5 IDENTIFICATION

A. Install continuous plastic underground warning tapes during back filling of trenches for underground hydronic piping. Locate tapes 6 to 8 inches below finished grade, directly over piping. See Section 312000 "Earth Moving" for warning-tape materials and devices and their installation.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Prepare hydronic piping for testing according to ASME B31.9 and as follows:

a. Leave joints, including welds, uninsulated and exposed for examination during test.
b. Fill system with water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
c. Use vents installed at high points to release trapped air while filling system.

2. Test hydronic piping as follows:

a. Subject hydronic piping to hydrostatic test pressure that is not less than 1.5 times the design pressure.

b. After hydrostatic test pressure has been applied for 60 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.

E. Prepare test and inspection reports for review and approval by the engineer.

3.7 BACKFILL

A. A 4-inch layer of sand or fine gravel shall be placed and tamped in the trench to provide stable and uniform bedding for the piping system. Once the system is in place, the trenches shall be carefully backfilled and hand tamped in 6" layers until a cover of at least 24" from the top of the pipe has been achieved. The first 12" of backfill shall be sand or fine gravel less than ½" in diameter. The remainder of the backfill shall be void of rocks, frozen earth and foreign material over 6" in diameter. The trench shall be compacted to comply with H-20 Highway loading.

END OF SECTION 232113.13

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SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes special-duty valves and specialties for the following:

1. Hot-water heating piping.
2. Chilled-water piping.
3. Makeup-water piping.
4. Condensate-drain piping.
5. Blowdown-drain piping.
6. Air-vent piping.
7. Safety-valve-inlet and -outlet piping.
8. Vibration Isolation
9. Expansion fittings for hydronic piping
10. Pipe guides and anchors

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
2. Air-control devices.
3. Hydronic specialties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: **150** psig at **200 deg F**
2. Chilled-Water Piping: **150 psig** at **200 deg F.**
3. Glycol Cooling-Water Piping: **150 psig** at **150 deg F**
4. Makeup-Water Piping: **80 psig** at **150 deg F**
5. Condensate-Drain Piping: **150 deg F**.
6. Blowdown-Drain Piping: **200 deg F**
7. Air-Vent Piping: **200 deg F** .
8. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523.10 "Valves for HVAC Piping,"

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230923.11 "Control Valves.

2.3 Bronze, Calibrated-Orifice, Balancing Valves:

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

a. Armstrong Pumps, Inc.
b. Bell & Gossett; a Xylem brand.
c. Nexus Valve, Inc.
d. TACO Comfort Solutions, Inc.
e. Tour & Andersson; available through Victaulic Company.
f. Victaulic Company.

2. Body: Bronze, ball or globe type with calibrated orifice or venturi.

3. Ball: Brass or stainless steel.
4. Seat: PTFE.
5. End Connections: Threaded or socket.
6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
7. Handle Style: Lever, with memory stop to retain set position.
8. CWP Rating: Minimum **125 psig**
9. Maximum Operating Temperature: 250 deg F

B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

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

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett; a Xylem brand.
    c. Nexus Valve, Inc.
    d. Tour & Andersson; available through Victaulic Company.

2. Body: Cast-iron or steel body, globe pattern with calibrated orifice or venturi.

3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum **125 psig**
11. Maximum Operating Temperature: 250 deg F

C. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

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

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett; a Xylem brand.
    d. Spence Engineering Company, Inc.
    e. Watts; a Watts Water Technologies company.

2. Body: Bronze or brass.

3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.

10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

D. Diaphragm-Operated Safety Valves: ASME labeled.

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

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett; a Xylem brand.
    d. Spence Engineering Company, Inc.
    e. Watts; a Watts Water Technologies company.

2. Body: Bronze or brass.

3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

E. Automatic Flow-Control Valves: **(NOT USED)**

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

    a. Flow Design, Inc.
    b. Griswold Controls.
    c. Nexus Valve, Inc.
    d. NuTech Hydronic Specialty Products.

2. Body: Brass or ferrous metal.

3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: **175 psig**
9. Maximum Operating Temperature: **200 deg F**

2.4 AIR-CONTROL DEVICES

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

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett; a Xylem brand.
d. TACO Comfort Solutions, Inc.
e. John Wood

B. Manual Air Vents:

1. Body: Bronze.

2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig
7. Maximum Operating Temperature: 225 deg F

C. Automatic Air Vents:
1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2
5. Discharge Connection: NPS 1/4
6. CWP Rating: 150 psig
7. Maximum Operating Temperature: 240 deg F

D. Expansion Tanks:
1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested after taps are fabricated and shall be labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

2. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Provide tank fittings for **125-psig** working pressure and **250 deg F** maximum operating temperature.
3. Tank Drain Fitting: Brass body, nonferrous internal parts; **125-psig** working pressure and **240 deg F** maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
4. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- diameter gage glass, and slotted-metal glass guard.

E. Diaphragm or Bladder-Type Expansion Tanks as scheduled or noted on plans:
1. Tank: Welded steel, rated for **125-psig** working pressure and **375 deg F** maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

2. Diaphragm or Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

F. Tangential-Type Air Separators:
1. Tank: Welded steel; ASME constructed and labeled for **125-psig** minimum working pressure and **375 deg F** maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for **NPS 2** and smaller; flanged connections for **NPS 2-1/2** and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

G. In-Line Air Separators:
1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to **175 psig**
3. Maximum Operating Temperature: Up to **300 deg F**

H. Air Purgers:
1. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
2. Maximum Working Pressure: **150 psig**
3. Maximum Operating Temperature: **250 deg F**

2.5 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: **125 psig**

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: **125 psig**

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.

2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: **750 psig**

D. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: **150 psig**
5. Maximum Operating Temperature: 250 deg F

E. Spherical, Rubber, Flexible Connectors:

1. Rubber flexible connections shall be peroxide cured EPDM throughout with Kevlar tire cord reinforcement. The raised face rubber flanges must encase solid steel rings to prevent pull out. Flexible cable wire is not acceptable. Sizes 1-1/2" through 14" shall have a ductile iron external ring between the two spheres. Sizes 3/4" through 2" may have one sphere, bolted threaded flange assemblies and cable retention.

2. Minimum ratings shall be 250 psi at 170°F and 215 psi at 250°F. Higher published rated connectors may be used where required.

3. Safety factors shall be a minimum of 3/1. All flexible connections must be factory tested to 150% of maximum pressure for 12 minutes before shipment. The piping gap shall be equal to the length of the expansion joint under pressure. Control rods passing through 1/2" thick Neoprene washer bushings large enough to take the thrust at 1000psi of surface area may be used on unanchored piping where the manufacturer determines the condition exceeds the expansion joint rating without them.

4. All flexible joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc
   a. Body: Fiber-reinforced rubber body.
   b. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
   c. Performance: Capable of misalignment.
   d. CWP Rating: **150 psig**
   e. Maximum Operating Temperature: 250 deg F

F. Braided Pipe Flexible Connection;

1. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3"and larger shall be flanged. Smaller sizes may have male nipples. Minimum sizes listed below.

Flanged (Pipe Dia x Flexible Pipe Length)		
3" x 12"	6" x 18"	12" x 24"
4" x 12"	8" x 18"	14" x 30"
5" x 18"	10" x 18"	16" x 32"

Male Nipples (Pipe Dia x Flexible Pipe Length)		
1/2" x 12"	1-1/4" x 12"	2" x 12"
3/4" x 12"	1-1/2"x 12"	2-1/2" x 18"
1" x 12"		

2. At equipment connections, hoses shall be installed on the equipment side of the shut-off valves horizontal and parallel to the equipment shafts wherever possible. Hoses shall be type FFL or type MN as manufactured by Mason Industries, Inc

G. Vibration isolation pipe hangers; pre-compressed and locked at the rated deflection by means of a resilient up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc

H. Acoustic Split Seals; consist of pipe halves with minimum 3/4" thick neoprene sponge cemented to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Grout seals to make it integral with the floor, wall or ceiling in masonry construction. Seals shall project a minimum of 1" past either face of the wall. Where temperatures exceed 240F, 10 lb. density fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.

2.6 PACKLESS EXPANSION JOINTS

A. Metal, Compensator Packless Expansion Joints: Metraflex Model HPFF – for copper, Model HP for steel pipe

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

   a. Flexicraft Industries.
   b. Mason Industries, Inc.
   c. Metraflex Company (The).

2. Minimum Pressure Rating: 150 psig, unless otherwise indicated.

3. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.
4. Joint Axial Movement: 2 inches of compression and 1/2 inch of extension.
5. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.

   a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint or threaded.
   b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Threaded.

6. Configuration for Steel Piping: Multi-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.

a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Threaded Welded.

2.7 GROOVED-JOINT EXPANSION JOINTS

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

1. Anvil International.
2. Grinnell G-Fire by Johnson Controls Company.
3. Victaulic Company.

B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

C. Standard: AWWA C606, for grooved joints.

D. Nipples: ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.

E. Couplings: flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water, and bolts and nuts.

2.8 ALIGNMENT GUIDES AND ANCHORS

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

a. Advanced Thermal Systems, Inc.
b. Flexicraft Industries.
c. Mason Industries, Inc.
d. Metraflex Company (The).

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

3. Steel Shapes and Plates: ASTM A 36/A 36M.
4. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
5. Washers: ASTM F 844, steel, plain, flat washers.
6. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened concrete, with tension and shear capacities appropriate for application. Threaded stud, expansion plug, nuts and washers shall be zink-coated carbon steel.

7. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened concrete, with tension and shear capacities appropriate for application.

a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

b. Stud: threaded stud washers and nuts shall be ASTM A 307, zinc-coated carbon steel.
c. Alignment Guides
    1) Horizontal split spider type guide – Metraflex – Style IV
    2) Slide guide - – Metraflex – model PTFE
    3) Pre-insulated guide – Metraflex – model PG PRE
    4) Vertical glide riser - – Metraflex – model PGQ
d. Anchors
    1) Anchor clamp – Metraflex – model PA
    2) Structural I Beam Anchors – Metraflex
    3) Pre-insulated Anchor – Metraflex – model PAPI
    4) Modular riser guide – Metraflex – modular riser with EPDM insert

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

G. All valves and specialties installed in the system shall have a pressure rating that exceeds the system working pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. All valves and specialties installed in the system shall have a pressure rating that exceeds the system working pressure.

B. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

C. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

D. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

E. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

F. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

G. Install steel braided flexible pipe connections at all coil connections and at all piping connections to motor driven equipment.

H. Isolate piping from base mounted pumps with spherical rubber flexible connections

I. Install vibration isolation hangers or supports on all piping connected to motor driven equipment for a distance of 20' or the first two hangers.

J. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

K. Install expansion tanks on the floor. Vent and purge air from hydronic system, and **ensure that tank is properly charged with air to suit system Project requirements. System pressure shall be 5psi minimum residual at the top of the system.**

L. Install Acoustic split seals on all piping penetrating mechanical equipment room walls.

M. Install Packless expansion fittings in all hydronic pipe sections, regardless of service, that is over 100' long.

3.3 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install grooved-joint expansion joints to grooved-end steel piping.

C. Grooved end pipe applications can use multiple grooved coupling installed in an arrangement as approved by the manufacture for the specific application. The manufacture shall recommend the number, placement and arrangement in the piping systems. Submit to the engineer for review and approval.

3.4 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

C. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.5 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint or loop not more than three pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 232116

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Close-coupled, in-line centrifugal pumps.
2. Close-coupled, end-suction centrifugal pumps.
3. Separately coupled, horizontally mounted, in-line centrifugal pumps.
4. Separately coupled, vertically mounted, in-line centrifugal pumps.
5. Separately coupled, base-mounted, end-suction centrifugal pumps.
6. Automatic condensate pump units.

1.3 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

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

1. Armstrong Pumps, Inc.
2. ITT Corporation.
3. Mepco, LLC.
4. PACO Pumps; Grundfos Pumps Corporation, USA.
5. Patterson Pump Company; a Gorman-Rupp company.
6. Peerless Pump Company.
7. TACO Comfort Solutions, Inc.
8. Thrush Co. Inc.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings, and threaded or companion-flange connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: stainless steel
4. Motor shaft; carbon steel .
1. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N or EPT bellows and gasket. Include water slinger on shaft between motor and seal.
2. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
3. Pump Bearings: Oil lubricated; bronze-journal or thrust type.

D. Motor: Single speed and rigidly mounted to pump casing.

1. 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.

2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

   a. Enclosure: Open, dripproof.
   b. Enclosure Materials: Cast iron or Rolled steel.
   c. Motor Bearings: Permanently lubricated ball bearings up through 5 HP
   d. Motor Bearings Grease lubricated ball bearings over 5 HP.
   e. Unusual Service Conditions:

      1) Ambient Temperature: **40 deg C 104 F.**
      2) Altitude: 100 feet above sea level.
      3) High humidity.

   f. Efficiency: Premium efficient.
   g. NEMA Design: B or C
   h. Service Factor: 1.15.
   i. All motors used with VFDs shall be inverter duty rated

E. Capacities and Characteristics: Refer to plans and schedules.

F. Electrical Characteristics: Refer to plans and schedules.

2.2 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

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

1. Armstrong Pumps, Inc.
2. Aurora Pump; Pentair Ltd.
3. Buffalo Pumps, Inc.
4. ITT Corporation.
5. Mepco, LLC.
6. PACO Pumps; Grundfos Pumps Corporation, USA.
7. Patterson Pump Company; a Gorman-Rupp company.
8. Peerless Pump Company.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and flanged connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Shaft: Carbon steel.

4. Shaft sleeve ; brass or stainless steel
5. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N or EPT bellows and gasket. Include water slinger on shaft between motor and seal.
6. Pump Bearings: Permanently lubricated ball bearings.

D. Motor: Single speed and rigidly mounted to pump casing with integral pump support.

1. 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.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

    a. Enclosure: Open, dripproof.
    b. Enclosure Materials: Cast iron or Rolled steel.
    c. Motor Bearings: Permanently lubricated ball bearings up through 5HP
    d. Motor Bearings Grease lubricated over 5HP.
    e. Unusual Service Conditions:

        1) Ambient Temperature: **40 deg C 104 F.**
        2) Altitude: 100 feet above sea level.
        3) High humidity.

    f. Efficiency: Premium efficient.
    g. NEMA Design: B or C.
    h. Service Factor: 1.15.
    i. All motors used with VFDs shall be inverter duty rated

E. Capacities and Characteristics: Refer to plans and schedules.

F. Electrical Characteristics: Refer to plans and schedules.

2.3 SEPARATELY COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

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

1. Armstrong Pumps, Inc.
2. ITT Corporation.
3. Mepco, LLC.
4. PACO Pumps; Grundfos Pumps Corporation, USA.
5. Patterson Pump Company; a Gorman-Rupp company.
6. Peerless Pump Company.
7. TACO Comfort Solutions, Inc.
8. Thrush Co. Inc.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded companion-flange connections.
2. Impeller: ASTM B 584, cast bronze or brass ; statically and dynamically balanced, and keyed to shaft. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Carbon Steel
4. Sleeve; Alloy Copper 110.
5. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.)
6. Pump Bearings: permanently Oil lubricated; bronze-journal or thrust type.

D. Shaft Coupling: Molded-rubber insert with interlocking spider capable of absorbing vibration.

E. Motor: Single speed and rigidly mounted to pump casing.

1. 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.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

    a. Enclosure: Open, dripproof.
    b. Enclosure Materials: Cast iron or Rolled steel.
    c. Motor Bearings: Permanently lubricated ball bearings. Upto 5 hp
    d. Motor Bearings: Grease-lubricated ball bearings. Over 5 hp
    e. Unusual Service Conditions:

        1) Ambient Temperature: **40 deg C 104 F.**
        2) Altitude: 100 feet above sea level.
        3) High humidity.

    f. Efficiency: Premium efficient.
    g. NEMA Design: B or C
    h. Service Factor: 1.15.
    i. All motors used with VFDs shall be inverter duty rated

F. Capacities and Characteristics: Refer to plans and schedules.

G. Electrical Characteristics: Refer to plans and schedules.

2.4 SEPARATELY COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

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

1. Armstrong Pumps, Inc.
2. ITT Corporation.
3. Mepco, LLC.
4. PACO Pumps; Grundfos Pumps Corporation, USA.
5. Patterson Pump Company; a Gorman-Rupp company.
6. Peerless Pump Company.
7. TACO Comfort Solutions, Inc.
8. Thrush Co. Inc.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange or union-end connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N or EPT bellows and gasket. Include water slinger on shaft between motor and seal.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Permanently lubricated ball bearings.

D. Shaft Coupling: Axially split spacer coupling.

E. Motor: Single speed and rigidly mounted to pump casing with lifting eyebolt and supporting lugs in motor enclosure.

1. 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.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Enclosure: Open, dripproof.
b. Enclosure Materials: Cast iron or Rolled steel.
c. Motor Bearings: Permanently lubricated ball bearing upto 5 hp
d. Motor Bearings Grease-lubricated ball bearings over 5 hp.

e. Unusual Service Conditions:

1) Ambient Temperature: **40 deg C 104 F.**
2) Altitude: 100 above sea level.
3) High humidity.

f. Efficiency: Premium efficient.
g. NEMA Design: B or C
h. Service Factor: 1.15.
i. All motors used with VFDs shall be inverter duty rated

F. Capacities and Characteristics: Refer to plans and schedules.

G. Electrical Characteristics: Refer to plans and schedules.

2.5 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

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

1. Armstrong Pumps, Inc.
2. ITT Corporation.
3. Mepco, LLC.
4. PACO Pumps; Grundfos Pumps Corporation, USA.
5. Patterson Pump Company; a Gorman-Rupp company.
6. Peerless Pump Company.
7. TACO Comfort Solutions, Inc.
8. Thrush Co. Inc.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and threaded companion-flange, flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N or EPT bellows and gasket.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.

6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor. EPDM coupling sleeve for variable-speed applications.

E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

G. Motor: Single speed, secured to mounting frame, with adjustable alignment.

1. 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.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Enclosure: Open, dripproof.
b. Enclosure Materials: Cast iron or Rolled steel.
c. Motor Bearings: Permanently lubricated or Grease-lubricated ball bearings.
d. Unusual Service Conditions:

1) Ambient Temperature: **40 deg C 104 F.**.
2) Altitude: 100 above sea level.
3) High humidity.

e. Efficiency: Premium efficient.
f. NEMA Design: B or C
g. Service Factor: 1.15.
h. All motors used with VFDs shall be inverter duty rated

H. Capacities and Characteristics: Refer to plans and schedules.

I. Electrical Characteristics: Refer to plans and schedules.

2.6 AUTOMATIC CONDENSATE PUMP UNITS

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

1. Little Giant
2. Armstrong Pumps, Inc.
3. ITT Corporation.
4. Mepco, LLC.
5. PACO Pumps; Grundfos Pumps Corporation, USA.

6. Patterson Pump Company; a Gorman-Rupp company.
7. Peerless Pump Company.
8. TACO Comfort Solutions, Inc.
9. Thrush Co. Inc.

B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch-minimum, electrical power cord with plug.

C. Capacities and Characteristics: Refer to plans and schedules.

D. Condensate overflow switch.

E. Electrical Characteristics: Refer to plans and schedules.

2.7 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig pressure rating, ductile-iron body and end cap, pump-inlet fitting.
3. Bronze startup and bronze or stainless-steel permanent strainers.
4. Bronze or stainless-steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

B. Triple-Duty Valve:

1. Angle or straight pattern.
2. 175-psig pressure rating, ductile-iron body, pump-discharge fitting.
3. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
4. Brass gage ports with integral check valve and orifice for flow measurement.

C. Flexible Pipe/Pump Connections;

1. Rubber flexible connections shall be peroxide cured EPDM throughout with Kevlar tire cord reinforcement. The raised face rubber flanges must encase solid steel rings to prevent pull out. Flexible cable wire is not acceptable. Sizes 1-1/2" through 14" shall have a ductile iron external ring between the two spheres. Sizes 3/4" through 2” may have one sphere, bolted threaded flange assemblies and cable retention.

2. Minimum ratings shall be 250 psi at 170°F and 215 psi at 250°F. Higher published rated connectors may be used where required.

3. Safety factors shall be a minimum of 3/1. All flexible connections must be factory tested to 150% of maximum pressure for 12 minutes before shipment. The piping gap shall be equal to the length of the expansion joint under pressure. Control rods passing through 1/2" thick Neoprene washer bushings large enough to take the thrust at 1000psi of surface area may be used on unanchored piping where the manufacturer determines the condition exceeds the expansion joint rating without them. All flexible joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc

4. All flexible joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc

   a. Body: Fiber-reinforced rubber body.
   b. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
   c. Performance: Capable of misalignment.
   d. CWP Rating: **150 psig**
   e. Maximum Operating Temperature: 250 deg F

2.8 VIBRATION ISOLATION AND INERTIA BASES FOR PUMPS

A. Rectangular steel concrete pouring forms for floating concrete inertia base. Bases for split case pumps shall be large enough to provide support for suction and discharge elbows. Bases shall be a minimum of 6” longer then the pump on all sides. The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include concrete reinforcing bars welded in place on 6” centers running both ways in a layer 1-1/2" above the bottom. Minimum reinforcing bar size shall be ½”. Forms shall be furnished with steel templates to hold the anchor bolt sleeves and anchor bolts while concrete is being poured. Height saving spring brackets shall be used in all mounting locations to maintain a 1" clearance below the base. Wooden formed bases leaving a concrete are not acceptable. Base shall be type BMK as manufactured by Mason Industries, Inc

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.2 PUMP INSTALLATION

A. Comply with ANSI standard HI 1.4 and HI 2.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to discharge indirectly to an open drain.

E. Equipment Mounting:

1. Install base-mounted pumps on cast-in-place concrete housekeeping pads Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." and Section 033053 "Miscellaneous Cast-in-Place Concrete." Concrete housekeeping pads shall be 3 ½" high and extend 6" longer on all sides then the mountings, and shall have 45° chamfered edges.
   a. Pumps located above the lowest level (or when the lowest level is above grade), of the building shall be mounted on spring isolation inertia bases.

2. Install in-line pumps with continuous-thread hanger rods and elastomeric hangers, spring hangers, spring hangers with vertical-limit stop of size required to support weight of in-line pumps as per specification section 23 21 16 Hydronic Piping Specialties.

3. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 ALIGNMENT

A. Perform pump alignment. For pumps 20 HP or larger engage a factory-authorized service representative to perform alignment service.

B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install line size check, shutoff, and balancing valves or triple-duty valve on discharge side of pumps.

F. Install line size Y-type strainer or suction diffuser and shutoff valve on suction side of pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.

I. Install check valve and gate or ball valve on each condensate pump unit discharge.

J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 STARTUP SERVICE

A. Perform the following startup service;. For motors 20 HP and over engage a factory-authorized service representative to perform the start up.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.6 DEMONSTRATION

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

END OF SECTION 232123

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Refrigerant pipes and fittings.
2. Refrigerant piping valves and specialties.
3. Refrigerants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve, refrigerant piping, and piping specialty.

1. Include pressure drop, based on manufacturer's test data, for the following:

a. Thermostatic expansion valves.
b. Solenoid valves.
c. Hot-gas bypass valves.
d. Filter dryers.
e. Strainers.
f. Pressure-regulating valves.

B. Shop Drawings:
1. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
2. Show interface and spatial relationships between piping and equipment.
3. Shop Drawing Scale: 1/4 inch equals 1 foot.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-134a:

1. Suction Lines for Air-Conditioning Applications: 115 psig.
2. Suction Lines for Heat-Pump Applications: 225 psig.
3. Hot-Gas and Liquid Lines: 225 psig.

B. Line Test Pressure for Refrigerant R-407C:

1. Suction Lines for Air-Conditioning Applications: 230 psig.
2. Suction Lines for Heat-Pump Applications: 380 psig.
3. Hot-Gas and Liquid Lines: 380 psig.

C. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type L – Refer to section 3 for applications

B. ASTM B 280, Type ACR. – Refer to section 3 for applications

C. Wrought-Copper Fittings: ASME B16.22.

D. Wrought-Copper Unions: ASME B16.22.

E. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

F. Brazing Filler Metals: AWS A5.8/A5.8M.

G. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
4. Working Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

H. Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket.
2. End Connections:

    a. NPS 2 and Smaller: With threaded-end connections.
    b. NPS 2-1/2 and Larger: With flanged-end connections.

3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.3 VALVES AND SPECIALTIES

A. Manufactures:

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

    a. Danfoss Inc.
    b. Heldon Products; Henry Technologies.
    c. Paul Mueller Company.
    d. Danfoss Inc.
    e. Parker Hannifin Corp.
    f. Keep-Rite Co.

B. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.

2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

C. Packed-Angle Valves:
1. Body and Bonnet: Forged brass or cast bronze
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

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

E. Service Valves:
1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

F. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).
1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.

G. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.

2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

H. Thermostatic Expansion Valves: Comply with AHRI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
6. Superheat: Adjustable or Nonadjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig.

I. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: Internal or External.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter and 24-V ac coil.
8. End Connections: Socket.
9. Throttling Range: Maximum 5 psig.
10. Working Pressure Rating: 500 psig.
11. Maximum Operating Temperature: 240 deg F.

J. Straight-Type Strainers:
1. Body: Brass or welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

K. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

L. Moisture/Liquid Indicators:
1. Body: Forged brass.

2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in parts per million (ppm).
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

M. Replaceable-Core Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow: .
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

N. Permanent Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow: .
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

O. Mufflers:
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

P. Receivers: Comply with AHRI 495.
1. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

Q. Liquid Accumulators: Comply with AHRI 495.
   1. Body: Welded steel with corrosion-resistant coating.
   2. End Connections: Socket or threaded.
   3. Working Pressure Rating: 500 psig.
   4. Maximum Operating Temperature: 275 deg F.

R. FLEXIBLE CONNECTORS
   1. Corrugated stainless steel bronze hose with single layer of stainless steel exterior braiding, minimum 6 inches long with copper tube ends; for maximum working pressure 500 psi.

2.4 REFRIGERANTS

A. ASHRAE 34, R-134a: Tetrafluoroethane.

B. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

C. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT;

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, Type K, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

C. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

D. Alternative - Safety-Relief-Valve Discharge Piping: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless or packed-angle valves on inlet and outlet side of filter dryers.

E. Install a full-size, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

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

B. Install refrigerant piping according to ASHRAE 15 and in accordance the unit manufactures guidelines. Maintain refrigerant velocities within manufactures recommendations in order to keep oil entrained.

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

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

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

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

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

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

J. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

V. Install refrigerant pipping to allow expansion and contraction of piping without deformation or bending or sagging. Provide expansion fittings, bends or elbows to allow expansion in accordance with manufactures temperature operating range.

3.4 PIPE JOINT CONSTRUCTION

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

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

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

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

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

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12M/D10.12.

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

3.5 HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:

1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod, 1/2 inch.

D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2: Maximum span, 10 feet; minimum rod, 3/8 inch.
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod, 3/8 inch.
3. NPS 3: Maximum span, 12 feet; minimum rod, 3/8 inch.
4. NPS 4: Maximum span, 14 feet; minimum rod, 1/2 inch.

E. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.

b. System shall maintain test pressure at the manifold gage throughout duration of test.
c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 232513 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes the following water treatment for closed-loop hydronic systems:

1. Automatic chemical-feed equipment.
2. Chemicals.
3. Glycol Automatic feed Unit

1.3 DEFINITIONS

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

B. RO: Reverse osmosis.

C. TSS: Total suspended solids are solid materials, including organic and inorganic, that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

1. Bypass feeders.
2. Water meters.
3. Inhibitor injection timers.
4. pH controllers.
5. TSS controllers.
6. Chemical solution tanks.
7. Injection pumps.
8. Chemical test equipment.
9. Chemical material safety data sheets.

B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to hydronic systems.

1. Include plans, elevations, sections, and attachment details.

2. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

C. Field quality-control reports.

D. Other Informational Submittals:

1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
2. Water Analysis: Illustrate water quality available at Project site.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

1.8 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion and scale formation for hydronic piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.

4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Aqua-Chem, Inc.
2. Cascade Water Services, Inc.
3. Metro Group, Inc. (The).
4. Watcon, Inc.
5. Water Services Inc.

2.2 PERFORMANCE REQUIREMENTS

A. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including hot-water heating, shall have the following water qualities:

1. pH: Maintain a value within 9.0 to 10.5.
2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
3. Boron: Maintain a value within 100 to 200 ppm.
4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
6. TSS: Maintain a maximum value of 10 ppm.
7. Ammonia: Maintain a maximum value of 20 ppm.
8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
9. Microbiological Limits:

    a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
    c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
    d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
    e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT (HOT WATER SYSTEM)

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

1. Capacity: 5 gal..
2. Minimum Working Pressure: 125 psig.

2.4 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

2.5 AUTOMATIC GLYCOL MAKE UP UNIT (chilled water system)

A. Factory packaged and assembled simplex or duplex pump, mixing tank, and expansion tank, with level and pump controls, starters and control wiring.

B. Reservoir
1. Industrial grade polyethylene tank
2. Suited for glycol solution or potable water
3. 55 gallon capacity
4. 2" opening on top for ventilation/fill
5. Observable fluid level with scale
6. Removable Lid
7. Y-strainer

C. Pump
1. 10 GPM capacity at 30 psi, 1/2 HP,
2. low pressure
3. 5 GPM capacity at 60 psi, 3/4 HP, high pressure
4. Operates as needed to restore system pressure with the solution contained in the unit's reservoir
5. Pump isolation valves, check and balance valve
6. Discharge pressure gage
7. Motor contactor with pressure control
8. System HOA switch with green running light
9. Single power connectio

D. Pressure Control
1. Cut off provides protection from excess pressure
2. Cut in 3-10 psi,cut out 9-30 psi for GMU30
3. Cut in 10-45 psi,cut out 20-60 psi for GMU60

E. Level Control
1. Safely shuts down pump when solution level is low

2. Remote alarm contact
3. Red indicator light

F. Valves
1. Shut-off
2. Non-slam check
3. Calibrated balance valve

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install water testing equipment on wall near water chemical application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Bypass Feeders: Install in closed hydronic systems, including hot-water heating chilled water dual-temperature water and glycol cooling, and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
2. Install water meter in makeup-water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
5. Install a swing check on the inlet after the isolation valve.

3.3 CONNECTIONS

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

B. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232116 "Hydronic Piping Specialties."

C. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523. "Valves for HVAC Piping,".

D. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

E. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

C. Equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. At four-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to "Performance Requirements" Article.

F. Comply with ASTM D 3370 and with the following standards:

1. Silica: ASTM D 859.
2. Acidity and Alkalinity: ASTM D 1067.
3. Iron: ASTM D 1068.
4. Water Hardness: ASTM D 1126.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION 232513

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SECTION 23 29 13 - VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Variable frequency drives.

1.02 RELATED SECTIONS

A. Section 23 21 23 - Hydronic Pumps.

B. Section 16195 - Electrical Identification: Engraved nameplates.

1.03 REFERENCES

A. Division 1 - Reference Standards: Requirements for references and standards.

B. NEMA ICS 3.1 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems.

C. NEMA ICS 7 - Industrial Control and Systems: Adjustable Speed Drives.

D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

E. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (International Electrical Testing Association).

F. NFPA 70 - National Electrical Code.

1.04 SUBMITTALS FOR REVIEW

A. Division 1 - Submittals: Procedures for submittals.

B. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and over current 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.

1.05 SUBMITTALS FOR INFORMATION

A. Division 1 - Submittals: Submittals for information.

B. Test Reports: Indicate field test and inspection procedures and test results.

C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.

D. Manufacturer's Field Reports: Indicate start-up inspection findings.

1.06 SUBMITTALS FOR CLOSEOUT

A. Division 1 - Contract Closeout.

B. Operation Data: NEMA ICS 3.1. Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.

C. Maintenance Data: NEMA ICS 3.1. Include routine preventive maintenance schedule.

D. Furnish two of each air filters.

1.07 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Division 1 - Material and Equipment: Transport, handle, store, and protect products.

B. Accept controllers on site in original packing. Inspect for damage.

C. 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.

D. 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.

1.09 MAINTENANCE SERVICE

A. Division 1 - Contract Closeout.

B. Provide service and maintenance of controller for two years from Date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Equipment and devices can be provided by Danfoss Graham VLT 6000 Series 414-355-8800.

B. Manufacturer Qualifications: Company specializing in manufacturing variable frequency controllers with minimum five years documented experience, and with service facilities within 50 miles of Project.

2.02 DESCRIPTION

A. Enclosed variable frequency controllers suitable for operating the indicated loads, in conformance with requirements of NEMA ICS 7.

B. Select unspecified features and options in accordance with NEMA ICS 3.1.

C. Furnish complete variable frequency VFDs as specified herein for the equipment designated on the drawing schedules to be variable speed. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. VFD shall be housed in a metal NEMA 1 enclosure, or other NEMA type according to the installation and operating conditions at the job site. The VFD's UL listing shall allow mounting in plenum or other air handling compartments. If a NEMA 12 enclosure is required for the plenum rating, the manufacturer must supply a NEMA 12 rated VFD. VFD's used out doors must be in a NEMA 4x rated enclosure.

D. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. 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 and fan control and to eliminate the need for motor derating.

E. With the motor's rated voltage applied to the VFD input, the VFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor's service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

F. The VFD shall include an input full-wave bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.

G. The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be assembled by the manufacturer, which shall be UL-508 certified for the building and assembly of option panels. Assembly of the option panels by a third-party panel shop is not acceptable. The appropriate UL stickers shall be applied to both the VFD and option panel, in the case where these are not contained in one panel. When these VFDs are to be located in Canada, CSA or C-UL certifications shall apply. Both VFD and option panel shall be manufactured in ISO 9001 certified facilities.

H. The VFD shall have DC link reactors on both the positive and negative rails of the DC bus to minimize power line harmonics. VFDs without DC link reactors shall provide a minimum 3% impedance line reactor.

I. The VFD's full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% of rated current for up to 0.5 second while starting.

J. The VFD shall be able to provide full torque at any selected frequency from 28 Hz to base speed to allow driving direct drive fans without derating.

K. An automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continually monitor the motor's speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.

L. Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.

M. An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.

N. Galvanic and/or optical isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete I/O shall include additional isolation modules.

O. VFD shall minimize the audible motor noise through the used of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.

2.03 PROTECTIVE FEATURES

A. A minimum of Class 20 I^2t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications shall be provided.

B. Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain English. Codes are not acceptable.

C. Protect VFD from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output with an input voltage as low as 164 V AC for 208/230 volt units, and 313 V AC for 460 volt units.

D. The VFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.

E. VFD package shall include semi-conductor rated input fuses to protect power components.

F. To prevent breakdown of the motor winding insulation, the VFD shall be designed to comply with IEC Part 34-17. Otherwise the VFD manufacturer must ensure that inverter rated motors are supplied.

G. VFD shall include a "signal loss detection" circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10 V DC, and shall be programmable to react as desired in such an instance.

H. VFD shall function normally when the keypad is removed while the VFD is running and continue to follow remote commands. No warnings or alarms shall be issued as a result of removing the keypad.

I. VFD shall catch a rotating motor operating forward or reverse up to full speed.

J. VFD shall be rated for 100,000 amp interrupting capacity (AIC).

K. VFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.

L. VFD shall continue to operate without faulting until input voltage reaches 300 V AC on 208/230 volt VFDs, and 539 V AC on 460 volt VFDs.

M. All three pole variable frequency controllers (VFD) either integral to equipment or field supplied shall contain voltage fault protection specifically designed to protect all motors and all other 3 phase loads, and associated control circuits from failure or damage due to voltage unbalance, over/under voltage, phase loss, reversal, incorrect sequencing and rapid short cycling." The VFD shall be arranged to monitor critical faults including phase loss or reversal, and when detected, de-energize the load. It shall monitor non-critical faults including high/low voltage, voltage unbalance and when detected, after a time delay de-energize the load."

2.04 INTERFACE FEATURES

A. Hand/Start, Off/Stop and Auto/Start selector switches shall be provided to start and stop the VFD and determine the speed reference.

B. The VFD shall be able to be programmed to provide a 24 V DC output signal to indicate that the VFD is in Auto/Remote mode.

C. The VFD shall provide digital manual speed control. Potentiometers are not acceptable.

D. Lockable, alphanumeric backlit display keypad can be remotely mounted up to 10 feet away using standard 9-pin cable.

E. The keypads for all sizes of VFDs shall be identical and interchangeable.

F. To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters.

G. Display shall be programmable to display in 9 languages including English, Spanish and French.

H. The display shall have four lines, with 20 characters on three lines and eight large characters on one line.

I. A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.

J. A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD eliminating the need for macros.

K. The VFD shall include a standard RS-485 communications port and capabilities to be connected at a future date to a Johnson Controls N2 Metasys or Siemens FLN system at no additional cost to the owner. The connection shall be software selectable by the user.

L. As a minimum, the following points shall be controlled and/or accessible:

1. VFD Start/Stop
2. Speed reference
3. Fault diagnostics
4. Meter points

a. Motor power in HP
b. Motor power in kW
c. Motor kW-hr
d. Motor current
e .Motor voltage
f. Hours run
g. Feedback signal #1
h. Feedback signal #2
i. DC link voltage
j. Thermal load on motor
k. Thermal load on VFD
l. Heat sink temperature

5. Four additional Form C 230 volt programmable relays shall be available for factory or field installation within the FD.

M. The communication protocol shall be native BACNET, LonWorks communication shall be available for factory or field installation within the VFD.

N. Two set-point control interface (PID control) shall be standard in the unit. VFD shall be able to look at two feedback signals, compare with two set-points and make various process control decisions.

O. An output signal as a start command to actuate external equipment before allowing the VFD to start.

P. The following displays shall be accessible from the control panel in actual units: Reference Signal Value in actual units, Output Frequency in Hz or percent, Output Amps, Motor HP, Motor kW, kWhr, Output Voltage, DC Bus Voltage, VFD Temperature in degrees, and Motor Speed in engineering units per application (in GPM, CFM, etc.). VFD will read out the selected engineering unit either in a linear, square or cubed relationship to output frequency as appropriate to the unit chosen.

Q. The display shall be programmed to read in inches of water column (in-wg) for an air handler application, pressure per square inch (psi) for a pump application, and temperature (^{o}F) for a cooling tower application.

R. VFD shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.

S. If the temperature of the VFD's heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the VFD shall automatically reduce its output frequency to the motor. As the VFD's heat sink temperature returns to normal, the VFD shall automatically increase the output frequency to the motor and return the carrier frequency to it's normal switching speed.

T. The VFD shall have temperature controlled cooling fans for quiet operation and minimized losses.

U. The VFD shall store in memory the last 10 faults and related operational data.

V. Eight programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.

W. Two programmable relay outputs, one Form C 240 V AC, one Form A 30 V AC, shall be provided for remote indication of VFD status.

X. Three programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two voltage (0 to 10 V DC, 2 to 10 V DC) and one current (0 to 20 mA, 4 to 20 mA) input.

Y. Two programmable 0 to 20 mA analog outputs shall be provided for indication of VFD status. These outputs shall be programmable for output speed, frequency, current and power. They shall also be programmable to provide a selected 24 V DC status indication.

Z. Under fire mode conditions, the VFD shall be able to be programmed to automatically default to a preset speed.

2.05 ADJUSTMENTS

A. VFD shall have an adjustable carrier frequency in steps of not less than 0.1 kHz to allow tuning the VFD to the motor.

B. Sixteen preset speeds shall be provided.

C. Four acceleration and four deceleration ramps shall be provided. Accel and decel time shall be adjustable over the range from 0 to 3,600 seconds to base speed. The shape of these curves shall be automatically contoured to ensure no-trip acceleration and deceleration.

D. Four current limit settings shall be provided.

E. If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: under voltage, over voltage, current limit and inverter overload.

F. The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.

G. An automatic “on delay” may be selected from 0 to 120 seconds.

2.06 BYPASS

A. Provide a manual 3-contactor bypass consisting of a door interlocked main fused disconnect padlockable in the off position, a built-in motor starter and a four position DRIVE/OFF/BYPASS/TEST switch controlling three contactors. In the DRIVE position, the motor is operated at an adjustable speed from the VFD. In the OFF position, the motor and VFD are disconnected. In the BYPASS position, the motor is operated at full speed from the AC power line and power is disconnected from the VFD so that service can be performed. In the TEST position, the motor is operated at full speed from the AC line power while power is applied to the input of the VFD. This allows the VFD to be given an operational test while continuing to run the motor at full speed in bypass. In case of an external safety fault, a customer supplied normally closed dry contact shall be able to stop the motor whether in DRIVE or BYPASS mode.

B. Service personnel shall be able to defeat the main power disconnect and open the bypass enclosure without disconnecting power. This shall be accomplished through the use of a specially designed tool and mechanism while meeting all local and national code requirements for safety.

C. Bypass shall only be required for applications where equipment is stand alone. Such as an air handling unit or roof top AC unit. For application where redundant pumps, fans or other equipment and the standby equipment utilizes a VFD bypass is not required.

2.07 SERVICE CONDITIONS

A. Ambient temperature, -10 to 40°C (14 to 104°F).

B. 0 to 95% relative humidity, non-condensing.

C. Elevation to 3,300 feet without derating.

D. AC line voltage variation, -10 to +10% of nominal with full output.

E. No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.

PART 3 EXECUTION

3.01 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 and as instructed by manufacturer.

3.02 INSTALLATION

A. Section 01400 - Quality Control: Manufacturer's instructions.

B. Install in accordance with NEMA ICS 3.1.

C. Tighten accessible connections and mechanical fasteners after placing controller.

D. Provide fuses in fusible switches; refer to Section 16477 for product requirements.

E. Select and install overload heater elements in motor controllers to match installed motor characteristics.

F. Provide engraved plastic nameplates; refer to Section 16195 for product requirements and location.

G. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place in clear plastic holder.

3.03 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.16.2.

3.04 MANUFACTURER'S FIELD SERVICES

A. The manufacturer shall provide start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system.

3.05 ADJUSTING

A. Division 1 - Contract Closeout.

B. Make final adjustments to installed controller to assure proper operation of load system. Obtain performance requirements from installer of driven loads.

3.06 DEMONSTRATION AND INSTRUCTIONS

A. Division 1 - Contract Closeout:

B. Demonstrate operation of controllers in automatic and manual modes. Furnish 2 (1) one hour training sessions on the project site with the owner, by factory authorized personal.

END OF SECTION

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round and flat-oval ducts and fittings.
4. Double-wall round and flat-oval ducts and fittings.
5. Sheet metal materials.
6. Duct liner.
7. Sealants and gaskets.
8. Hangers and supports.
9. Seismic-Restraint Devices

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7. SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment.
13. Seismic restraints, where applicable
14. Vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints. For seismic bracing only

1.5 INFORMATIONAL SUBMITTALS

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

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.

2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

    a. Luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. **Welding Qualifications:** Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

C. Construct ductwork to NFPA 90A and NFPA 90B standards. All work, materials and equipment shall comply with the latest requirements of NFPA 90A, standards and the local authorities having jurisdiction.

D. All ductwork and fan and apparatus plenums constructed and having supported in accordance with the latest standards of the ASHRAE Guide and the Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

E. Bracing, gauges, and supports indicated in SMACNA manuals are the minimum acceptable. Additional bracing or supports shall be installed to eliminate any distortion or vibration when the systems are operating or under tests.

PART 2 - PRODUCTS

2.1 General

A. General: Non-combustible or conforming to requirements for Class 1 air duct materials, or UL 181.

B. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized steel sheet, lock-forming quality, having zinc coating of 1.25 oz per sq ft for each side in conformance with ASTM A90.

C. Dissimilar Metals: Separate connections between dissimilar metals with Dielectric Insulation. Joints between dissimilar metal duct sections to be made with Companion flanges separated by a Neoprene gasket.

D. Fasteners: Rivets, bolts, screens, and other hardware used in the sheet metal construction to be constructed of materials identical or similar to the duct material to prevent galvanic corrosion.

E. Sealant: Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic as manufactured by 3M Company EC-800.

F. Hanger Rod: Steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. Provide products from one of the following manufactures
   1. McGill Airflow LLC
   2. Zen Industries
   3. Lindab
   4. Spiral Manufacturing Co. Inc

B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard." **For standard applications**

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

G. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B. **For Humid and damp area applications including Natatoriums and Saunas.**

H. Retain subparagraph below to require thermal conductivity exceeding the requirements in ASTM C 1071. Retaining subparagraph may create a restrictive proprietary specification. Verify availability of performance with manufacturers.

1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

I. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

J. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Traverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

K. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-

support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Provide products from one of the following manufactures
   1. McGill Airflow LLC
   2. Zen Industries
   3. Lindab
   4. Spiral Manufacturing Co. Inc

C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
   2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

F. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.5 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. Provide products from one of the following manufactures
   1. McGill Airflow LLC
   2. Zen Industries

3. Lindab
4. Spiral Manufacturing Co. Inc

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

    a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

    a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
    b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard." **For standard applications.**

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

A. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B. **For application in damp or humid environments including natatoriums and Saunas.**

B. Retain subparagraph below to require thermal conductivity exceeding the requirements in ASTM C 1071. Retaining subparagraph may create a restrictive proprietary specification. Verify availability of performance with manufacturers.

1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F at75 deg F mean temperature.

2.6 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil thick on opposite surface.
3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

F. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

G. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: Black OR White.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

H. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

I. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.7 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

a. Maximum Thermal Conductivity:

1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Solvent Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

C. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B. **For application in damp or humid environments including natatoriums and Saunas .**

D. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel, aluminum, or stainless steel to match ductwork; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

E. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.8 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

2. Tape Width: 4 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

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

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
9. Service: Indoor or outdoor.
10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

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

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.9 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.10 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service or an agency acceptable to authorities having jurisdiction.

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

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

C. Restraint Cables: ASTM A 603, galvanized or ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

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

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths and with fewest possible joints

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections. *Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 0 degrees divergence upstream of equipment and 45 degrees convergence downstream.*

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 2 inch, plus allowance for insulation thickness and with sufficient space around equipment to allow normal operating and maintenance activities. *Provide easements where ductwork conflicts with piping and structure. Where easements exceed 10 percent duct area, split into two ducts maintaining original duct area.*

H. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for all installations as well as fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. 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.

N. Where hanger rods must pierce ducts, provide closure plates around rods and fasten to duct using screws, rivets or welding. Seal with sealing compound.

O. 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 are used, provide airfoil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.

P. Where ductwork penetrates roofs or outside walls, seal the space around ductwork air tight with fire rated expanding spray foam sealer similar to 3-M Fire Block Foam. This also applies to duct roof penetrations into roof curbs.

Q. All ductwork shall be inspected and pressure tested prior to enclosing in general construction or concealment above hung ceilings

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

F. Prime ductwork and paint with one coat enamel base paint. Color as per architectural plans. All ductwork surface finish shall be treated prior to priming by “pickling” in accordance with industry standards and paint manufactures requirements.

G. All ductwork in any building that is exposed to view, (except mechanical equipment rooms), shall double wall round ductwork or oval as indicated on plan. Where ductwork is to be painted, it shall be primed. Refer to the architectural plans for where ductwork shall be painted. Submit paint color chart for review and approval. Primer shall be specifically formulated for galvanized steel.

H. Duct sealants used on exposed ductwork of any type shall be clear.

3.3 DUCT SEALING;

A. Seal ducts at a minimum to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible": typical for all services;

Leakage and Seal Classification Table			
System operating pressure in wc	<2" low	2"≥med<3"	High≥3"
Seal Class	C	B	A
Sealing	Transverse joints	Transverse joints and seams	Transverse joints and seams and all wall penetrations
Leakage class CL factor	24	12	4
In addition to the above, any variable air volume system duct of 1″ and ½″ wg con-struction class that is upstream of the VAV boxes shall meet Seal Class C.			

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

G. Where hanger rods must pierce ducts, provide closure plates around rods and fasten to duct using screws, rivets or welding. Seal with sealing compound

3.5 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

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

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service or an agency acceptable to authorities having jurisdiction.

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

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

C. Smoke purge supply and exhaust systems and stair pressure systems. Flexible connection shall be permitted at diffusers, a maximum of 3' long, and flexible connections are permitted at air handling equipment for vibration isolation only.

D. INSULATED FLEXIBLE DUCTS
1. UL 181, Class 0, interlocking spiral of aluminum foil; fiberglass insulation; polyethylene vapor barrier film.
2. Pressure Rating: 8 inches WG positive or negative.
3. Maximum Velocity: 5000 fpm
4. Temperature Range: -20 degrees F to 250 degrees F.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
    a. All Ducts with a Pressure Class eaqual to or Higher Than 2-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each system of the designated pressure class.

b. All smoke purge system Ducts, including supply exhaust and return air. All stair pressurization ductwork. Test representative duct sections totaling no less than 50 percent of total installed duct area of each system.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.10 SMOKE AND HEAT DETECTOR INSTALLATION

A. Duct mounted smoke and heat detectors will be supplied under the Electrical Division. This Contractor to coordinate duct sizes and provide labor to install sensing probes into ductwork.

3.11 DUCTWORK PROTECTION

A. Duct work under construction or alteration shall not be left open ended during dust producing construction. All new and existing ductwork systems in the area of alteration or under construction shall be protected during construction. Open ends ducts shall be sealed with sheet metal or as approved.

B. For unenclosed buildings ductwork shall be kept dry and water tight. Seal open ends water tight during construction to prevent water infiltration. Keep all acoustical lining dry during construction. Lining that has become we shall be replaced. all incomplete ductwork being used

to condition spaces in phase I or phase II that will be completed under a later phase must be protect from being internally contaminated by construction dust. All returns opening must have filters placed over then to prevent dust from being returned to the unit.

3.12 DUCT SCHEDULE

A. Fabricate ducts using the following material;

1. Underground Ducts: Concrete-encased PVC-coated galvanized steel, or Concrete-encased stainless steel, or fiberglass.
2. Natatorium ductwork – PVC coated galvanized steel
3. Kitchen exhaust – welded stainless steel or black steel 18 gage
4. Smoke purge ductwork - welded stainless steel or black steel 18 gage
5. Shower room exhaust – aluminum
6. Dryer exhaust – aluminum
7. Outside air intake plenum and ductwork - Aluminum
8. All exposed ductwork in any occupied area, (does not include MER), shall be constructed of double wall round or oval spiral ductwork.

B. Duct Pressure class;

1. All duct systems shall be constructed to have a pressure classification based on the maximum static pressure (positive or negative) developed by the air handling apparatus connected to the ductwork system. Unless otherwise noted below, refer to the equipment schedules and equipment notes for the design operating pressure of each system. Systems with operating pressures between pressure classes shall be constructed to the next higher pressure class.

Pressure Classification Table						
System operating pressure (OP) in wc	OP≤1"	1"≥OP<2"	2"≥OP<3"	3"≥OP<4"	4"≥OP<6"	6"≥OP<10"
SMACNA Construction classification	1"	2"	3"	4"	6"	10"

2. All ductwork shall be constructed in accordance with the leakage and seal classification. Note that the leakage and seal classification required by current code is more stringent than SMACNA requirements refer to the table below.

Leakage and Seal Classification Table			
System operating pressure in wc	<2" low	2"≥med<3"	High≥3"
Seal Class	C	B	A
Sealing	Transverse joints	Transverse joints and seams	Transverse joints and seams and all wall penetrations
Leakage class CL factor	24	12	4
In addition to the above, any variable air volume system duct of 1″ and ½″ wg con-struction class that is upstream of the VAV boxes shall meet Seal Class C.			

C. Liner for sound attenuation:

1. Supply, Return and exhaust air ducts: ½” inches thick.
2. Supply and return fan Plenums: 1” inches thick.
3. Transfer Ducts: 1 inch thick.
4. Ductwork downstream from VAV boxes for 10’
5. At the inlet and discharge of all fans for a distance of 20’
6.

D. Double-Wall Duct Interstitial Insulation:

1. Supply, Return, Exhaust Air Ducts: 1” inches thick. (when ducts are exposed in the conditions space)
2. Supply, Return, Exhaust Air Ducts: 1 1/2” inches thick. (when ducts are concealed in plenums or are located in unconditioned spaces)

E. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Velocity 1000 fpm or Lower:

      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.

   b. Velocity 1000 to 1500 fpm:

      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with turning vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with turning vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with turning vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter:
c. Round Elbows, 14 Inches and Larger in Diameter:

F. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm or Lower: 90-degree tap.

b. Velocity 1000 to 1500 fpm: Conical tap.
c. Velocity 1500 fpm or Higher: 45-degree lateral.

3.13 DUCTWORK PRESSURE TESTING

A. All ductwork design or operated at 3wc or greater shall pressure tested in accordance with specification section 23 05 93 Testing Adjusting and Balancing.

B. The contractor review test report results and repair or replace any sections of ductwork with and air leakage rate over 4.0

END OF SECTION 233113

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SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Ceiling radiation dampers.
7. Smoke dampers.
8. Combination fire and smoke dampers.
9. Corridor dampers.
10. Flange connectors.
11. Duct silencers.
12. Turning vanes.
13. Remote damper operators.
14. Duct-mounted access doors.
15. Flexible connectors.
16. Duct security bars.
17. Duct accessory hardware.

B. Related Requirements:

1. Section 233113 Metal Ducts
2. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
3. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

    a. Special fittings.
    b. Manual volume damper installations.
    c. Control-damper installations.
    d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
    e. Duct security bars.
    f. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

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

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

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

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Pottorff.
4. Ruskin Company.
5. Buckley

B. Description: Gravity balanced.

C. Maximum Air Velocity: 1000 fpm.

D. Maximum System Pressure: up to 6”wc.

E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel or 0.063-inch-thick extruded aluminum, with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, center pivoted, or off-center pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum or 0.050-inch-thick aluminum sheet noncombustible, tear-resistant, neoprene-coated fiberglass with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:

1. Material: Galvanized, steel Stainless steel, or Aluminum.
2. Diameter: 0.20 inch min.

J. Tie Bars and Brackets: Aluminum or Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball or synthetic pivot bushings.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.

    a. Sleeve Thickness: 20 gage minimum.
    b. Sleeve Length: 6 inches minimum.

6. Screen Mounting: Rear mounted.
7. Screen Material: Galvanized steel or Aluminum.
8. Screen Type: Bird. ½ x ½ max opening
9. 90-degree stops.

2.4 BAROMETRIC RELIEF DAMPERS

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

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Pottorff.
4. Ruskin Company.
5. Buckley

B. Suitable for horizontal or vertical mounting.

C. Maximum Air Velocity: 1000 fpm.

D. Maximum System Pressure: upto 6-inch wg.

E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel or 0.063-inch-thick extruded aluminum, with welded corners or mechanically attached and mounting flange.

F. Blades:

1. Multiple, 0.025-inch-thick, roll-formed aluminum or 0.050-inch-thick aluminum sheet.
2. Maximum Width: 6 inches.
3. Action: Parallel.

4. Balance: Gravity.
5. Eccentrically pivoted or Off-center pivoted.

G. Blade Seals: Neoprene.

H. Blade Axles: Galvanized steel, aluminum, or Stainless steel.

I. Tie Bars and Brackets:

1. Material: Aluminum or Galvanized steel.
2. Rattle free with 90-degree stop.

J. Return Spring: Adjustable tension.

K. Bearings: Synthetic, Stainless steel, Bronze.

L. Accessories:

1. Flange on intake.
2. Adjustment device to permit setting for varying differential static pressures.

2.5 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

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

a. Flex-Tek Group.
b. McGill AirFlow LLC.
c. Nailor Industries Inc.
d. Pottorff.
e. Ruskin Company.
f. Vent Products Co., Inc.
g. Buckley

2. Standard leakage rating, with linkage outside airstream.

3. Suitable for horizontal or vertical applications.
4. Frames:

a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel or 0.05-inch-thick stainless steel.
b. Mitered and welded corners.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.

c. Stiffen damper blades for stability.
d. Galvanized or Stainless-steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel, Stainless or steel Nonferrous metal.
7. Bearings:

a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless-steel sleeve.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

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

a. McGill AirFlow LLC.
b. Nailor Industries Inc.
c. Pottorff.
d. Ruskin Company.
e. Vent Products Co., Inc.

2. Standard leakage rating, with linkage outside airstream.

3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
e. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.

6. Blade Axles: Galvanized steel or Stainless steel.
7. Bearings:

a. Oil-impregnated bronze, Molded synthetic, or Stainless-steel sleeve.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

C. Low-Leakage, Steel, Manual Volume Dampers:

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

a. McGill AirFlow LLC.

b. Nailor Industries Inc.
c. Pottorff.
d. Ruskin Company.
e. Vent Products Co., Inc.

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames:

a. U or Angle shaped.
b. 0.094-inch-thick, galvanized sheet steel or 0.05-inch-thick stainless steel.
c. Mitered and welded corners.
d. Flanges for attaching to walls and flangeless frames for installing in ducts.

6. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Galvanized or Stainless, roll-formed steel, 0.064 inch thick.

7. Blade Axles: Galvanized steel or Stainless steel.
8. Bearings:

a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless-steel sleeve, Stainless-steel sleeve.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals: Neoprene.
10. Jamb Seals: Cambered stainless steel or aluminum.
11. Tie Bars and Brackets: Galvanized steel or Aluminum.
12. Accessories:

a. Include locking device to hold single-blade dampers in a fixed position without vibration.

D. Low-Leakage, Aluminum, Manual Volume Dampers:

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

a. McGill AirFlow LLC.
b. Nailor Industries Inc.
c. Pottorff.
d. Ruskin Company.
e. Vent Products Co., Inc.

2. Comply with AMCA 500-D testing for damper rating.

3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames: U or Angle-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
    d. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.

7. Blade Axles: Galvanized steel, Stainless steel.
8. Bearings:

    a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless-steel sleeve, Stainless-steel sleeve.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals: Neoprene.
10. Jamb Seals: Cambered stainless steel, aluminum.
11. Tie Bars and Brackets: Galvanized steel, Aluminum.
12. Accessories:

    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

E. Jackshaft:

1. Size: 0.5-inch diameter min.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

F. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.6 CONTROL DAMPERS

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

1. Arrow United Industries.
2. Greenheck Fan Corporation.

3. McGill AirFlow LLC.
4. Nailor Industries Inc.
5. Pottorff.
6. Ruskin Company.

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:

1. U or Angle shaped.
2. 0.094-inch-thick, galvanized sheet steel or 0.05-inch-thick stainless steel.
3. Mitered and welded corners.

D. Blades:

1. Multiple blade with maximum blade width of 6 inches.
2. Parallel blade for non modulating application
3. Opposed-blade design for all modulating applications
4. Galvanized-steel, Stainless steel, Aluminum.
5. 0.064 inch thick single skin or 0.0747-inch-thick dual skin.
6. Blade Edging: Closed-cell neoprene.
7. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

E. Blade Axles: 1/2-inch-diameter; galvanized steel, or stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F.

F. Bearings:

1. Oil-impregnated bronze, Molded synthetic, Oil-impregnated, stainless-steel sleeve, or Stainless-steel sleeve.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.7 FIRE DAMPERS

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

1. Arrow United Industries.
2. Greenheck Fan Corporation.
3. Nailor Industries Inc.
4. Pottorff.
5. Ruskin Company.
6. Ward Industries; a brand of Hart & Cooley, Inc.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Curtain type with blades inside airstream for application in duct over 24” in height. Curtain type with blades outside airstream for ducts 24” or less in height. Multiple-blade type; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.138 inch upto 4 SF 0.39 over 4 SF inch thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.8 CEILING RADIATION DAMPERS

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

1. Aire Technologies.
2. Nailor Industries Inc.
3. Pottorff.
4. Prefco.
5. Ruskin Company.

B. General Requirements:

1. Labeled according to UL 555C by an NRTL.
2. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."

C. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.

D. Blades: Galvanized sheet steel with refractory insulation.

E. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

F. Fire Rating: 1hr for applications in assemblies up to 1 ½ hr rating. 2hr for application in assemblies of up to 3hr

2.9 SMOKE DAMPERS

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

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Pottorff.
4. Ruskin Company.

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: Integral, factory wired for single-point connection. Except for NYC smoke detector shall be provided by the fire alarm contractor.

D. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded or mechanically attached corners and mounting flange.

E. Blades: Roll-formed, horizontal, overlapping, 0.063-inch- thick, galvanized sheet steel.

F. Leakage: Class I.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.05-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

I. Damper Motors: Modulating or two-position action.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.

6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

K. Accessories:

1. Auxiliary switches for signaling, fan control and position indication.
2. Test and reset switches, damper or remote mounted.
3. Manual damper testing by physically depressing the low temperature thermal disc from the inside of the damper sleeve and resetting the sensor from the exterior side of the damper sleeve.
4. Dual position blade indicator switch package shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.
5. Dual Position Indicator Switch Package: Shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.
6. Duct Smoke Detector: Factory mounted in the damper sleeve with interconnecting wiring from the damper actuator to the smoke detector enabling a single power connection point for easy field wiring.

2.10 COMBINATION FIRE AND SMOKE DAMPERS

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

1. Greenheck Fan Corporation.
2. Pottorff.
3. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

D. Fire Rating: 1-1/2 for assemblies upto 2 hour and 3 hr rating for assemblies over 1 1/2hours.

E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded corners and mounting flange.

F. Primary heat responsive device set at 285 deg F, resettable.

G. Secondary heat closure device, set at 350 deg F, resettable.

H. Smoke Detector: Integral, factory wired for single-point connection.

I. Blades: Roll-formed, horizontal, interlocking, 0.063-inch- thick, galvanized sheet steel.

J. Leakage: Class I.

K. Rated pressure and velocity to exceed design airflow conditions.

L. Mounting Sleeve: Factory-installed, 0.039-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

M. Master control panel for use in dynamic smoke-management systems.

N. Damper Motors: Modulating or two-position action.

O. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. **Electrical Connection: 115 V, single phase, 60 Hz.**

P. Accessories:

A. DRS-30 Two-Temperature Fire Closure Device:

1. UL classified two-temperature device permits the damper to be re-opened after initial temperature closure allowing the damper to remain operable for smoke management purposes until the high temperature limit is reached.

2. Manual damper testing is permitted by physically depressing the low temperature thermal disc from the inside of the damper sleeve and resetting the sensor from the exterior side of the damper sleeve.

3. Dual position blade indicator switch package shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.

B. PI-50 Dual Position Indicator Switch Package: Shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.

C. Duct Smoke Detector: Factory mounted in the damper sleeve with interconnecting wiring from the damper actuator to the smoke detector enabling a single power connection point for easy field wiring.

2.11 FLANGE CONNECTORS

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

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Hardcast, Inc.
4. Ward Industries; a brand of Hart & Cooley, Inc.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.12 DUCT SILENCERS

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

1. Industrial Noise Control, Inc.
2. McGill AirFlow LLC.
3. Ruskin Company.
4. Vibro-Acoustics.
5. Industrial Acoustics

B. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.
5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90 , galvanized sheet steel, 0.040 inch thick.

E. Round Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034 inch thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040 inch thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.05 inch thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064 inch thick.

F. Inner Casing and Baffles: ASTM A 653/A 653M, G60 galvanized sheet metal, 0.034 inch thick, and with 1/8-inch-diameter perforations.

G. Special Construction:

1. Suitable for outdoor use.
2. High transmission loss to achieve STC 45.

H. Connection Sizes: Match connecting ductwork unless otherwise indicated.

I. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Dissipative or Film-lined type with fill material.

    a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 15 percent compression and Moisture-proof nonfibrous material.
    b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

3. Lining: Fiberglas cloth.

J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Joints: Lock formed and sealed or continuously welded or flanged connections.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

K. Accessories:

1. Integral 1-1/2 3-hour fire damper with access door. Access door to be high transmission loss to match silencer.
2. Factory-installed end caps to prevent contamination during shipping.
3. Removable splitters.
4. Airflow measuring devices.

L. Source Quality Control: Test according to ASTM E 477.

1. Testingto be witnessed by Engineer.
2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

M. Capacities and Characteristics:

1. Configuration: Straight or 90-degree elbow as indicated on plan
2. Shape: Rectangular or Round as indicated on plan
3. Attenuation Mechanism: Acoustical glass fiber with protective film liner.
4. Maximum Pressure Drop: 0.25-inch wg.
5. Casing:

    a. Attenuation: Standard.
    b. Outer Material: Galvanized steel.
    c. Inner Material: Galvanized steel.

6. Velocity Range: 500 fpm max.
7. End Connection: 1-inch slip joint or Flange.
8. Length: as per plan
9. Face Dimension:

    a. Width: as per plan
    b. Height: as per plan

10. Face Velocity: as per plan
11. Dynamic Insertion Loss: as per plan
12. Generated Noise: as per plan
13. Accessories:

    a. Access door.
    b. Birdscreen.

2.13 TURNING VANES

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

1. Aero-Dyne Sound Control Co.
2. CL WARD & Family Inc.
3. Ductmate Industries, Inc.
4. Duro Dyne Inc.
5. METALAIRE, Inc.
6. Ward Industries; a brand of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.14 REMOTE DAMPER OPERATORS

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

1. Pottorff.
2. Ventfabrics, Inc.
3. Young Regulator Company.

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: Copper or Aluminum.

D. Cable: Steel.

E. Wall-Box Mounting: Recessed.

F. Wall-Box Cover-Plate Material: Stainless steel.

2.15 DUCT-MOUNTED ACCESS DOORS

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

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Greenheck Fan Corporation.
4. McGill AirFlow LLC.
5. Nailor Industries Inc.
6. Pottorff.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

    a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
    b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
    c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles for plenum applications.
    d. Access Doors Larger Than 24 by 48 Inches: Four hinges or Continuous and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 3.0- to 8.0-inch wg.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch-thick, fibrous-glass or polystyrene-foam board.

2.16 DUCT ACCESS PANEL ASSEMBLIES

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

1. 3M.
2. Ductmate Industries, Inc.
3. Flame Gard, Inc.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.17 FLEXIBLE CONNECTORS

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

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Duro Dyne Inc.
4. Elgen Manufacturing.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches or 5-3/4 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd..
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

H. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd..
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

I. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.18 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.
3. Install stainless steel volume dampers in stainless steel ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Connect ducts to duct silencers rigidly.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot spacing and the bottom of all riser in Laundry exhaust ducts.
8. Upstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

P. Connect diffusers or light troffer boots to ducts with maximum 30-inch lengths of flexible duct clamped or strapped in place.

Q. Connect flexible ducts to metal ducts with draw bands.

R. Install duct test holes where required for testing and balancing purposes.

S. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

T. Install remote volume damper operators for all volume dampers that are concealed an not accessible after finished construction is complete.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 23 34 23 HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Utility set fans.
2. Centrifugal roof ventilators.
3. Centrifugal wall ventilators.
4. Ceiling-mounted ventilators.
5. In-line centrifugal fans.
6. Propeller fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on sea level.

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

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

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

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

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Design Calculations: Calculate requirements for selecting vibration isolatorsand for designing vibration isolation bases.

D. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

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

E. Field quality-control reports.

F. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

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

1.6 COORDINATION

A. Coordinate size and location of structural-steel support members.

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

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

1.7 EXTRA MATERIALS

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

1. Belts: 2 set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 UTILITY SET FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ACME Company.
2. Loren Cook Company.
3. New York Blower Company
4. PennBarry.
5. Greenheck.

B. Housing: Fabricated of galvanized steel with side sheets fastened with a deep lock seam or welded to scroll sheets.

1. Housing Discharge Arrangement: Adjustable to eight standard positions.

C. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.

1. Blade Materials: Steel or Aluminum.
2. Blade Type: Backward inclined or Forward curved, or Airfoil. As scheduled
3. Spark-Resistant Construction: AMCA 99, Type A

D. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

E. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L_{50} of 200,000 hours.

1. Extend grease fitting to accessible location outside of unit.

F. Belt Drives:

1. Factory mounted, with final alignment and belt adjustment made after installation
2. Service Factor Based on Fan Motor Size: 1.5
3. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
5. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

G. Accessories:

1. Inlet and Outlet: Flanged.
2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
3. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades with felt edges in steel frame installed on fan discharge.
4. Access Door: Gasketed door in scroll with latch-type handles.
5. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
6. Inlet Screens: Removable wire mesh.
7. Drain Connections: NPS 3/4 threaded coupling drain connection installed at lowest point of housing.
8. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
9. Discharge Dampers: Assembly with opposed blades constructed of two plates formed around and to shaft, channel frame, sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
10. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
11. Disconnect switch - Nonfusible type, with thermal-overload protection. Externally mounted outdoor disconnects shall be NEMA 3R

2.2 CENTRIFUGAL ROOF VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ACME Company.
2. Central Blower Company.
3. Greenheck Fan Corporation.
4. Loren Cook Company.
5. PennBarry.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector (for kitchen hood applications).
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside or outside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Barometric Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
6. Kitchen hood exhaust applications
    a. No back draft discharge damper for kitchen hood exhaust applications
    b. Minimum curb Height: 8". Coordinate the exact curb height in the field so that the top of the fan is a minimum of 40" above the roof.
    c. Roof curb shall be vented without insulation.
    d. Provide grease drain line and cup
    e. Provide hinged
    f. NEMA 3R external unit mounted disconnect switch.
    g. Bird screen with heat baffle
    h. Fan shall be hinge mounted to curb for access to the wheel and ductwork
    i. UL 762 rated for continuous operation up to 300 deg F.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Minimum Height: 18 inches. For Kitchen exhaust applications coordinate the curb height in the field so that the top of the fan is a minimum of 40" above the roof.
3. Sound Curb: Curb with sound-absorbing insulation.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Burglar Bars: 1/2-inch- thick steel bars welded in place to form 6-inch squares. (Not required unless scheduled)
7. Mounting Pedestal: Galvanized steel with removable access panel.
8. Vented Curb: Unlined with louvered vents in vertical sides. (for kitchen hood exhaust applications)

2.3 CENTRIFUGAL WALL VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carnes Company.
2. Greenheck Fan Corporation.
3. ACME Fan Incorporated.
4. Loren Cook Company.
5. PennBarry.

B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.

C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Wall Grille: Ring type for flush mounting.
5. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.
6. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

2.4 CEILING-MOUNTED VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carnes Company.
2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. PennBarry.

B. Housing: Steel, lined with acoustical insulation. Housing shall be field adaptable for inline installation.

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

D. Grille: Aluminum or Painted aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit. Externally mounted disconnects shall be NEMA 3R
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Wall Grille: Ring type for flush mounting.
5. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.
6. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

2.5 IN-LINE CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carnes Company.
2. Greenheck Fan Corporation.
3. ACME Fan Incorporated.
4. Loren Cook Company.
5. PennBarry.

B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent. (where scheduled or indicated on plan)
2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
3. Companion Flanges: For inlet and outlet duct connections.
4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
6. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside or outside fan housing, factory wired through an internal aluminum conduit

2.6 PROPELLER FANS

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

1. Carnes Company.
2. Chicago Blower Corporation.
3. Loren Cook Company.
4. ACME
5. PennBarry.

B. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.

C. Steel Fan Wheels: Formed-**steel blades** riveted to heavy-gage steel spider bolted to cast-iron hub.

D. Fan Wheel: Replaceable, **cast or extruded-aluminum,** airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

E. Fan Drive: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

F. Fan Drive:

1. Resiliently mounted to housing.
2. Statically and dynamically balanced.
3. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
4. Extend grease fitting to accessible location outside of unit.
5. Service Factor Based on Fan Motor Size: 1.4.
6. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
7. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

    a. Ball-Bearing Rating Life: ABMA 9, L_{10} of 100,000 hours.

8. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
9. Motor Pulleys: Adjustable pitch for use with motors through 3 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
10. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
11. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

G. Accessories:

1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Weathershield Hood: Galvanized steel to match fan and accessory size.
5. Weathershield Front Guard: Galvanized steel with expanded metal screen.
6. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

7. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

2.7 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

B. Enclosure Type: Totally enclosed, fan cooled.

2.8 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using spring isolators or restrained spring isolators for projects with seismic requirements having a static deflection of 1 inch. Vibration- and seismic-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounted units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

D. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

E. Support suspended units from structure using threaded steel rods and elastomeric hangers or spring hangers with vertical-limit stops having a static deflection of 1 inch.

F. Install units with clearances for service and maintenance.

G. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section "Air Duct Accessories."

B. Kitchen exhaust hood fans shall not have flexible connections or back draft dampers.

C. Install ducts adjacent to power ventilators to allow service and maintenance.

D. Prove flexible duct connections for all fans except Kitchen exhaust fans.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.

10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. Comply with requirements in "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

E. Mechanical schedules and equipment notes indicate estimated static pressures and resultant RPM. If, during balancing, it is determined that the sheaves supplied with and fan or air handling unit have reached the maximum adjustment and design static pressure and or CFM can not be obtained then it shall be the mechanical contractors responsibility to remove and change the drive as required to reach design conditions. And it shall be the balancers responsibility to rebalance the system as appropriate to achieve design conditions after the drives have been changed.

END OF SECTION

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SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Shutoff, single-duct air terminal units.
   2. Casing liner.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For air terminal units.

   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

   1. Ceiling suspension assembly members.
   2. Size and location of initial access modules for acoustic tile.
   3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Instructions for resetting minimum and maximum air volumes.
b. Instructions for adjusting software set points.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

B. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Manufactures;
1. Tittus
2. Anomastat
3. Carnes
4. Greenheck

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.040-inch- thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from zero to 140 deg F, shall be impervious to moisture and fungus, shall be suitable for 10-inch wg static pressure, and shall be factory tested for leaks.

E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 6-inch wg inlet static pressure.
2. Damper Position: Normally open.

F. Attenuator Section: 0.034-inch steel sheet.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

G. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

H. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
1. Electronic Damper Actuator: 24 V, powered open, spring return.
2. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit refer to DDC controls specifications.
3. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
4. Terminal Unit Controller: Pressure-independent, variable-air-volume (VAV) controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

    a. Occupied and unoccupied operating mode.
    b. Remote reset of airflow or temperature set points.
    c. Adjusting and monitoring with portable terminal.
    d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

5. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

I. Controls:

1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.
2. System-powered, wall-mounted thermostat.

2.3 CASING LINER

A. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Minimum Thickness: 1/2 inch.
2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.2 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

3.3 CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

D. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 235123 - GAS VENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Listed double-wall vents.

B. Related Requirements:

1. Section 235216.11 "Condensing Boilers”

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

B. Shop Drawings: For vents.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Sample Warranty: For special warranty.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.

2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents.

B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1 LISTED SPECIAL GAS VENTS

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

1. Heatfab Saf-T Vent.
2. Metal-Fab, Inc.
3. Security Chimneys International.
4. Selkirk Corporation.

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch insulation

D. Inner Shell: ASTM A959, Type 29-4C stainless steel.

E. Outer Jacket: Aluminized steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

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

3.2 APPLICATION

A. Listed Special Gas Vent: Condensing gas appliances. Boilers, domestic hot water heaters, H&V units and gas fired unit heaters.

3.3 INSTALLATION OF LISTED VENTS

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

B. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

D. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

E. Lap joints in direction of flow.

F. Provide water proof vent cap at termination. Terminate all vent through roof a minimum of 3’ feet above the roof and terminate 3’ above any structure within 10’.

G. Provide wall or wall thimbles as required. Fire stop and water proof penetrations. Provide flashing and counter flashing as necessary.

H. Coordinate termination location with outside air intakes as per the manufacture’s requirements.

3.4 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION 235123

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SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes gas-fired, fire-tube condensing boilers, trim, and accessories for generating hot water.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories.

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

C. Delegated-Design Submittal: For each boiler.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for boiler, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

E. Product Certificates:

1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
2. CSA B51 pressure vessel Canadian Registration Number (CRN).

1.5 CLOSEOUT SUBMITTALS

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

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fire-Tube Condensing Boilers:

a. Leakage and Materials: 10 years from date of Substantial Completion.
b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Nonprorated for ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N.

E. UL Compliance: Test boilers for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

F. CSA Compliance: Test boilers for compliance with CSA B51.

G. Mounting Base: For securing boiler to concrete base.

1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

2.2 WATER JACKETED FORCED-DRAFT, FIRE-TUBE CONDENSING BOILERS

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

1. AERCO; A WATTS Brand.
2. Riello.
3. Camus.
4. Raypack
5. Fulton.
6. Lochinvar.

B. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water-heating service only.

C. Heat Exchanger: Stainless-steel primary and secondary combustion chamber.

D. Pressure Vessel: Carbon steel with welded heads and tube connections where not in contact with combustion or flue gases.

E. Burner: Natural gas, forced draft; swing-open front and burner observation port.

F. Blower: Centrifugal fan to operate during each burner firing sequence and to pre-purge and post-purge the combustion chamber.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

G. Gas Train: Combination gas valve with manual shutoff and pressure regulator. Include 100 percent safety shutoff with electronic flame supervision.

H. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

I. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Baked-enamel or Powder-coated protective finish.
4. Insulation: Minimum 4-inch-thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

J. Capacities and Characteristics:
1. Refer to plans and schedules for capacities

2. HeaRetain "Minimum Efficiency AFUE," "Minimum Thermal Efficiency," or "Minimum Combustion Efficiency" Subparagraph below. Specify standing or intermittent pilot with minimum AFUE. Sustainable design systems require compliance with ASHRAE/IES 90.1 and may require efficiency in excess of minimum efficiency required by ASHRAE/IES 90.1.
3. Minimum Efficiency AFUE: percent.
4. Minimum Thermal Efficiency: 96.5 percent.
5. Minimum Combustion Efficiency: 95 percent.
6. AGA Output Capacity: refer to plans
7. DOE Output Capacity: refer to plans.

2.3 TRIM

A. Include devices sized to comply with ASME B31.9.

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Safety (pressure) Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch-diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic.

F. Drain Valve: Minimum NPS 3/4 hose-end drain valve.

G. Circulation Pump: Nonoverloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

H. Condensate neutralization and drain kit with marble chips.

2.4 CONTROLS

A. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Boiler operating controls shall be direct digital and fully self-contained. The operating control panel shall be mounted on the boiler front panel and shall be fully installed and programmed factory packed controller by the boiler manufacture. The controller shall have an LCD screen for user or operator interface.

C. Boiler operating controls shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.
3. Operating Pressure Control: Factory wired and mounted to cycle burner.
4. Low-Water Cutoff and Pump Control: Cycle feedwater pump(s) for makeup water control.

5. Sequence of Operation: Electric, factory-fabricated and OR field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F outside-air temperature, set supply-water temperature at 180 deg F; at 50 deg F outside-air temperature, set supply-water temperature at 140 deg F.

    a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

D. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design temperature.
2. Low-Water Cutoff Switch: (1) Electronic AND (1) Float and electronic probe shall prevent burner operation on low water. Cutoff switch shall be (1) manual AND (1) automatic-reset type.
3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

E. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. Hardwired Points:

    a. Monitoring: On/off status, common trouble alarm low-water-level alarm.
    b. Control: On/off operation, hot-water-supply temperature set-point adjustment.

2. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator

workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.5 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface shall be to nonfused disconnect switch.
5. Provide branch power circuit to each motor and to controls with a disconnect switch. Provide each motor with overcurrent protection.

2.6 VENTING KITS

A. Provide full boiler venting and OAI ducting. Refer to Section 23 52 23 "Gas Vents." For full requirements. The following paragraphs are the minimum requirements.

B. ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
1. Provide all specialty fittings, including offsets, elbows, roof thimble, wall thimble screens and caps from boiler flue to termination point outdoors. Refer to plans for duct arrangement. Boiler vent piping shall be double wall with 1” of insulation and aluminum jacket. Vertical vent piping located inside existing masonry chimneys shall be single wall.

C. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.
1. Provide all specialty fittings, including offsets, elbows, screens for CA intake from boiler to OAI louver or termination point outdoors. Refer to plans for duct arrangement.

2.7 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

C. Allow Owner access to source quality-control testing of boilers. Notify engineer 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

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

3.2 BOILER INSTALLATION

A. Equipment Mounting:

1. Install boilers on cast-in-place concrete housekeeping pads Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." and Section 033053 "Miscellaneous Cast-in-Place Concrete." Concrete housekeeping pads shall be 5 ½" high and extend 6" longer on all sides then the mountings, and shall have 45° chamfered edges.
   a. Pumps located above the lowest level (or when the lowest level is above grade), of the building shall be mounted on spring isolation inertia bases.
   b. Grout between boiler base and house keep pad.

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Install all piping in accordance with manufactures recommendations.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from acid neutralizing device / equipment drain connection to discharge indirectly to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required by manufacturer. Drain piping shall be PVC

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 "Hydronic Piping Specialties."

E. Safety relief valves shall be hard piped, full size of relief valve outlet. Pipe down to within 18" of floor or to nearest floor drain. Discharge at floor drain shall be indirect connection.

F. Connect gas piping to boiler gas-train inlet with union and shut off valve. Piping shall be at least full size of gas-train connection. Provide a reducer if required. Provide plug valve for shut off and 6" drip leg.

G. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

H. Install piping from safety valves to drip-pan elbow and to nearest floor drain.

I. Boiler Venting:

1. Install flue venting kit and combustion-air intake.
2. Connect full size to boiler connections. Comply with requirements in Section 235123 "Gas Vents."

J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Boiler will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

G. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.

    a. Test for full capacity.
    b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
7. Notify engineer 48 hours minimum in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235216

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SECTION 235533.16 - GAS-FIRED UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes gas-fired unit heaters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of gas-fired unit heater.

1. Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: For gas-fired unit heaters. Include plans, elevations, sections, and attachment details.

1. Prepare by or under the supervision of a qualified professional engineer detailing fabrication and assembly of gas-fired unit heaters, as well as procedures and diagrams.
2. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which equipment will be attached.
2. Items penetrating roof and the following:

a. Vent and gas piping rough-ins and connections.
b. Concentric vent assemblies

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas-fired unit heaters to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fan Belts and filters: One for each belt-driven fan size.

1.7 QUALITY ASSURANCE

A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace heat exchanger of gas-fired unit heater that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Modine Manufacturing Company.
2. REZNOR, a brand of Nortek Global HVAC.
3. Sterling HVAC Products; a Mestek company.

2.2 PERFORMANCE REQUIREMENTS

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

B. Capacities and Characteristics: refer to plans and schedules

2.3 MANUFACTURED UNITS

A. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.

B. Gas Type: Design burner for natural gas having characteristics same as those of gas available at Project site. Natural gas.

C. Type of Venting: Indoor, separated combustion, power vented.

D. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.

1. External Casings and Cabinets: Baked enamel or Powder coating over corrosion-resistant-treated surface.
2. Discharge Louvers: Independently adjustable, horizontal and vertical blades.
3. Discharge Nozzle: Discharge at 10 to 65 degrees from horizontal.

E. Accessories:

1. Four-point suspension kit.
2. Power Venter: Centrifugal aluminized-steel fan, with stainless-steel shaft; 120-V ac motor.
3. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes, and flashing for wall or roof penetration.

F. Heat Exchanger: Stainless steel.

G. Burner Material: Stainless steel.

H. Propeller Unit Fan:

1. Formed-steel or Aluminum propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
2. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.

I. Centrifugal Unit Fan:

1. Steel, centrifugal fan dynamically balanced and resiliently mounted.
2. Belt-Driven Drive Assembly:

a. Resiliently mounted to housing, with the following features:

1) Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2) Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3) Pulleys: Cast-iron, adjustable-pitch motor pulley.

J. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure Materials: Rolled steel.
3. Motor Bearings: 200000.

4. Efficiency: Premium efficient.
5. NEMA Design: 1.
6. Service Factor: 1.5.

K. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

1. Gas Control Valve: Modulating.
2. Ignition: Electronically controlled electric spark with flame sensor.
3. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
4. Vent Flow Verification: Flame rollout switch or Differential pressure switch to verify open vent.
5. Control transformer.
6. High Limit: Thermal switch or fuse to stop burner.
7. Thermostat: Devices and wiring are specified in Section 230923.27 "Temperature Instruments."
8. Wall Mounted Thermostat:

    a. Two stage.
    b. Fan on-off-automatic switch.
    c. 24-V ac.
    d. 50 to 90 deg F operating range.

L. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and connect gas-fired unit heaters and associated gas and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written instructions.

3.2 EQUIPMENT MOUNTING

A. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to gas-fired unit heater, allow space for service and maintenance.

C. Gas Piping: Comply with Section 221123 "Facility Natural-Gas Piping." Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.

D. Vent Connections: Comply with Section 235123 "Gas Vents."

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify bearing lubrication.
3. Verify proper motor rotation.
4. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Gas-fired unit heater will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain gas-fired unit heaters.

END OF SECTION 235533.16

SECTION 236423.13 - AIR-COOLED, SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes packaged, air-cooled, electric-motor-driven, scroll water chillers.

B. Section includes split, air-cooled, electric-motor-driven, scroll water chillers. (delete condensing unit section)

1.3 DEFINITIONS

A. BAS: Building automation system.

B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

C. DDC: Direct digital control.

D. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in Btu/h to the total power input given in watts at any given set of rating conditions.

E. GFI: Ground fault interrupt.

F. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.

G. I/O: Input/output.

H. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.

I. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.

J. SCCR: Short-circuit current rating.

K. TEAO: Totally enclosed air over.

L. TENV: Totally enclosed nonventilating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include refrigerant, rated capacities, operating characteristics, and furnished specialties and accessories.
2. Performance at AHRI standard conditions and at conditions indicated.
3. Performance at AHRI standard unloading conditions.
4. Minimum evaporator flow rate.
5. Refrigerant capacity of water chiller.
6. Oil capacity of water chiller.
7. Fluid capacity of evaporator.
8. Characteristics of safety relief valves.
9. Force and moment capacity of each piping connection.

B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

a. Structural supports.
b. Piping roughing-in requirements.
c. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
d. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

2. Coordination drawings showing plan, section and elevation views, drawn to 3/8”=1’-0” scale.
3. Each view to show screened background with the following:

a. Column grids, beams, columns, and concrete housekeeping pads.
b. Layout with walls, floors, and roofs, including each room name and number.
c. Equipment and products of other trades that are located in vicinity of chillers and part of final installation, such as plumbing systems.

B. Certificates: For certification required in "Quality Assurance" Article.

C. Installation instructions.

D. Source quality-control reports.

E. Startup service reports.

F. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.

B. Spare Parts List: Recommended spare parts list with quantity for each.

C. Touchup Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.

D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Tool kit to include the following:

1. A tool kit specially designed by chiller manufacturer for use in servicing chiller(s) furnished.
2. Special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance.
3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Chiller Tool Kit." Text size shall be at least 1 inch high.
4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least 1/2 inch high.

B. Touchup Paint: 32 oz. container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.8 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 590 certification program.

B. Unit shall be rated in accordance with AHRI (Air-Conditioning, Heating and Refrigeration Institute) Standard 550/590, latest edition (U.S.A.) and all units shall be in compliance with ASHRAE (American Society of Heating, Refrigeration, and Air-Conditioning Engineers) 90.1.2007 and ASHRAE 90.1 2010.

C. Unit construction shall comply with ASHRAE 15 Safety Code, UL (Underwriters Laboratories) latest edition, and ASME (American Society of Mechanical Engineers) applicable codes (U.S.A. codes).

D. The management system governing the manufacture of this product is ISO 9001:2008 certified.

E. Unit shall be full load run tested at the factory.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.

B. Package water chiller for export shipping.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.

1. Extended warranties include, but are not limited to, the following:

a. Complete chiller including refrigerant and oil charge.
b. Complete compressor and drive assembly including refrigerant and oil charge.
c. Refrigerant and oil charge.

1) Loss of refrigerant charge for any reason due to manufacturer's product defect and product installation.

d. Parts and labor.

2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

B. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:

1. Allowable Capacity Tolerance: 1 percent.
2. Allowable Full-Load Energy Efficiency Tolerance: Zero percent.
3. Allowable Part-Load Energy Efficiency Tolerance: Zero percent.

C. AHRI Rating: Rate water chiller performance according to requirements in AHRI 550/590.

D. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.

E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.

G. Comply with NFPA 70.

H. Comply with requirements of UL 1995, "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.

I. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
2. See drawings for equipment served by backup power systems.
3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

J. Outdoor Installations:

1. Chiller shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 20-year period with minimal degradation due to exposure to outdoor ambient conditions.

2.2 MANUFACTURERS

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

1. Carrier Corporation; a unit of United Technologies Corp.
2. Daikin Applied.
3. YORK; a Johnson Controls company.
4. Aaon

2.3 MANUFACTURED UNITS

A. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser with fans, electrical power, controls, and indicated accessories.

B. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.

C. Sound-reduction package shall have the following:

1. Acoustic enclosure around compressors.
2. Reduced-speed fans with acoustic treatment.
3. Designed to reduce sound level without affecting performance.

D. Security Package: Security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.

2.4 CABINET

A. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.

B. Frame: Rigid galvanized-steel 7 ga frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.

C. Casing: Galvanized steel.

D. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.

2.5 COMPRESSOR-DRIVE ASSEMBLIES

A. Compressors:

1. Description: Positive-displacement direct drive with hermetically sealed casing.
2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.

    a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.

3. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
4. Capacity Control: On-off compressor cycling, plus hot-gas bypass.
5. Digital compressor unloading is an acceptable alternative to achieve capacity control.

6. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug or removable magnet in sump, and initial oil charge.

    a. Manufacturer's other standard methods of providing positive lubrication are acceptable in lieu of an automatic pump.

7. Vibration Isolation: Mount individual compressors on vibration isolators.

8. Each compressor shall be equipped with crankcase heaters to minimize oil dilution

    a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.

B. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

C. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

2.6 REFRIGERATION

A. Refrigerant: R-410A. Classified as Safety Group A1 according to ASHRAE 34.

B. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

C. Refrigerant Circuit: Each circuit shall include an electronic or a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

D. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

1. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in each circuit in lieu of each compressor.

E. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
3. ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger.

2.7 EVAPORATOR

A. Shell-and-tube design, as indicated. Plate and frame heat exchanger will not be accepted.

B. Shell and Tube:

1. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
2. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
3. Shell Material: Carbon steel.

4. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
5. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping. Furnish flange adapters to mate to flanged piping.
6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
7. Cooler shall be tested and stamped in accordance with ASME Code for a refrigerant working side pressure of 445 psig. Cooler shall have a maximum water-side pressure of 300 psig.

C. Flow Switch: Factory or field-furnished, thermal-type flow switch (factory or filed installed), wired to chiller operating controls.

D. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F.

E. Remote-Mounting Kit: Designed for remote field mounting where indicated. Provide kit for field installation.

2.8 AIR-COOLED CONDENSER SECTION

A. Coil(s) with integral subcooling on each circuit.

B. Copper Tube with Plate Fin Coils:

1. Construct coils of copper tubes mechanically bonded to aluminum fins.

C. Aluminum Microchannel Coils:

1. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
2. Single- or multiple-pass arrangement.
3. Construct fins, tubes, and header manifolds of aluminum alloy treated with a corrosion-resistant coating.

D. Corrosion-Resistant Coating: Coat coils with an epoxy or a phenolic corrosion-resistant coating after fabrication.

E. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

F. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.

G. Fan Motors: TENV or TEAO enclosure, with sealed and permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.

1. Overcurrent- and thermal-overload protection not integral to motor is acceptable if provided with chiller electrical power package.

H. Fan Guards: Removable steel safety guards with corrosion-resistant PVC coating.

2.9 CHILLED-WATER HYDRONIC PACKAGE

A. Factory-furnished and -installed hydronic package consisting of the following:

1. Pumps: Single or dual pumps with capacity, as indicated IN SCHEDULE

    a. Vertical in-line type, single-stage design, serviceable without disturbing piping connections.
    b. Cast-iron, ductile-iron, bronze, or stainless-steel body.
    c. Bronze or stainless-steel impeller keyed to shaft and secured with screw.
    d. Premium efficient motor with TEFC motor enclosure.
    e. Dual pump packages to provide for servicing and replacement of failed pump with other pump operating.
    f. Variable-speed pumps with variable-frequency controllers integral to pump motor or provided with chiller electrical package.

2. Expansion Tank: Replaceable bladder type.
3. Storage Tank: Insulated carbon-steel tank with internal baffles, drain and vent connections; with capacity indicated.
4. Piping: Copper tube or carbon-steel pipe.
5. Strainers: Y-type at suction side of each pump.
6. Valves:

    a. Ball- or butterfly-style valves for isolation and balancing.
    b. Check valve on each pump discharge for dual pump packages.
    c. Drain valves to be positioned to drain isolated sections of pipe and equipment.
    d. Option to use combination valves.

7. Hydronic Specialties:

    a. Air Vents: Automatic or manual air vents located and arranged to vent air from high points and locations capable of trapping air.
    b. Test Plugs: Located to measure pressure difference across each pump and strainer.

B. Hydronic package rated for same pressure as evaporator. 150 psi min

C. Pressure and leak tested before apply insulation.

D. Insulation on hydronic package shall match evaporator.

E. Controls:

1. Lead/lag operation for dual pump packages.
2. Controlled to automatically equalize run time.
3. Control of variable-speed pumps.
4. Integral to chiller control package.
5. Remotely controlled through field interface with building controls.

F. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the heat recovery condenser to minus 20 deg F.

2.10 INSULATION

A. Closed-cell, flexible, elastomeric thermal insulation complying with ASTM C 534/C 534M, Type I for tubular materials and Type II for sheet materials.

1. Thickness: 1-1/2 inches.

B. Adhesive: As recommended by insulation manufacturer.

C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

1. Apply adhesive to 100 percent of insulation contact surface.
2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
3. Seal seams and joints to provide a vapor barrier.
4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
5. Manufacturer has option to factory or field insulate chiller components to reduce potential for damage during installation.
6. Field-Applied Insulation:

    a. Components that are not factory insulated shall be field insulated to comply with requirements indicated.
    b. Manufacturer shall be responsible for chiller insulation whether factory or field installed to ensure that manufacturer is the single point of responsibility for chillers.
    c. Manufacturer's factory-authorized service representative shall instruct and supervise installation of field-applied insulation.
    d. After field-applied insulation is complete, paint insulation to match factory-applied finish.

2.11 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.

C. House in a unit-mounted, NEMA 250, Type 1 Insert type enclosure with hinged access door with lock and key or padlock and key.

D. Wiring shall be numbered and color-coded to match wiring diagram.

E. Factory wiring located outside of an enclosure in a metal raceway. Terminal connections shall be made with not more than a 24-inch length of liquidtight or flexible metallic conduit.

F. Field power interface shall be to, heavy-duty, nonfused disconnect switch. Minimum SCCR according to UL 508 shall be as required by electrical power distribution system, but not less than 65,000 A.

G. Each motor shall have branch power circuit and controls with one of the following disconnecting means having SCCR to match main disconnecting means:

1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.

H. Each motor shall have overcurrent protection.

I. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.

J. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.

K. Power Factor Correction: Capacitors to correct power factor to 0.95 at full load.

L. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

M. Control Relays: Auxiliary and adjustable time-delay relays, or an integral to water chiller microprocessor.

N. Service Receptacle:

1. Unit-mounted, 120-V GFI duplex receptacle.
2. Power receptacle from chiller internal electrical power wiring.

O. Indicate the following for water chiller electrical power supply:

1. Current, phase to phase, for all three phases.
2. Voltage, phase to phase and phase to neutral for all three phases.
3. Three-phase real power (kilowatts).
4. Three-phase reactive power (kilovolt amperes reactive).
5. Power factor.
6. Running log of total power versus time (kilowatt hours).
7. Fault log, with time and date of each.

2.12 CONTROLS

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Standalone, microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

C. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.

D. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, digital display. Display the following:

1. Date and time.
2. Operating or alarm status.
3. Operating hours.
4. Outside-air temperature if required for chilled-water reset.
5. Temperature and pressure of operating set points.
6. Chilled-water entering and leaving temperatures.
7. Refrigerant pressures in evaporator and condenser.
8. Saturation temperature in evaporator and condenser.
9. No cooling load condition.
10. Elapsed time meter (compressor run status).
11. Pump status.
12. Antirecycling timer status.
13. Percent of maximum motor amperage.
14. Current-limit set point.
15. Number of compressor starts.
16. Alarm history with retention of operational data before unit shutdown.
17. Superheat.

E. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Capacity control based on evaporator leaving-fluid temperature.
3. Capacity control compensated by rate of change of evaporator entering-fluid temperature.
4. Chilled-water entering and leaving temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on [**return-water**] [**outside-air**] temperature.
5. Current limit and demand limit.
6. Condenser-water temperature.
7. External water chiller emergency stop.
8. Antirecycling timer.
9. Automatic lead-lag switching.

F. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

1. Low evaporator pressure or high condenser pressure.
2. Low chilled-water temperature.
3. Refrigerant high pressure.
4. High or low oil pressure.
5. High oil temperature.
6. Loss of chilled-water flow.
7. Loss of condenser-water flow.
8. Control device failure.
9. .

G. BAS or DDC System Interface: Factory-install hardware and software to enable system to monitor, control, and display chiller status and alarms. BACnet Compatible output.

1. Hardwired I/O Points:

a. Monitoring: On/off status, common trouble alarm.
b. Control: On/off operation, chilled-water discharge temperature set-point adjustment electrical power demand limit.

2. Communication Interface: ASHRAE 135 (BACnet) communication interface shall enable control system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through DDC system for HVAC.

H. Factory-installed wiring outside of enclosures shall be in NFPA 70-complaint raceway.

2.13 ACCESSORIES

A. Factory-furnished neoprene isolators for field installation.

B. Provide the following factory options for each chiller.

1. Concrete pad mounted machines shall be mounted on factory spring or neoprene vibration isolators.
2. High-efficiency variable condenser fans: All fans on the unit shall have variable speed fan motors to provide higher part load efficiency and reduced acoustic levels. Each fan circuit shall have a factory-installed, independent variable speed drive with display. Variable speed drives are rated IP-55 enclosures and UL Listed. The use of this option, with the addition of antifreeze in the cooler circuit and wind baffles, shall allow running with outdoor ambient temperatures down to –20°F. This option is not available with sizes 060 and 070, and it is not available in combination with low ambient head pressure control.
3. Unit-Mounted Non-Fused Disconnect: Unit shall be supplied with factory-installed, non-fused electrical disconnect for main power supply.
4. Minimum Load Control:
5. Unit shall be equipped with field-installed, microprocessor-controlled, minimum load control that shall permit unit operation down to a minimum of 6% capacity (varies with unit size).
6. Energy Management Control Module: A field-installed module shall provide the following energy management capabilities: 4 to 20 mA signals for leaving fluid temperature reset, cooling set point reset or demand limit control; 2-step demand limit control (from 0% to 100%) activated by a remote contact closure; and discrete input for “Ice Done” indication for ice storage system interface.
7. Condenser Coil Trim Panels and Security Grilles: Unit shall be supplied with factory or field-installed coil covers and painted grilles to protect the condenser coil and internal chiller components from physical damage.
8. Full End Screen: Unit shall be equipped with a factory-installed option consisting of louvered panels that cover the machine ends from top to bottom and firmly fasten to the machine frame. These end screens function as a privacy screen and also provide hail protection.

9. BACnet Communication: Shall provide pre-programmed factory or field-installed communication capability with a BACnet MS/TP network. Allows integration with i-Vu® Open control system or a third-party BACnet building automation system.
10. No field programming shall be required.
11. Compressor Suction Service Valve: Standard refrigerant discharge isolation and liquid valves shall enable service personnel to store the refrigerant charge in the cooler or condenser during servicing. This factory-installed option (one valve per refrigerant circuit) shall allow for further isolation of the compressor from the cooler vessel.
12. Suction Line Insulation: Insulation shall be tubular closed-cell insulation. This option shall be required on applications with leaving fluid temperatures below 30°F and recommended for areas of high dewpoints where condensation may be a concern.
13. Compressor Sound Reduction: Shall provide sound reduction for the scroll compressors.
14. Unit shall be equipped with factory-installed option low sound - compressor sound reduction blanket which reduces unit sound levels by providing an acoustic blanket on each compressor.
15. Unit shall be equipped with factory-installed option ultra low sound - compressor sound reduction enclosure which provides an enclosure to encase each compressor that is covered with an acoustic blanket.
16. GFI Convenience Outlet: Shall be field installed and mounted with easily accessible 115-v female receptacle and shall include a 4-amp GFI receptacle.

2.14 CAPACITIES AND CHARACTERISTICS

A. Refer to equipment notes and schedules

2.15 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

B. Factory performance test water chillers, before shipping, according to AHRI 550/590.

1. Test the following conditions:

a. Design conditions indicated.
b. AHRI 550/590 part-load points.

C. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. For water chillers located outdoors, rate sound power level according to AHRI 370 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.

1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.

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

3.2 WATER CHILLER INSTALLATION

A. Coordinate sizes and locations of bases with actual equipment provided. Cast anchor-bolt inserts into concrete bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures with actual equipment provided.

C. Install water chillers on support structure indicated.

D. Equipment Mounting:

1. Install water chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."

2. Concrete pad shall be 12” longer and wider than the bas of the unit. Refer to the structural plans for pad detail. Coordinate size and location with general contractor.

3. Coordinate location to ensure manufactures required clearances.

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

G. Chiller manufacturer's factory-trained service personnel shall charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

H. Install separate devices furnished by manufacturer and not factory installed.

1. Chillers shipped in multiple major assemblies shall be field assembled by chiller manufacturer's factory-trained service personnel.

3.3 PIPING CONNECTIONS

A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Evaporator Fluid Connections:

1. Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage.
2. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, and drain connection with valve.
3. Make connections to water chiller with a union, flange or mechanical coupling.

D. Connect each drain connection with a drain valve, full size of drain connection. Connect drainpipe to drain valve with union and extend drainpipe to terminate over floor drain.

E. Connect each chiller vent connection with an automatic or a manual vent, full size of vent connection.

3.4 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Provide nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high. Locate nameplate where easily visible.

3.5 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.

C. Connect control wiring between chiller control interface and DDC system for remote monitoring and control of chillers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Provide nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled- and heat recovery condenser-water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.

E. Prepare a written startup report that records results of tests and inspections.

3.7 DEMONSTRATION

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

1. Instructor shall be factory trained and certified.
2. Provide not less than one hours of training.
3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
5. Obtain Owner sign-off that training is complete.
6. Owner training shall be held at Project site.

END OF SECTION 236423.13

SECTION 237313.13 - INDOOR, AIR-HANDLING UNITS

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes: Factory-assembled, indoor air-handling units with limited features.

1.3 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

1. Unit dimensions and weight.
2. Cabinet material, metal thickness, finishes, insulation, and accessories.
3. Fans:

    a. Certified fan-performance curves with system operating conditions indicated.
    b. Certified fan-sound power ratings.
    c. Fan construction and accessories.
    d. Motor ratings, electrical characteristics, and motor accessories.

4. Certified coil-performance ratings with system operating conditions indicated.
5. Dampers, including housings, linkages, and operators.
6. Filters with performance characteristics.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
2. Support location, type, and weight.
3. Field measurements.

B. Source quality-control reports:

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Filters: One set(s) for each air-handling unit.
2. Gaskets: One set(s) for each access door.
3. Fan Belts: One set(s) for each air-handling unit fan.

1.7 COORDINATION

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

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Structural Performance: Casing panels shall be self-supporting and capable of withstanding positive/negative 4-inch wg of internal static pressure, without exceeding a midpoint deflection of 0.005 inches/inch of panel span.

2.2 INDOOR AIR-HANDLING UNIT MANUFACTURERS

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

1. AAON

2. Carrier Corporation; a unit of United Technologies Corp.
3. Daikin Applied.
4. Dunham-Bush, Inc.
5. YORK; a Johnson Controls company.

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings;

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Joints: Sheet metal screws or pop rivets.
3. Sealing: Seal all joints with water-resistant sealant. Hermetically seal at each corner and around entire perimeter.
4. Base Rail:

a. Material: Galvanized steel.
b. Height: 4 inches.

B. Double Wall:

1. Outside Casing Wall: Galvanized steel, minimum 20 gauge thick, with manufacturer's standard finish.
2. Inside Casing Wall: G 90 Galvanized steel, solid 20 gauge thick.
3. Floor Plate: double wall galvanized steel, minimum 18 gauge thick.
4. Casing Insulation:

a. Materials: Glass-fiber blanket or board insulation, Type I or Type II ASTM C 1071 or injected polyurethane foam insulation.
b. Casing Panel R-Value: Minimum 8
c. Insulation Thickness: 1.5 inch. Nominal density of 1.5 lb per cubic foot.
d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

5. Base Rail:

a. Material: Galvanized steel.
b. Height: 4 inches min

C. Pressure Classifications:

1. For Unit Sections Upstream of Fans: Minus 2-inch wg minimum but not less than the system operating pressure.
2. For Unit Sections Downstream and Including Fans: 2-inch wg minimum, but not less than the system operating pressure.

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. Access Doors:

1. Doors:

    a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
    b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
    c. Gasket: Neoprene, applied around entire perimeters of frame.
    d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.

2. Locations and Applications:
    a. Provide access doors for the following sections
        1) Fan Section:
        2) Access Section:
        3) Access Sections Immediately Upstream and Downstream of Coil Sections: Doors.
        4) Damper Section: Doors.
        5) Filter Section: Doors large enough to allow periodic removal and installation of filters.
        6) Mixing Section: Doors.

F. Condensate Drain Pans:

1. Construction:

    a. Double wall, stainless steel.

2. Drain Connection:

    a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.
    b. Minimum Connection Size: NPS 1 ¼".

3. Slope: Minimum 0.125 in./ft. slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers, and to direct water toward drain connection.
4. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1. or a minimum of 6"
5. Width: Entire width of water producing device.

2.4 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

1. Shafts: With field-adjustable alignment.

a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontal-Flanged, Split Housing: Bolted construction.
3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
4. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inchwide by 0.028-inch- thick, galvanized-steel sheet.

a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

1) Fabric Minimum Weight: 26 oz./sq. yd..
2) Fabric Minimum Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F.

C. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel aluminum hub swaged to backplate and fastened to shaft with setscrews. Wheels shall be bonderized steel with baked enamel, or galvanized steel.

D. Fan Shaft Bearings:

1. Self-aligning, pillow-block type with an L-50 rated life of minimum 200,000 hours according to ABMA 9.
2. 4. Fan shafts shall be solid steel, turned, ground and polished

E. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.

1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
2. Motor Pulleys: Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions. Motors over 5 hp shall use VFD
3. Belts: Oil resistant, non-sparking, and non-static; in matched sets for multiple-belt drives.
4. Belt Guards: For air-handling units with motors mounted on outside of casing. Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146-inch- thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.

Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Mount unit-mounted disconnect switches on exterior of unit.
6. Design B with sizes and electrical characteristics as shown on the equipment schedule.
7. Service factor 1.5

2.5 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with AHRI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit.
4. All coils shall have mill galvanized casings. Coils shall be factory leak tested at 450 psig air pressure

2.6 HYDRONIC COILS (Heating or Cooling)

A. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

B. Minimum Working-Pressure/Temperature Ratings:
   a. Hot water; 175 psig, 400 deg F.
   b. Chilled water; 300 psig, 200 deg F.

C. Source Quality Control: Factory tested to 300 psig.

D. Tubes: ASTM B 743 copper, minimum thickness;
   1. ½" OD tubes - .025" thick
   2. 5/8" OD tubes - .035" thick
   3. 7/8" OD tubes - .049" thick

E. Fins: Aluminum, minimum thickness;
   1. Plate fins – 0.0065" thick
   2. Spiral fins – 0.010" thick

Copper type L header for up to 150 psi
Copper type K header for up to 250 psi
Steel headers should use steel tubes
SS headers should use SS tube schedule 10 SS up to header OD 2 7/8" schedule 40 for larger. 304 or 316
Cupro-Nickels for steam up to 450 deg headers and tubes should be the same 90/10 or 70/30
Sch 10 upto 2 3/8" OD schedule 40 above

F. Headers: Seamless copper tube with brazed joints, prime coated.

G. Frames: Galvanized-steel channel frame, minimum thickness;

1. ½" OD and smaller, up to 4 rows and not longer than 48" fined length – 18 gage galvanized steel.
2. 5/8" OD and larger, longer than 48" and less than 72" fined length – 16 gage galvanized steel.
3. 5/8" OD and larger, longer than 72" fined length – 14 gage galvanized steel

H. Mounting; Slip in frame for retrofits, Flange frame for new construction.

I. Connections;
1. Coordinate left hand, right hand connections or supply return on opposite sides in the field. Coordinate with field requirements. Use supply and return connections on the same side whenever possible

2.7 REFRIGERANT AIR COILS

A. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

B. Minimum Working-Pressure Rating: 300 psig.

C. Source Quality Control: Factory tested to 450 psig.

D. Tubes: ASTM B 743 copper, minimum thickness;
1. 3/8" OD tubes - .020" thick
2. ½" OD tubes - .025" thick
3. 5/8" OD tubes - .035" thick
4. 7/8" OD tubes - .049" thick

E. Full or face split – shall have intertwined circuits.

F. Fins: Aluminum, minimum thickness;
1. Plate fins – 0.0065" thick
2. Spiral fins – 0.010" thick

G. Suction and Distributor Piping: ASTM B 88, Type L copper tube with brazed joints.

H. Frames: Galvanized-steel channel frame, minimum thickness;
1. ½" OD and smaller, up to 4 rows and not longer than 48" fined length – 18 gage galvanized steel.
2. 5/8" OD and larger, longer than 48" and less than 72" fined length – 16 gage galvanized steel.
3. 5/8" OD and larger, longer than 72" fined length – 14 gage galvanized steel

I. Coils shall be designed and tested in accordance with ANSI/ASHRAE 15.

2.8 AIR FILTRATION SECTION

A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

B. The filter section shall be designed and constructed to house the specific type of filter specified on the equipment schedule.

C. Angle filter section shall accept 2-in. filters arranged in horizontal V formation. Double- walled hinged doors shall be provided.

D. Side-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized steel track.

    a. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.9 DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.

B. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."

C. Dampers shall be sectionalized to limit blade width to no more than 50-in. to minimize blade warpage and to ensure tight closure.

D. Damper operators may be supplied by the AHU manufacturer or field supplied.

1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
    c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
6. Size dampers for running torque calculated as follows:

    a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.

b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.
d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

7. Coupling: V-bolt and V-shaped, toothed cradle.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
10. Power Requirements (Two-Position Spring Return): 24 V dc.
11. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
12. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
13. Temperature Rating: Minus 22 to plus 122 deg F.
14. Run Time: 12 seconds open, 5 seconds closed.

E. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.

F. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.

G. Combination Filter and Mixing Section:

1. Cabinet support members shall hold 2-inch- thick, pleated, flat, permanent or throwaway filters.
2. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.
3. Mixing boxes and filter mixing boxes shall have parallel blade, interconnecting outside-air and return-air dampers.

2.10 Access Sections:

A. Access sections shall be installed where indicated on the drawings and shall be as specified on the equipment schedule.

B. Access sections shall have double-walled hinged doors.

2.11 STARTERS AND DISCONNECTS

A. All fan and damper motors shall be furnished with starter and disconnect switches. **All VAV units shall be furnished with variable frequency drives.**

B. Starters that are unit mounted may be combination motor starter/disconnect switches. When fan starters are remoted mounted, or installed in a motor control center, provide separate disconnect for all fan motors mounted on the fan section of the air handler. Refer to plans and schedules for starter / disconnect locations

C. For a complete description of requirements for motor starters and combination starters/disconnects refer to specification section 23 05 13 Common motor requirements for HVAC.

D. Minimum requirements for starters without disconnect switch.
1. Adjustable motor overload with trip indication.
2. Manual overload reset button (accessible without opening enclosure).
3. 115-v fused secondary control transformer (fuse included — fused primary and secondary over 50 amps).
4. Hand/Off/Auto selector switch (accessible without opening enclosure).
5. Separate 4-position terminal strip for remote H-O-A wiring.
6. C series contactors.
7. Horsepower rated for motor applications.
8. NEMA 4X type non-metallic enclosures.
9. Lug connections for field wiring.
10. Factory mounted, wired, and run tested with factory-supplied motor.
11. UL listed.

E. Minimum requirements for combination starters / disconnect switch.
1. Non-fused UL 508 disconnect switch with lockable handle (locks not provided).
2. Cover interlock.
3. Adjustable motor overload with trip indication.
4. Manual overload reset button (accessible without opening enclosure).
5. 115-v fused secondary control trans- former (fuse included — fused primary and secondary over 50 amps).
6. Hand/Off/Auto selector switch (accessible without opening enclosure).
7. Separate 4-position terminal strip for remote H-O-A wiring.
8. C series contactors.
9. Horsepower rated for motor applica- tions.
10. NEMA 4X type non-metallic enclosures.
11. Lug connections for field power wiring.
12. Factory mounted, wired, and run tested with factory-supplied motor.
13. UL listed.

F. For a complete description of requirements for Variable-Frequency Motor Controller: Comply with Section 262923 "Variable-Frequency Motor Controllers."

G. Minimum requirements for variable-Frequency Motor Controller:

1. Manufactured Units: Pulse-width modulated; variable torque for Design A and Design B inverter-duty motors.
2. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
3. Unit Operating Requirements:

    a. Internal Adjustability:

1) Minimum Speed: 5 to 25 percent of maximum rpm.
2) Maximum Speed: 80 to 100 percent of maximum rpm.
3) Acceleration: 0.1 to 999.9 seconds.
4) Deceleration: 0.1 to 999.9 seconds.
5) Current Limit: 30 to minimum of 150 percent of maximum rating.

b. Self-Protection and Reliability Features:

1) Surge suppression.
2) Loss of input signal protection.
3) Under- and overvoltage trips.
4) Variable-frequency motor controller and motor-overload/overtemperature protection.
5) Critical frequency rejection.
6) Loss-of-phase protection.
7) Reverse-phase protection.
8) Motor-overtemperature fault.

c. Bidirectional autospeed search.
d. Torque boost.
e. Motor temperature compensation at slow speeds.

1) Panel-mounted operator station.
2) Historical logging information and displays.
3) Digital indicating devices.

f. Control Signal Interface: Electric.
g. Proportional Integral Directive (PID) control interface.
h. DDC system for HVAC Protocols for Network Communications: ASHRAE 135.

4. Line Conditioning:

a. Input line conditioning.
b. Output filtering.
c. EMI/RFI filtering.

2.12 FILTER/MIXING BOX

A. Section shall be designed to accommodate 2" angled filter media. The filter media shall be side-loading.

B. A magnahelic differential pressure gauge shall be factory installed and flush mounted to measure the pressure drop across the filter bank.

C. The return air inlet shall have standard control damper, constructed of aluminumor galvanized steel with opposed blades. Damper configuration shall be full faced. [**25%/75% split**].

D. The outside air inlet have Airflow Monitoring Station have standard control damper, constructed of aluminum or galvanized steel with opposed blades. Damper configuration shall be full faced.

E. The airflow monitoring station must be tested for pressure drop in accordance with AMCA Stan- dard 611-95 in an AMCA registered laboratory. The airflow monitoring station must bear the AMCA Certified Ratings Seal for Airflow Measure- ment Performance.

2.13 AIR FLOW MONITORING (25-OAF, 75/100 OAF)

A. Optional airflow monitoring stations will be provided on air inlets, as shown in performance specifications.

B. Airflow monitoring stations will bear the AMCA Certified Ratings Seal for Airflow Measurement Performance.

C. Airflow monitoring station dampers will comply with leakage rates per ASHRAE 90.1.

D. Airflow monitoring stations will be accurate within 5% of actual airflow between 350 FPM and 4000 FPM free area velocity.

E. Outdoor air intake openings with air flow monitoring stations will have rain louver.

F. Louver will be a wind-driven rain penetration class A louver.

G. Louver effectiveness ratio will be 100% at the following conditions:

H. Wind velocity, 29 mph into louver.

I. Rain fall rate, 3 in./hr.

J. Free area air velocity, 1500 FPM.

K. All VAV units shall be equipped with an outside air volume measurement system similar to Tek-Air. The system shall continuously measure outside air and adjust the outside air damper to maintain the minimum air volume as indicated in the unit schedule.

2.14 MATERIALS

A. Steel:

1. ASTM A 36/A 36M for carbon structural steel.
2. ASTM A 568/A 568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A 240/A 240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A 653/A 653M.

D. Aluminum: ASTM B 209.

2.15 SOURCE QUALITY CONTROL

A. AHRI 430 Certification: Air-handling units and their components shall be factory tested according to AHRI 430 and shall be listed and labeled by AHRI.

1. AMCA 210 Compliance: Fan performance according to AMCA 210.

B. AMCA 300 and AMCA 301, or AHRI 260 Certification: Air-handling unit fan sound ratings shall comply with AMCA 300, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data" and AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data," or with AHRI 260, "Sound Rating of Ducted Air Moving and Conditioning Equipment."

C. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

D. Steam Coils: Factory tested to 300 psig, and to 200 psig underwater, according to AHRI 410 and ASHRAE 33.

E. Refrigerant Coils: Factory tested to minimum 450-psig internal pressure, and to minimum 300-psig internal pressure while underwater, according to AHRI 410 and ASHRAE 33.

2.16 VIBRATION ISOLATION EXTERNAL TO THE UNIT.

A. Floor mounted air handling units shall be mounted on free standing Spring isolators and laterally stable without any housing and complete with a molded neoprene cup or 1/4" neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment and housekeeping pad. Installed and operating heights shall be equal. The ratio of the spring diameter divided by the compressed spring height shall be no less than 0.8. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Mountings shall be type SLR, as manufactured by Mason Industries, Inc

B. All suspended air handling units shall use hanger consisting of rigid steel frames containing minimum 1-1/4" thick neoprene elements at the top and a steel spring seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. In order to maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing and short circuiting the spring. Submittals shall include a hanger drawing showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Replace with new insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Equipment Mounting:

1. Install base-mounted air handling units on cast-in-place concrete housekeeping pads Concrete housekeeping pads shall be 3 ½" high and extend 6" longer on all sides then the mountings, and shall have 45° chamfered edges.
   a. Air handling units shall be mounted on spring isolation in accordance with section 2.16
2. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in section 2.16

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

D. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. **Hot- and Chilled-Water Piping**: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. **Refrigerant Piping**: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

   1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
   2. Charge refrigerant coils with refrigerant and test for leaks.
   3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
7. Comb coil fins for parallel orientation.
8. Verify that proper thermal-overload protection is installed for electric coils.
9. Install new, clean filters.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.8 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.9 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling unit and air-distribution systems, and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237313.13

SECTION 237333.16 - INDOOR, INDIRECT, GAS-FIRED HEATING AND VENTILATING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes indirect, gas-fired heating and ventilating units, including the following components:

1. Casings.
2. Fans, drives, and motors.
3. Air filtration.
4. Dampers.
5. Indirect, gas-fired burners.
6. Unit control panel.
7. Controls.

1.3 ACTION SUBMITTALS

A. Product Data: For each indoor, indirect, gas-fired heating and ventilating unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:

    a. Include certified fan-performance curves with system operating conditions indicated.
    b. Include certified fan-sound power ratings.
    c. Include fan construction and accessories.
    d. Include motor ratings, electrical characteristics, and motor accessories.

6. Include filters with performance characteristics.
7. Include direct, gas-fired burners with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each type and configuration of indoor, indirect, gas-fired heating and ventilating unit.

1. Include plans, elevations, sections, and mounting attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

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

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Sample Warranty: For manufacturer's warranty.

C. Seismic Qualification Data: Certificates for indoor, indirect, gas-fired heating and ventilating units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Restraint of internal components.

D. Startup service reports.

E. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For indirect, gas-fired heating and ventilating units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Filters: One set(s) for each unit.

2. Gaskets: One set(s) for each access door.
3. Fan Belts: One set(s) for each unit.

1.7 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of indirect, gas-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Entire Unit: Manufacturer's standard, but not less than one year) from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

2.2 CAPACITIES AND CHARACTERISTICS; refer to plans and schedules

2.3 MANUFACTURERS

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

1. Cambridge Engineering, Inc.
2. Greenheck Fan Corporation.
3. Rezner
4. Modine
5. Sterling

2.4 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
3. Heating and Ventilating Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

B. Configuration: Horizontal unit with horizontal discharge for suspended installation.

C. Single-Wall Construction:

1. Material: Galvanized-steel with manufacturer's standard finish.
2. Floorplate: Galvanized steel, minimum 18 gauge thick.
3. Insulation and Adhesive:

a. Materials: ASTM C1071, Type I or Type II glass-fiber blanket or board insulation, neoprene coated or foil faced.
b. Insulation R-Value: Minimum 8.
c. Insulation Thickness: 1.5 inch.
d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
e. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of complete unit.

1) Insulation Adhesive: Comply with ASTM C916, Type I.
2) Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.

D. Double-Wall Construction:

1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick, with manufacturer's standard finish.
2. Inside Casing Wall:

a. Inside Casing, Burner Section: Galvanized steel, solid, minimum 14-gauge thick steel.
b. Inside Casing, All Other Sections: Galvanized steel solid or perforated steel.

3. Floor Plate: Galvanized steel, minimum 18 gauge thick.
4. Casing Insulation:

a. Materials: Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071.
b. Casing Panel R-Value: Minimum 10.
c. Insulation Thickness: 2 inches.
d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.

5. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

E. Panels, Doors, and Windows:

1. Panels:

a. Fabrication: Formed and reinforced, with same materials and insulation thickness as casing.
b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.

2. Doors:

a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.

3. Locations and Applications:

a. Fan Section: Inspection and access panels.
b. Access Section: Doors.
c. Gas-Fired Burner Section: Doors.
d. Damper Section: Inspection and access panels.
e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
f. Mixing Section: Doors.

2.5 FAN, DRIVE, AND MOTOR

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.
2. Shaft Bearings: Heavy-duty, self-aligning, permanently lubricated ball bearings, or pillow-block bearings with an L50 rated life of 100,000 hours according to ABMA 9.
3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

4. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
5. Shaft Lubrication Lines: Extended to a location outside the casing.
6. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.

    a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

C. Drive: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.

1. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
2. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
3. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146-inch- thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.

D. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Maximum sizes as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Enclosure: Open, drip proof.
4. Enclosure Materials: Cast iron.

5. Efficiency: Premium efficient as defined in NEMA MG 1.
6. NEMA Design: inverter duty
7. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions. With variable speed drive

2.6 AIR FILTRATION

A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

B. Panel Filters:

1. Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
4. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.

C. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.

D. Side-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized-steel track.

a. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.7 DAMPERS

A. Dampers: Comply with requirements in Section 230923.12 "Control Dampers."

B. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.

C. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."

D. Electronic Damper Operators:

1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
6. Size dampers for running torque calculated as follows:

a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.

d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

7. Coupling: V-bolt and V-shaped, toothed cradle.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
10. Power Requirements (Two-Position Spring Return): 24 V dc.
11. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
12. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
13. Temperature Rating: Minus 22 to plus 122 deg F.
14. Run Time: 12 seconds open, 5 seconds closed.

2.8 INDIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54.

B. CSA Approval: Designed and certified by and bearing label of CSA.

C. Burners: Stainless steel.

1. Rated minimum turndown ratio: 30 to 1.
2. Fuel: Natural gas.
3. Ignition: Electronically controlled electric spark with flame sensor.
4. Gas Control Valve: Modulating.
5. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

D. Venting, Gravity: Gravity vented.

E. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.

F. Combustion-Air Intake: Separate combustion-air intake and vent terminal assembly.

G. Heat Exchanger: Stainless steel.

H. Heat-Exchanger Drain Pan: Stainless steel.

I. Safety Controls:

1. Gas Manifold: Safety switches and controls complying with ANSI standards.
2. Vent Flow Verification: Differential pressure switch to verify open vent or Flame rollout switch.
3. High Limit: Thermal switch or fuse to stop burner.

4. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
5. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
6. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
7. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
8. Control Transformer: 24 V ac.

2.9 UNIT CONTROL PANEL

A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.

B. Control Panel: unit Surface-mounted or remote mounted, with engraved plastic cover, and the following lights and switches:

1. On-off-auto fan switch.
2. Heat-vent-off switch.
3. Supply-fan operation indicating light.
4. Heating operation indicating light.
5. Thermostat.
6. Damper position potentiometer.
7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
8. Safety-lockout indicating light.
9. Enclosure: NEMA 250, Type 1.

2.10 CONTROLS

A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.

B. Control Devices:

1. Remote Thermostat: Adjustable room thermostat with temperature readout.
2. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
3. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
4. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature.
5. Timers, Seven Day:

    a. Programming-switch timer with synchronous-timing motor and seven-day dial.
    b. Continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover.
    c. Multiple-switch trippers.

d. Minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.

6. Timers, Solid State:

a. Programmable time control with four separate programs.
b. 24-hour battery carryover.
c. Individual on-off-auto switches for each program.
d. 365-day calendar with 20 programmable holidays.
e. Choice of fail-safe operation for each program.
f. System fault alarm.

7. Ionization-Type Smoke Detectors:

a. 24 V dc, nominal.
b. Self-restoring.
c. Plug-in arrangement
d. Integral visual-indicating light.
e. Sensitivity that can be tested and adjusted in place after installation.
f. Integral addressable module.
g. Remote controllability.
h. Responsive to both visible and invisible products of combustion.
i. Self-compensating for changes in environmental conditions.
j. Located in return air, shall stop fans when the presence of smoke is detected.

C. Fan Control, Interlocked: Fan to start automatically with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.

D. Outdoor-Air Damper Control, of 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.

E. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air as follows:

1. Minimum 30 percent outdoor air.
2. Outdoor-air quantity adjusted by potentiometer on control panel.
3. There shall be three levels of OAI.
   a. Level 1 – min as per schedule
   b. Level 2 – 50 % as reset by BMS or CO sensor control panel.
   c. Level 3 -100 % as reset by BMS or CO sensor control panel.

F. Temperature Control:
1. Operates gas valve to maintain set point.
2. with wall-mounted, field-wired sensor with temperature adjustment, and adjustment on remote-control panel.
3. Burner Control, Modulating: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual burner units.

G. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.

1. Hardwired Points:

    a. Room temperature.
    b. Discharge-air temperature.
    c. Burner operating.
    d. Return air temperature
    e. Mixed air temperature

2. ASHRAE 135.1 (BACnet) communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

2.11 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

2.12 VIBRATION ISOLATION EXTERNAL TO THE UNIT.

A. Floor mounted air handling units shall be mounted on free standing Spring isolators and laterally stable without any housing and complete with a molded neoprene cup or 1/4" neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment and housekeeping pad. Installed and operating heights shall be equal. The ratio of the spring diameter divided by the compressed spring height shall be no less than 0.8. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Mountings shall be type SLR, as manufactured by Mason Industries, Inc

B. All suspended air handling units shall use hanger consisting of rigid steel frames containing minimum 1-1/4" thick neoprene elements at the top and a steel spring seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. In order to maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing and short circuiting

the spring. Submittals shall include a hanger drawing showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of indirect-fired heating and ventilating units.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.

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

3.2 INSTALLATION

A. Equipment Mounting:

B. Suspended Units: Suspend and brace units from structural-steel support frame, secured to building structural members, using threaded steel rods and spring hangers. Coordinate sizes and locations of structural-steel support members with actual equipment provided.

1. Comply with requirements for vibration isolation and seismic control devices specified in 2.12 vibration isolation external to unit

C. Install gas-fired units in accordance with NFPA 54.

D. Install controls and equipment shipped by manufacturer for field installation with indirect, gas-fired heating and ventilating units.

3.3 PIPING CONNECTIONS

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

1. Gas Piping: Comply with requirements in Section 221123"Facility Natural-Gas Piping." Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers.

C. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

3.4 DUCTWORK CONNECTIONS

A. Connect supply and return ducts to indirect, gas-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

3.5 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

a. Inspect for visible damage to burner combustion chamber.
b. Inspect casing insulation for integrity, moisture content, and adhesion.
c. Verify that clearances have been provided for servicing.
d. Verify that controls are connected and operable.
e. Verify that filters are installed.
f. Purge gas line.

g. Inspect and adjust vibration isolators.
h. Verify bearing lubrication.
i. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
j. Adjust fan belts to proper alignment and tension.

B. Start unit according to manufacturer's written instructions.

1. Complete startup sheets and attach copy with Contractor's startup report.
2. Inspect and record performance of interlocks and protective devices; verify sequences.
3. Operate unit for run-in period recommended by manufacturer.
4. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:

    a. Measure gas pressure at manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

5. Calibrate thermostats.
6. Adjust and inspect high-temperature limits.
7. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
9. Measure and record airflow. Plot fan volumes on fan curve.
10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:

    a. High-limit heat.
    b. Alarms.

11. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
12. Verify drain-pan performance.
13. Verify outdoor-air damper operation.

3.8 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.9 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Units will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.11 DEMONSTRATION

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

END OF SECTION 237333.16

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SECTION 237416.11 - PACKAGED, SMALL-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes packaged, small-capacity, rooftop air-conditioning units (RTUs) with the following components and accessories:

1. Casings.
2. Fans.
3. Motors.
4. Rotary heat exchangers.
5. Coils.
6. Refrigerant circuit components.
7. Air filtration.
8. Gas furnaces.
9. Dampers.
10. Electrical power connections.
11. Controls.
12. Accessories.
13. Roof curbs.

1.3 DEFINITIONS

A. DDC: Direct digital controls.

B. ECM: Electronically commutated motor.

C. MERV: Minimum efficiency reporting value.

D. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

E. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, small-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

F. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

G. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

1.4 ACTION SUBMITTALS

A. Product Data: For each RTU.

1. Include manufacturer's technical data.
2. Include rated capacities, dimensions, required clearances, characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

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

1. Include design calculations for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. [**Wind-**] [**and**] [**Seismic-**]Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.5 INFORMATIONAL SUBMITTALS

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

1. Structural members to which RTUs will be attached.
2. Roof openings.
3. Roof curbs and flashing.

B. Seismic Qualification Data: Certificates, for RTUs, accessories, and components, from manufacturer.

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

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Restraint of internal components, including fans, coils, and refrigeration components.

C. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control reports.

E. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

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

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fan Belts: [One] set(s) for each belt-driven fan.
2. Filters: One set(s) of filters for each unit.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than five 10 years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

5. Warranty Period for evaporator and condenser coils: Three years from date of Substantial Completion.
6. Warranty of any of the above components shall also include the cost of refrigerant replacement to component failure.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. AHRI Compliance:

1. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.
2. Comply with AHRI 270 for testing and rating sound performance for RTUs.
3. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

B. AMCA Compliance:

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested according to AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

C. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Comply with applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. NFPA Compliance: Comply with NFPA 90A or NFPA 90B.

F. UL Compliance: Comply with UL 1995.

G. 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.

2.2 MANUFACTURERS

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

1. AAON.
2. Addison.
3. Carrier Corporation; a unit of United Technologies Corp.
4. Daikin Applied.

5. Lennox Industries, Inc.; Lennox International.
6. YORK; a Johnson Controls company.

2.3 CAPACITIES AND CHARACTERISTICS

A. Refer to plans and schedules for unit performance characteristics.

2.4 CASINGS

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Double-Wall Construction: Fill space between walls with 2-inch foam insulation and seal moisture tight for R-13 performance.

C. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

D. Inner Casing Fabrication Requirements:

1. Inside Casing: G-90-coated galvanized steel, 0.034 inch thick, perforated 40 percent free area.

E. Corrosion-Resistant Coating: Apply a corrosion-resistant coating capable of withstanding a 3,000-hour salt-spray test according to ASTM B 117.

1. Standards:

a. ASTM B-117 for salt spray.
b. ASTM D-2794 for minimum impact resistance of 100 in-lb
c. ASTM B-3359 for cross-hatch adhesion of 5B.

2. Application: Immersion or Spray.
3. Thickness: 1 mil.
4. Gloss: Minimum of 50 gloss units on a single-angle, 60-degree meter.
5. UV Protection: Spray-applied topcoat.

F. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

1. Materials: ASTM C 1071, Type I.
2. Thickness: 2 inch.
3. Liner materials shall have airstream surface coated with erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
4. Liner Adhesive: Comply with ASTM C 916, Type I.

G. Condensate Drain Pans: Fabricated using G-90-coated galvanized-steel sheet 0.028 inch thick or stainless-steel sheet 0.025 inch thick, a minimum of 2 inches deep, and complying with ASHRAE 62.1 for design and construction of drain pans.

1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
2. Drain Connections: min ¾” Threaded nipple.

H. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.5 FANS

A. Supply-Air Fans: Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

1. Direct-Driven Supply-Air Fans: Motor shall be resiliently mounted in the fan inlet.
2. Belt-Driven Supply-Air Fans: Motors shall be installed on an adjustable fan base resiliently mounted in the casing.

B. Condenser-Coil Fan: Variable-speed or constant speed propeller, mounted on shaft of permanently lubricated multispeed ECM motors.

C. Relief-Air: Barometric relief Fan:

2.6 MOTORS

A. Comply with Section 230513 "Common Motor Requirements for HVAC Equipment" and the requirements of this Article.

B. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

C. Service Factor: 1.15.

D. Efficiency: Premium efficient.

2.7 COILS

A. Supply-Air Refrigerant Coil:

1. Aluminum -plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coils from contacting steel coil frame or condensate pan.
3. Coil Split: Interlaced.
4. Corrosion-Resistant Coating: Apply a corrosion-resistant coating capable of withstanding a 3,000-hour salt-spray test according to ASTM B 117 to base, frame, and casing coils and fan guards.

a. Standards:

1) ASTM B-117 for salt spray.

2) ASTM D-2794 for minimum impact resistance of 100 in-lb
3) ASTM B-3359 for cross-hatch adhesion of 5B.

b. Application: Immersion or Spray.
c. Thickness: 1 mil.
d. Gloss: Minimum of 50 gloss units on a single-angle, 60-degree meter.

B. Outdoor-Air Refrigerant Coil:

1. Aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coils from contacting steel coil frame or condensate pan.
3. Corrosion-Resistant Coating: Apply a corrosion-resistant coating capable of withstanding a 3,000-hour salt-spray test according to ASTM B 117 to base, frame, and casing coils and fan guards Insert component.

a. Standards:

1) ASTM B-117 for salt spray.
2) ASTM D-2794 for minimum impact resistance of 100 in-lb
3) ASTM B-3359 for cross-hatch adhesion of 5B.

b. Application: Immersion or Spray.
c. Thickness: 1 mil.
d. Gloss: Minimum of 50 gloss units on a single-angle, 60-degree meter.

C. Hot-Gas Reheat Refrigerant Coil:

1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coils from contacting steel coil frame or condensate pan.
3. Suction-discharge bypass valve.

2.8 REFRIGERANT CIRCUIT COMPONENTS

A. Compressor: Hermetic, variable-speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

B. Refrigeration Specialties:

1. Refrigerant: R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.

9. Low-ambient kit high-pressure sensor.
10. Hot-gas reheat solenoid valve modulating with a replaceable magnetic coil.
11. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
12. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

2.9 AIR FILTRATION

A. Minimum arrestance and MERV according to ASHRAE 52.2.

2.10 GAS FURNACE

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.

1. CSA Approval: Designed and certified by and bearing label of CSA.

B. Burners: Stainless steel.

1. Fuel: Natural gas.
2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.

C. Heat-Exchanger and Drain Pan: Stainless steel.

D. Venting: Gravity vented with vertical extension.

E. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve with vertical extension.

F. Gas Valve Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

2.11 DAMPERS

A. Leakage Rate: Comply with ASHRAE/IES 90.1.

B. Damper Motor: Modulating with adjustable minimum position.

2.12 ELECTRICAL POWER CONNECTIONS

A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

B. Each fan and motor internal to the unit shall have a separate motor starter and disconnect switch by the unit manufacture. The supply fan shall have a variable frequency drive motor starter disconnect switch built into the unit by the manufacture.

2.13 CONTROLS

A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

B. Basic Unit Controls:

1. Control-voltage transformer.
2. Wall-mounted thermostat or sensor with the following features:

a. Heat-cool-off switch.
b. Fan on-auto switch.
c. Fan-speed switch.
d. Manual and Automatic changeover.
e. Adjustable deadband.
f. Exposed set point.
g. Exposed indication.
h. Degree F indication.
i. Unoccupied-period-override push button.
j. Data entry and access port to input temperature set points, occupied and unoccupied periods, and output room temperature, supply-air temperature, operating mode, and status.

C. DDC Controller:

1. Controller shall have volatile-memory backup.
2. Safety Control Operation:

a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire-alarm control panel.
b. Firestats: Stop fan and close outdoor-air damper if air greater than 130 deg F enters unit. Provide additional contacts for alarm interface to fire-alarm control panel.
c. Fire-Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Retain "Low-Discharge Temperature" Subparagraph below for low-ambient feature.
d. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply-air temperature is less than 40 deg F .
e. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.

3. Scheduled Operation: Occupied and unoccupied periods on seven 365-day clock with a minimum of four programmable periods per day.
4. Unoccupied Period:

a. Heating Setback: 10 deg F.
b. Cooling Setback: System off.
c. Override Operation: Two hours.

5. Supply Fan Operation:

a. Occupied Periods: Run fan continuously.

b. Unoccupied Periods: Cycle fan to maintain setback temperature.

6. Refrigerant Circuit Operation:

a. Occupied Periods: Cycle or stage compressors to match compressor output to cooling load to maintain room temperature. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
b. Unoccupied Periods: Cycle compressors and condenser fans for heating to maintain setback temperature.
c. Switch reversing valve for heating or cooling mode on air-to-air heat pump.

7. Gas Furnace Operation:

a. Occupied Periods: Modulate burner to maintain room temperature.
b. Unoccupied Periods: Cycle burner to maintain setback temperature.

8. Fixed Minimum Outdoor-Air Damper Operation:

a. Occupied Periods: refer to plans for cfm
b. Unoccupied Periods: refer to plans for cfm .

9. Economizer Outdoor-Air Damper Operation:

a. Morning warm-up cool-down cycles.
b. Occupied Periods: Open to 10 percent fixed minimum intake, and maximum 100 percent of the fan capacity. Controller shall permit air-side economizer operation when outdoor air is less than [**60 deg F**]. Use outdoor-air enthalpy to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper. During economizer cycle operation, lock out cooling.
c. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
d. Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor shall adjust for temperature, and output shall range from 2- to 10-V dc or 4 to 20 mA.

10. Carbon Dioxide Sensor Operation:

a. Occupied Periods: Reset minimum outdoor-air ratio down to minimum Insert number percent to maintain maximum 1000-ppm concentration.
b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

11. Terminal-Unit Relays:

a. Provide heating- and cooling-mode changeover relays compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface relay for scheduled operation.

2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide BACnet compatible interface for central HVAC control workstation for the following:

    a. Adjusting set points.
    b. Monitoring supply fan start, stop, and operation.
    c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature.
    d. Monitoring occupied and unoccupied operations.
    e. Monitoring constant and variable motor loads.
    f. Monitoring variable-frequency drive operation.
    g. Monitoring cooling load.
    h. Monitoring economizer cycles.
    i. Monitoring air-distribution static pressure and ventilation air volume.

2.14 ACCESSORIES

A. Electric heater with integral thermostat maintains minimum 50 deg F temperature in gas burner compartment.

B. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required.

C. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

D. Remote potentiometer to adjust minimum economizer damper position.

E. Return-air bypass damper.

F. Factory- or field-installed, demand-controlled ventilation.

G. Safeties:

1. Smoke detector.
2. Condensate overflow switch.
3. Phase-loss reversal protection.
4. High and low pressure control.
5. Gas furnace airflow-proving switch.

H. Coil guards of painted, galvanized-steel wire.

I. Hail guards of galvanized steel, painted to match casing.

J. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.

K. Door switches to disable heating or reset set point when open.

L. Outdoor-air intake weather hood with moisture eliminator.

M. Oil separator.

2.15 SPRING VIBRATION ISOLATION ROOF CURBS (ALT VERSION)

A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

a. Materials: ASTM C 1071, Type I or II.
b. Thickness: 1-1/2 inches.

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

a. Liner Adhesive: Comply with ASTM C 916, Type I.
b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
d. Liner Adhesive: Comply with ASTM C 916, Type I.

B. Curb Dimensions: Height of 24 inches full length and width of unit.

C. The lower member shall consist of galvanized steel Z section or channel containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 1/4" thick. Steel springs shall be laterally stable and rest on 1/4" thick neoprene acoustical pads. Hardware must be nickel plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing fastened over the lower curb’s waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2" of insulation. Curb shall be type RSC as manufactured by Mason Industries, Inc

2.16

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

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

3.2 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

B. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

3.3 CONNECTIONS

A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.
5. Install normal-weight, 3000-psi, compressive strength (28-day) concrete mix inside roof curb, 4 inches thick. Concrete, formwork, and reinforcement are specified with concrete.

B. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

C. Where installing piping adjacent to RTUs, allow space for service and maintenance.

1. Gas Piping: Comply with applicable requirements in Section 221123 "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

D. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least 1/2 inch high.
3. Locate nameplate where easily visible.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. RTU will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Inspect for visible damage to unit casing.
3. Inspect for visible damage to furnace combustion chamber.
4. Inspect for visible damage to compressor, coils, and fans.
5. Inspect internal insulation.

6. Verify that labels are clearly visible.
7. Verify that clearances have been provided for servicing.
8. Verify that controls are connected and operable.
9. Verify that filters are installed.
10. Clean condenser coil and inspect for construction debris.
11. Clean furnace flue and inspect for construction debris.
12. Connect and purge gas line.
13. Remove packing from vibration isolators.
14. Inspect operation of barometric relief dampers.
15. Verify lubrication on fan and motor bearings.
16. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
17. Adjust fan belts to proper alignment and tension.
18. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.

19. Inspect and record performance of interlocks and protective devices; verify sequences.
20. Operate unit for an initial period as recommended or required by manufacturer.
21. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency:

    a. Measure gas pressure on manifold.
    b. Inspect operation of power vents.
    c. Measure combustion-air temperature at inlet to combustion chamber.
    d. Measure flue-gas temperature at furnace discharge.
    e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

22. Calibrate thermostats.
23. Adjust and inspect high-temperature limits.
24. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
25. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

26. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
27. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.
    b. Return-air volume.

c. Relief-air volume.
d. Outdoor-air intake volume.

28. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

29. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

    a. High-temperature limit on gas-fired heat exchanger.
    b. Low-temperature safety operation.
    c. Filter high-pressure differential alarm.
    d. Economizer to minimum outdoor-air changeover.
    e. Relief-air fan operation.
    f. Smoke and firestat alarms.

30. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.6 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.7 DEMONSTRATION

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

END OF SECTION 237416.11

SECTION 237423.16 - PACKAGED, INDIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes outdoor, indirect, gas-fired, heating-only, makeup air units, including the following components:

1. Casings.
2. Outdoor-air intake hood.
3. Roof curbs.
4. Fans, drives, and motors.
5. Air filtration.
6. Dampers.
7. Indirect, gas-fired burners.
8. Unit control panel.
9. Controls.
10. Accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each outdoor, indirect, gas-fired, heating-only, makeup air unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Fans:

a. Include certified fan-performance curves with system operating conditions indicated.
b. Include fan construction and accessories.
c. Include motor ratings, electrical characteristics, and motor accessories.

5. Include filters with performance characteristics.
6. Include direct, gas-fired burners with performance characteristics.
7. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each outdoor, indirect, gas-fired heating and ventilating unit.

1. Include plans, elevations, sections, and mounting attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Sample Warranty: For manufacturer's warranty.

C. Seismic Qualification Data: Certificates, for outdoor, indirect, gas-fired, makeup air units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Restraint of internal components.

D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Startup service reports.

F. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For indirect, gas-fired, makeup air units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Filters: One set(s) for each unit.
2. Gaskets: One set(s) for each access door.
3. Fan Belts: One set(s) for each unit.

1.7 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of indirect, gas-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Entire Unit: Manufacturer's standard, but not less than one year(s) from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: Not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

2.2 CAPACITIES AND CHARACTERISTICS Refer to plans and schedules

2.3 MANUFACTURERS

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

1. Cambridge Engineering, Inc.
2. Greenheck Fan Corporation.
3. Rezner
4. Modine
5. Sterling

2.4 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
3. Makeup Air Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

B. Configuration: Horizontal unit with bottom or front discharge for roof-mounting installation.

C. Double-Wall Construction:

1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick, with manufacturer's standard finish.
2. Inside Casing Wall:

    a. Inside Casing, Burner Section: Galvanized steel, solid, minimum 14-gauge thick steel.
    b. Inside Casing, All Other Sections: Galvanized steel solid or perforated steel.

3. Floor Plate: Galvanized steel, minimum 18 gauge thick.
4. Casing Insulation:

    a. Materials: Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071.
    b. Casing Panel R-Value: Minimum 8.
    c. Insulation Thickness: 1.5 inch Insert dimension.
    d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.

5. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

D. Panels and Doors:

1. Panels:

    a. Fabrication: Formed and reinforced, with same materials and insulation thickness as casing.
    b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow.
    c. Gasket: Neoprene, applied around entire perimeters of panel frames.

d. Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.

2. Doors:

a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
b. Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.

3. Locations and Applications:

a. Fan Section: Inspection and access panels.
b. Access Section: Doors.
c. Gas-Fired Burner Section: Inspection and access panels.
d. Damper Section: Inspection and access panels.
e. Filter Section: access door.
f. Mixing Section: panels

2.5 OUTDOOR-AIR INTAKE HOOD

A. Type: Manufacturer's standard hood or louver.

B. Materials: Match cabinet.

C. Bird Screen: Comply with requirements in ASHRAE 62.1.

D. Filter: Aluminum, 1 inch cleanable.

E. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.6 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Materials: min 18 gage Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

a. Materials: ASTM C 1071, Type I or Type II.
b. Thickness: 1-1/2 inches. 3 pound per cubic foot density

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

    a. Liner Adhesive: Comply with ASTM C 916, Type I.
    b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
    d. Liner Adhesive: Comply with ASTM C 916, Type I.

C. Curb Height: 24 inches.

D. Gasketing shall be provided for field mounting between the unit base and the roof curb.

E. The lower member shall consist of galvanized steel Z section or channel containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 1/4" thick. Steel springs shall be laterally stable and rest on 1/4" thick neoprene acoustical pads. Hardware must be nickel plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing fastened over the lower curb's waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2" of insulation. Curb shall be type RSC as manufactured by Mason Industries, Inc

1. Optional equipment;
    a. Integrated pitch corrections – steel framing to hold bottom section level with respect to roof.
    b. Sheet metal access doors in front of spring isolators
    c. Acoustic package (2) sealed layers of gypsum attached to the floating upper base supported by steel members around the perimeter and across the width of the curb.

2.7 FANS, DRIVES, AND MOTORS

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.
2. Shaft Bearings: Heavy-duty, self-aligning, permanently lubricated ball bearings,or pillow-block bearings with an L50 rated life of 100,000 hours according to ABMA 9.
3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
4. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.

5. Shaft Lubrication Lines: Extended to a location outside the casing.
6. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.

    a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

C. Drives: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.

1. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
2. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
3. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146-inch- thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.

D. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Maximum sizes as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Enclosure: Open, dripproof.
4. Enclosure Materials: Cast iron.

5. Efficiency: Premium efficient as defined in NEMA MG 1.
6. NEMA Design: 1
7. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.

2.8 AIR FILTRATION

A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

B. Panel Filters:

1. Description: Flat, pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
4. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.

C. Cleanable Filters:

1. Cleanable metal mesh.

D. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.

E. Side-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized steel track.

a. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.9 DAMPERS

A. Dampers: Comply with requirements in Section 230923.12 "Control Dampers."

B. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.

C. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."

D. Electronic Damper Operators:

1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
6. Size dampers for running torque calculated as follows:

a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.

b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.
d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

7. Coupling: V-bolt and V-shaped, toothed cradle.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
10. Power Requirements (Two-Position Spring Return): 24 V dc.
11. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
12. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
13. Temperature Rating: Minus 22 to plus 122 deg F.
14. Run Time: 12 seconds open, 5 seconds closed.

2.10 INDIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47 and with NFPA 54.

B. CSA Approval: Designed and certified by and bearing label of CSA.

C. Burners: Stainless steel.

1. Rated Minimum Turndown Ratio: 30 to 1.
2. Fuel: Natural gas.
3. Ignition: Electronically controlled electric spark with flame sensor.
4. Gas Control Valve: Modulating.
5. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

D. Venting, Gravity: Gravity vented.

E. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.

F. Heat Exchanger: Stainless steel.

G. Heat-Exchanger Drain Pan: Stainless steel.

H. Safety Controls:

1. Gas Manifold: Safety switches and controls complying with ANSI standards.
2. Vent Flow Verification: Differential pressure switch to verify open vent or Flame rollout switch.

3. High Limit: Thermal switch or fuse to stop burner.
4. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
5. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
6. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
7. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
8. Control Transformer: 24 V ac.

2.11 UNIT CONTROL PANEL

A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.

B. Control Panel: Surface-mounted or Recessed, with trim ring, remote panel, with engraved plastic cover and the following lights and switches:

1. On-off-auto fan switch.
2. Heat-vent-off switch.
3. Supply-fan operation indicating light.
4. Heating operation indicating light.
5. Thermostat.
6. Damper position potentiometer.
7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
8. Safety-lockout indicating light.
9. Enclosure: NEMA 250, Type 1.

2.12 CONTROLS

A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.

B. Control Devices:

1. Remote Thermostat: Adjustable room thermostat with temperature readout.
2. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
3. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
4. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature.
5. Timers, Seven Day:

    a. Programming-switch timer with synchronous-timing motor and seven-day dial.
    b. Continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover.
    c. Multiple-switch trippers.

d. Minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.

6. Timers, Solid State:

a. Programmable time control with four separate programs.
b. 24-hour battery carryover; individual on-off-auto switches for each program.
c. 365-day calendar with 20 programmable holidays.
d. Choice of fail-safe operation for each program.
e. System fault alarm.

7. Ionization-Type Smoke Detectors:

a. 24-V dc, nominal.
b. Self-restoring.
c. Plug-in arrangement.
d. Integral visual-indicating light.
e. Sensitivity that can be tested and adjusted in place after installation.
f. Integral addressable module.
g. Remote controllability.
h. Responsive to both visible and invisible products of combustion.
i. Self-compensating for changes in environmental conditions.

C. Fan Control, Interlocked: Fan to start automatically with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.

D. Fan Control, Timer: Timer starts and stops indirect-fired heating and ventilating unit and exhaust fan(s).

E. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.

F. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air as follows:

1. Minimum refer to schedule percent outdoor air.
2. Outdoor-air quantity adjusted by potentiometer on control panel.
3. Outdoor-air quantity to maintain minimum building static pressure.

G. Temperature Control:
1. Operates gas valve to maintain space temperature with wall-mounting, field-wired sensor with temperature adjustment, and unit-mounted control adjustment.
2. Burner Control, Stepped: Two or four steps of control using one or two burner sections in series.
3. Burner Control, Modulating: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual burner units.

H. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.

1. Hardwired Points:

    a. Room temperature.
    b. Discharge-air temperature.
    c. Burner operating.
    d. Return temperture

2. ASHRAE 135.1 (BACnet) communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

2.13 ACCESSORIES

A. Electric heater with integral thermostat maintains minimum 50 deg F temperature in gas burner compartment.

B. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required.

C. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

D. Coil guards of painted, galvanized-steel wire.

E. Hail guards of galvanized steel, painted to match casing.

2.14 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.

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

3.2 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." AHRI Guideline B. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment.

B. Unit Support: Install unit level on structural curbs. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of curbs with actual equipment provided.

C. Install gas-fired units in accordance with NFPA 54.

D. Install controls and equipment shipped by manufacturer for field installation with indirect, gas-fired heating and ventilating units.

3.3 PIPING CONNECTIONS

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

1. Gas Piping: Comply with requirements in Section 231123 Facility Natural-Gas Piping. Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers.

C. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

3.4 DUCTWORK CONNECTIONS

A. Duct Connections: Connect supply and return ducts to indirect-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

3.5 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Inspect for visible damage to burner combustion chamber.
2. Inspect casing insulation for integrity, moisture content, and adhesion.
3. Verify that clearances have been provided for servicing.
4. Verify that controls are connected and operable.
5. Verify that filters are installed.
6. Purge gas line.

7. Inspect and adjust vibration isolators.
8. Verify bearing lubrication.
9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
10. Adjust fan belts to proper alignment and tension.

C. Start unit according to manufacturer's written instructions.

1. Complete startup sheets and attach copy with Contractor's startup report.
2. Inspect and record performance of interlocks and protective devices; verify sequences.
3. Operate unit for run-in period recommended by manufacturer.
4. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:

    a. Measure gas pressure at manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

5. Calibrate thermostats.
6. Adjust and inspect high-temperature limits.
7. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
9. Measure and record airflow. Plot fan volumes on fan curve.
10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:

    a. High-limit heat.
    b. Alarms.

11. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
12. Verify drain-pan performance.
13. Verify outdoor-air damper operation.

3.8 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.9 CLEANING

A. After completing system installation and testing, adjusting, and balancing makeup air unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Units will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION 237423.16

SECTION 238123.13 – PRECISION DX SPLIT AIR-CONDITIONERS UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes ceiling-mounted, precision air conditioning unit with electric heat, dx cooling, hot gas reheat. Units are either split systems or close coupled.

1.3 DEFINITIONS

A. COP: Coefficient of performance.

B. EER: Energy efficiency ratio.

C. SCR: Silicon-controlled rectifier.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include material descriptions, dimensions of individual components and profiles, and finishes for computer-room air-conditioning units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For computer-room air conditioners.

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

C. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.

B. Seismic Qualification Certificates: For computer-room air conditioners, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fan Belts: One set(s) for each belt-driven fan.
2. Filters: One set(s) of filters for each unit.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Above Air
2. United Cool Air
3. Data Aire Inc.

2.2 PERFORMANCE REQUIREMENTS

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

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

2.3 MANUFACTURED UNITS

A. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls,

1. Mounting Configuration: Concealed or exposed hung from building. structure.

B. Cabinet: Galvanized steel serviceable from one side, with baked-enamel finish, insulated with 1/2-inch-thick duct liner, and mounting bracket attached to the unit.

1. Unit with supply and return collars for ducting in the field.
2. Unit with high static blower assembly consisting of field-attached blower box with double-inlet, centrifugal belt-driven fan; with single-speed motor mounted on an adjustable base, and providing up to 2 inches wc of external pressure.
3. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Supply-Air Fan:

1. Forward curved, double width, double inlet, centrifugal, with adjustable V-belt drive.

D. Refrigeration System:

1. Compressor: Scroll, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
2. Refrigeration Circuit Components:

a. Low-pressure switch.
b. Manually reset, high-pressure switch.
c. Thermal-expansion valve with external equalizer.
d. Sight glass with moisture indicator.
e. Service shutoff valves.
f. Charging valves.
g. Hot-gas bypass.
h. Refrigerant charge.
i. 2 stage hot gas reheat coil

3. Refrigerant: R-410A.
4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins. The coil shall be custom 6 row (min) coil specifically designed for 50% outdoor air and high latent loads.
5. Refrigerant line sets precharged in lengths of and of sufficient length to serve the unit from its condensing unit.
6. Refrigerant line-sweat-adapter kit to permit field brazing of refrigerant lines.

    a. Mount stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir under coil assembly.

7. Remote, or close coupled air-cooled refrigerant condenser: Integral, copper-tube aluminum-fin coil with direct-drive, propeller fan.
8. Split system shall have suction, liquid-line and or hot gas lines, compatible fittings and refrigerant piping for field interconnection.

E. Electric-Resistance Reheat Coil:

1. Finned-tube electric elements with contactor.
2. Dehumidification relay.
3. High-temperature-limit switches.
4. SCR to proportionally control the reheat elements providing precise temperature control.

F. Filter: 1-inch-thick, disposable, glass-fiber media.

1. Initial Resistance: .1 inches wg.
2. Recommended Final Resistance: .5 inches wg.

3. Pre-Filter Minimum Efficiency Reporting Value:

    a. MERV 6 according to ASHRAE 52.2.

4. Filter Minimum Efficiency Reporting Value:

    a. MERV Rating: MERV 9 according to ASHRAE 52.2.

G. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
2. Control: Fully modulating to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
3. Drain Cycle: Field-adjustable drain duration and drain interval.

H. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

I. Single point power kit permitting single electrical feed to the evaporator and condensing unit of a close-coupled system.

J. Epoxy-coated, step-down transformer suitable for mounting on the outdoor condensing unit to provide it with 277-V input power.

K. Control System:

1. Microprocessor remote-mounted panel. Located in music room
2. Fan contactor.
3. Compressor contactor.
4. Compressor start capacitor.
5. Control transformer with circuit breaker.
6. Solid-state temperature- and humidity-control modules.
7. Humidity contactor.
8. Time-delay relay.
9. Heating contactor.
10. Smoke sensor.
11. Filter clog switch.
12. Alarm contacts.
13. High-temperature thermostat.
14. DIRECT DIGITAL wall-mounted control panel with start-stop switch, adjustable humidity set point, remote temperature sensors remote humidity sensors and adjustable temperature set point. BACnet compatible ready for connection to bas building Andover DDC system.
15. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.

L. Fan Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

    a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
    b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.4 CAPACITIES AND CHARACTERISTICS Refer to Plans and Schedules

2.5 AUTOMATIC CONDENSATE PUMP UNITS

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

1. Little Giant
2. Armstrong Pumps, Inc.
3. ITT Corporation.

B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch-minimum, electrical power cord with plug float switch for auto shut off of AC unit on high water level.

C. Capacities and Characteristics: Refer to plans and schedules.

D. Electrical Characteristics: Refer to plans and schedules.

2.6

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for hydronic piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.

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

3.2 INSTALLATION

A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.

C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to AHRI Guideline B.

D. Suspended Air Conditioners: Install using continuous-thread hanger rods and elastomeric hangers or spring hangers of size required to support weight of air conditioner.

1. Air-Cooled Refrigerant Condenser Mounting: Install using elastomeric pads on concrete base. Condensing units installed on grade shall be installed on a concreate housekeeping pad 3 ½" thick and 6" longer and wider than unit mounts. Set pad level, slope soil away from pad. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

2. Fasten condensing unit to dunnage of pad with galvanized steel fasteners. Set units level with shims. Vibration isolators shall be mason industries model MBSW or super WSW.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to computer-room air conditioners, allow space for service and maintenance.

C. Water and Drainage Connections: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Provide adequate connections for condensate drain, and humidifier flushing system. Condensate drains shall be type L copper and shall be piped from the unit drain pan to indirectly discharge into floor drain or into condensate pump receiver.

D. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

E. Provide a supplemental float switch or water sensor in the drain pan arranged to shut the unit off if high water is detected.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

F. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 238123.13

SECTION 23 81 27 DUCTLESS SPLIT-SYSTEM AIR-CONDITIONERS/HEATPUMP

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fan Coil Unit.
2. Condensing unit.
3. For units/systems up to five tons maximum.

B. This applies to units less than 5 tons.

1.2 REFERENCES

A. Air-Conditioning and Refrigeration Institute:

1. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. ARI 270 - Sound Rating of Outdoor Unitary Equipment.
3. ARI 340/360 - Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.
4. ARI 365 - Commercial and Industrial Unitary Air-Conditioning Condensing Units.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
2. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.

C. ASTM International:

1. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.

D. National Electrical Manufacturers Association:

1. NEMA MG 1 - Motors and Generators.

E. National Fire Protection Association:

1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

1.3 SUBMITTALS 23 81 27

A. Product Data: Submit data indicating:

1. Cooling and heating capacities.
2. Dimensions.
3. Weights.
4. Rough-in connections and connection requirements.
5. Electrical requirements with electrical characteristics and connection requirements.
6. Controls.
7. Accessories.

B. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include start-up instructions.

1.4 QUALITY ASSURANCE

A. Performance Requirements: Energy Efficiency Rating (EER) and Coefficient of Performance (COP) not less than prescribed by ASHRAE 90.1 when used in combination with compressors and evaporator coils when tested in accordance with ARI Standards.

PART 2 - PRODUCTS

2.1 SPLIT SYSTEM AIR CONDITIONING UNITS

A. Product Description: Split system consisting of fan coil unit and condensing unit including cabinet, evaporator fan, refrigerant cooling coil, compressor, refrigeration circuit, condenser, air filters, controls, air handling unit accessories, condensing unit accessories, and refrigeration specialties.

B. Manufacturers:

1. Daikin
2. Carrier
3. Toshiba.
4. Sanyo.

C. Refrigerants R-410A and R-407C.

D. Unit shall be wall mounted, ceiling mounted, or ceiling cassette type (integral with grid).

2.2 CONDENSING UNIT

A. General: Factory assembled and tested air cooled condensing units, consisting of casing, compressors, condensers, coils, condenser fans and motors, and unit controls.

B. Unit Casings: Exposed casing surfaces constructed of galvanized steel with manufacturer's standard baked enamel finish. Designed for outdoor installation and complete with weather protection for components and controls, and complete with removable panels for required access to compressors, controls, condenser fans, motors, and drives.

1. 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.
2. The fan grill shall be of ABS plastic.
3. 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. Compressor: DC twin-rotor rotary compressor with Variable Speed Inverter Drive Technology Or compressor shall be a Frame Compliant Scroll compressor with Variable Speed Inverter Drive Technology. Compressor shall five (5) year warranty.

1 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.
2 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.
3 The outdoor unit shall have an accumulator and high pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration

A. Condenser Coil: Constructed of copper tubing mechanically bonded to copper fins, factory leak and pressure tested. Coil shall be coated with minimum 1.0 mil. aluminum impregnated polyurethane coating by Blygold PoluAl XT or approved equal. Coating shall withstand 4,000 hours in both salt spray test per ASTM B117 and acid salt spray test per ASTM D5339.

1. Refrigerant flow from the condenser shall be controlled by means of an electronic linear expansion valve (LEV) metering device. The LEV shall be control by a microprocessor controlled step motor.
2. 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 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.
3. Refrigerant shall be R407C or R410A.

B. Controls: Furnish operating and safety controls including high and low pressure cutouts.

Control transformer. Furnish magnetic contactors for compressor and condenser fan motors.

C. Condenser Fans and Drives: Direct drive propeller fans statically and dynamically balanced. Wired to operate with compressor. Permanently lubricated ball bearing type motors with built-in thermal overload protection. Furnish high efficiency fan motors.

1. The fan blade(s) shall be of aerodynamic design for quiet operation, and the fan motor bearings shall be permanently lubricated.
2. The outdoor unit shall have horizontal or vertical 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. The outdoor unit shall be able to operate with a maximum height difference of 100 feet (30 meters) between indoor and outdoor units. System shall operate at up to a maximum refrigerant tubing length of 100 feet for the 18,000 BTU/h and 165 feet for the 24,000, 30,000, 36,000, and 42,000 BTU/h units between indoor and outdoor units without the need for line size changes, traps or additional oil. Units shall be pre-charged for a maximum of 1000 feet of refrigerant tubing.

E. Condensing Unit Accessories: Furnish the following accessories:

1. 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).
2. Time delay relay.
3. Anti-short cycle timer.
4. Disconnect switch.
5. Vibration isolators.
6. Hot gas bypass kit.
7. Coil with corrosion resistant coating capable of withstanding salt spray test of 1000 hours in accordance with ASTM B117.
8. Condenser Coil Guard: Condenser fan openings furnished with PVC coated steel wire safety guards.
9. Suction and discharge pressure gauges.

F. Refrigeration specialties: Furnish the following for each circuit:

1. Charge of compressor oil.
2. Holding charge of refrigerant.
3. Replaceable core type filter drier.
4. Liquid line sight glass and moisture indicator.
5. Shut-off valves on suction and liquid piping.
6. Liquid line solenoid valve.

7. Charging valve.
8. Oil level sight glass.
9. Crankcase heater.
10. Hot gas muffler.
11. Pressure relief device.

G. 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 via Mitsubishi Electric A-Control 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 Units;

A. General All Units

1. Filter: Return air shall be filtered by means of an easily removable, washable filter or disposable. An optional MERV 8 filter shall be furnished. Efficiency based on ASHRAE 52.1

2. Coil: 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. Provide 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. Provide An optional drain lift mechanism, capable of lifting condensate 23-5/8" above the drain pan, shall be provided

3. Electrical: The electrical power of the unit shall be 208 volts or 230 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 187 volts to 253 volts. The power to the indoor unit shall be supplied from the outdoor unit using a three (3) conductor AWG-14 wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units.

4. Control: 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 CN24 and a 12 VDC output.

5. The system shall be capable of automatic restart when power is restored after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostics codes for indoor and outdoor units shall be displayed on the wired controller panel.

6. The Wired Remote Controller shall be approximately 5" x 5" in size and white in color with a light-green LCD display. 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). 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

7. 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.

B. Ceiling Suspended Type

1. The Ceiling Suspended type 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 remote 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 air before shipment from the factory.

2. The casing shall be ABS plastic and have a Munsell 6.4Y 8.9/0.4 white finish. Cabinet shall be designed for suspension mounting from above and horizontal operation. Indoor unit shall have removable mounting brackets. A mounting template with suspension bolt locations shall be furnished with indoor unit. Mounting bolts or threaded rod of 3/8" diameter shall be used to suspend unit and unit shall not require direct contact with ceiling or panel for proper operation. Mounting support shall be of sufficient strength and design to support full weight of indoor unit. The rear cabinet panel shall have knock-out provisions for a field installed filtered 4-5/16 diameter ventilation air intake connection.

3. The indoor unit fan shall have multiple high performance, double inlet, forward curve sirocco fans driven by 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 four (4) speeds: Low, M1, M2, and Hi plus AUTO fan setting. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set-point and sensed space temperature.

4. Vane: 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 provide a choice of five (5) vertical airflow patterns selected by remote control: 100% horizontal flow, 80% horizontal flow (plus 20% downward airflow), 60% horizontal airflow (plus 40% downward airflow), 40% horizontal airflow (plus 60% downward airflow), and swing. 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 selected by remote control.

C. Ducted Type

1. The Ducted type 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 or wireless wall-mounted 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 air before shipment from the factory.

2. The cabinet shall be space saving, low profile, horizontal, ducted type. Formed cabinet shall be constructed of G-60 galvanized steel with factory applied foam surface insulation to prevent condensation on outer surfaces. The cabinet shall be provided with four mounting brackets to accommodate suspension from threaded rod or structural support located on the side panels in all four corners. Brackets shall be suitable for supporting the weight of the indoor unit. The indoor unit cabinet shall be equipped with a ducted air outlet and ducted rear return air connection. units shall support an optional Bottom Return Adaptor. units shall have selectable rear or bottom return as a standard feature. The units shall be equipped with a 3-15/16” diameter ventilation air intake knock-out.

3. The indoor unit fan unit shall be an assembly with two (2) or four (4) Sirocco fans direct driven by a single motor. Fan shall develop airflow to deliver up to 0.20 - 0.60 inches wg of external static pressure. The indoor fans shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings. The indoor fans shall operate on any of three (3) speeds, High, Mid, Low 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. Wall Mounted Type

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, wireless wall-mounted 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 air before shipment from the factory.

2. Unit Cabinet: 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.

3. 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.

4. 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. Ceiling Recessed

1. The indoor unit shall be a space-saving ceiling-recessed cassette type, factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, drain left mechanism, control circuit board, fan, and fan motor. The unit, in conjunction with the remote 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 air before shipment from the factory.

2. The cabinet shall be formed from galvanized sheet metal coated with high-density foam insulation. Cabinet shall be for recessed mounting and provided with four (4) corner mounting supports behind removable corner pockets in Grille assembly allowing adjustment of mounting height from front of unit. The cabinet panel shall have provisions for a field installed filtered outside air intake. There shall be a knock-out to provide a branch air duct for conditioning a secondary space. There shall be an optional multi-function casement which will mount between the unit cabinet and the Grille assembly to provide a second field installed filtered outside air intake and provide a mount for a high-efficiency filter element.

3. A separate grill assembly shall be attached to the front of the cabinet to provide supply air

vanes in four directions and a center mounted return air section. The four-way grill shall be fixed to bottom of cabinet allowing two, three or four-way blow. The grill vane angles shall be individually adjustable from the wired remote controller to customize the airflow pattern for the conditioned space. Grill assembly color shall be white

4. The indoor fan shall be an assembly with a turbo fan propeller, direct driven by a single motor and shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings. The indoor fan shall consist of four (4) speed settings, Low, Med1, Med2, High 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.

5. The indoor unit shall have an adjustable air outlet system offering 4-way airflow, 3-way airflow, or 2-way airflow with switches that can be set to provide optimum airflow based on ceiling height and number of outlets used. The indoor unit vanes shall have 5 fixed positions and a swing feature that shall be capable of automatically swinging the vanes up and down for uniform air distribution. The vanes shall have an Auto-Wave selectable option in the heating mode that shall randomly cycle the vanes up and down to evenly heat the space. If specified, the grill shall have an optional sensor kit installed – sensor function described in System Control Section.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install per manufacturer's recommendations. Indoor concealed units suspended from building construction shall be hung using vibration isolation hangers.

1. Elastomeric hangers in a Steel Frame with upper and lower steel hanger rods. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact. Type LDS hander with HD rod attachment as manufactured by Mason Industries.

B. For wall or floor mounted units fasten units to structure with neoprene washers between unit structure

C. Mount condensing units on roof dunnage or curbs as detailed on plan. Install neoprene pads under unit mounts similar to Mason industries type SW or type BR

D. Install condensate piping with trap and route from drain pan to approved receptor.

E. Install condensing unit on concrete housekeeping pads. Pads shall be 3 1/2" think and at least

6” longer and wider than unit. Set pad level. Provide neoprene pads between unit and concrete pad similar to Mason industries type SW or type BR.

F. For ducted units. Provide flexible connections between ductwork and unit.

G. Concealed units. Coordinate location and size of access doors to provide full access to units for maintenance and filter change.

3.2 TRAINING

A. Training shall include minimum of 10 LAWA personnel for 40 hours three shifts total, 16 hours shall be classroom training and 24 hours shall be hands on training.

END OF SECTION 23 81 27

SECTION 238236 - FINNED-TUBE AND CONVECTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes;
   1. Hydronic finned-tube radiation
   2. Cabinet convectors

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

B. Shop Drawings:

   1. Include plans, elevations, sections, and details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include details and dimensions of custom-fabricated enclosures.
   4. Indicate location and size of each field connection.
   5. Indicate location and arrangement of piping valves and specialties.
   6. Indicate location and arrangement of integral controls.
   7. Include enclosure joints, corner pieces, access doors, and other accessories.
   8. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

D. Color Samples for Initial Selection: For finned-tube radiation heaters with factory-applied color finishes.

E. Color Samples for Verification: For each type of exposed finish.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members, including wall construction, to which finned-tube radiation heaters will be attached.
2. Method of attaching finned-tube radiation heaters to building structure.
3. Penetrations of fire-rated wall and floor assemblies.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 HOT-WATER FINNED-TUBE RADIATION:

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

1. Vulcan.
2. Rittling.
3. Slant/Fin.
4. Sterling.

B. Performance Ratings: Rate finned-tube radiation heaters according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."

C. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One end of tube shall be belled.

1. Tube Diameter: NPS 1 NPS 1-1/4 Insert pipe size.
2. Fin Size: 4 ¼ by 41/4 inches.
3. Fin Spacing: 48 per foot.
4. Number of Tiers: 1.
5. Heat Output: 1120 Btu/h per ft..
6. Entering-Air Temperature: 65 deg F.
7. Average Water Temperature: 180 deg F.
8. Minimum Water Velocity: 1/2 fps.

D. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.

E. Front Panel: Minimum 14 gage thick steel.

F. Wall-Mounted Back Panel: Minimum 0.0329-inch-thick steel, full height, with full-length channel support for front panel without exposed fasteners.

G. Floor-Mounted Pedestals: Conceal insulated piping at maximum 36-inch spacing. Pedestal-mounted back panel shall be solid panel matching front panel. Provide stainless-steel escutcheon for floor openings at pedestals.

H. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.

I. Finish: Baked-enamel finish in manufacturer's custom color as selected by Architect.

J. Damper: Knob-operated internal damper at enclosure outlet.

K. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.

L. Enclosure Style: Flat top.
   1. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
      a. Mill-finish aluminum.
      b. Anodized finish, color as selected by Architect from manufacturer's custom colors.
      c. Painted to match enclosure.
   2. Top Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
      a. Mill-finish aluminum.
      b. Anodized finish, color as selected by Architect from manufacturer's custom colors.
      c. Painted to match enclosure.
   3. Enclosure Height: 11’.
   4. Enclosure Depth: 5 9/16”.

M. Accessories: Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes. Refer to detail on plans

2.2 HOT-WATER CABINET CONVECTORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Vulcan.
   2. Rittling.
   3. Slant/Fin.
   4. Sterling.

B. Heating Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and rolled into cast-iron or brass headers with inlet/outlet and air vent; steel side plates and supports. Factory-pressure-test element at minimum 100 psig. For convector dimensions and capacities, refer to equipment notes and schedules on plan.

C. Ratings:
   1. Entering-Air Temperature: 65 deg F.
   2. Average Water Temperature: 170 deg F.
   3. Design Temperature Drop: 20 deg F .

D. Front Panel: Minimum 0.0528-inch- thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.

E. Wall-Mounted Back and End Panels: Minimum 0.0428-inch-thick steel.

F. Floor-Mounted Pedestals: Conceal conduit for control wiring at maximum 36-inch spacing. Pedestal-mounted back panel shall be solid panel matching front panel.

G. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.

H. Insulation: 1/2-inch-thick, fibrous glass on inside of the back of the enclosure.

I. Finish: Baked-enamel finish in manufacturer's custom color as selected by Architect.

J. Damper: Knob-operated internal damper.

K. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.

L. Enclosure Style: Recessed

1. bottom front Inlet Grille: Punched louver; painted to match enclosure.
2. top front Inlet Grille: Punched louver; painted to match enclosure.
3. Wall trim ring rounded corners.

M. For convector dimensions and capacities, refer to equipment notes and schedules on plan.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive finned-tube radiation heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for hydronic-piping steam-piping connections to verify actual locations before installation of finned-tube radiation heaters.

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

3.2 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect hot-water finned-tube radiation heaters and components to piping according to Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.

2. Install shutoff valve on inlet; install strainer, steam trap, and shutoff valve on outlet.

C. Install control valves as required by Section 230923.11 "Control Valves."

D. Install piping adjacent to finned-tube radiation heaters to allow service and maintenance.

E. Ground electric finned-tube radiation heaters according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238236

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SECTION 238239.16 - PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes propeller unit heaters with hot-water electric-resistance heating coils.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. PTFE: Polytetrafluoroethylene plastic.

C. TFE: Tetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include location and size of each field connection.
4. Include details of anchorages and attachments to structure and to supported equipment.
5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
6. Indicate location and arrangement of piping valves and specialties.
7. Indicate location and arrangement of integral controls.
8. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which propeller unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Other equipment

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For propeller unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products shall be one of the following;
1. Rattling
2. Sterling
3. Modine
4. Vulcan
5. Indeeco

2.2 DESCRIPTION

A. Assembly including casing, coil, fan, and motor in vertical and/or horizontal discharge configuration as scheduled with adjustable discharge louvers.

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

C. Electric propeller unit heaters shall comply with UL 2021

D. Explosion-proof electric propeller unit heaters shall comply with UL 823.

2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.4 HOUSINGS

A. Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.5 COILS

A. General Coil Requirements: Test and rate hot-water and steam propeller unit-heater coils according to ASHRAE 33.

B. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 deg F, with manual air vent. Test for leaks to 350 psig underwater.

C. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F at any point during normal operation.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

2.6 FAN AND MOTOR

A. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

B. Motor: Permanently lubricated, multispeed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.7 CONTROLS

A. Control Devices:

1. Wall-mounted, fan-speed switch, and thermostat compatible with building temperature control system. Unit shall be ordered with transformers and relays as required to integrate into BMS

2. Provide strap on “aquastat” on the HW supply line to prevent fan start up if hot water is not available.

2.8 CAPACITIES AND CHARACTERISTICS

A. Heating Capacity are as scheduled or noted on plans.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for **piping and** electrical connections to verify actual locations before unit-heater installation.

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

3.2 INSTALLATION

A. Install propeller unit heaters to comply with NFPA 90A.

B. Install propeller unit heaters level and plumb.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and **elastomeric hangers or spring hangers** Hanger rods.

D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

3.3 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties. Piping installation requirements are specified in the following Sections:
   1. Section 232113 "Hydronic Piping."
   2. Section 232116 "Hydronic Piping Specialties."

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to propeller unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. For units hot water or steam coils comply with safety requirements in UL 1995.

E. For hot water unit, unless otherwise indicated, install union and gate or ball valve and strainer on supply-water connection and union and calibrated balancing valve on return-water connection of propeller unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters.

END OF SECTION 238239.16

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SECTION 238316 – RADIANT HEATING SYSTEM PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes radiant-heating piping, consisting of pipes, fittings, and piping specialties including:

1. PEX pipe and fittings.
2. Piping specialties.
3. Distribution manifolds and compatible fittings.
4. Fasteners approved by manufacturer.
5. Mixing assemblies.
6. Controls.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. PEX: Crosslinked polyethylene.

C. PTFE: Polytetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include data for piping, fittings, manifolds, specialties, and controls; include pressure and temperature ratings, oxygen-barrier performance, fire-performance characteristics, and water-flow and pressure-drop characteristics.

B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.

1. Shop Drawing Scale: **1/8 inch = 1 foot**
2. Shop drawings and calculation reports with the following information:

a. Submit circuit layout that shows manifold location, pipe spacing, pipe size, circuit length, flow rates, head loss, supply water temperatures for heating, and supply water temperatures for cooling if applicable.

b. Provide calculation reports that show output of the heating/cooling system to include any excess or shortages of heating or cooling, heating/cooling entering the space, flow rates, head loss, back losses of heating/cooling, floor covering resistance, and floor surface temperatures.
c. Submit floor cross section details with fastener(s) being used, fastener spacing, insulation requirements, thermal mass thickness (if required), and intended floor covering.
d. Submit details of manifold, manifold cabinets, valves, and fittings either in a flush mounted installation or a recessed location.
e. Submit details of slab penetrations.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which radiant-heating piping will be attached.
3. Expansion joints and slab penetrations.
4. Items penetrating finished ceiling.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For radiant-heating piping valves and equipment to include in operation and maintenance manuals.

B. Technical data sheets.

C. Product instructions.

D. Design calculation reports.

1.7 WARRANTY

A. Manufacturer warranty shall include the following:

1. In the event that manufacturer determines that the failure or leak and any resulting damages were the result of a manufacturing defect in the products covered by the warranty and occurred during the first ten years of the time period covered by the warranty, the manufacturer will reimburse the property owner for reasonable repair or replacement charges resulting from the failure or leak and, additionally will reimburse damages to personal property resulting from the failure or leak.
2. Radiant heat pipe manufacturer shall warranty the tubing under normal conditions of use and properly maintained, will be free from failure caused by manufacturing defect for a period of thirty (30) years from date of installation, when properly installed by contractors trained by manufacturer.
3. PEX Press fittings, when installed with ViegaPEX Barrier and FostaPEX tubing, will be free from failure caused by manufacturing defect for a period of thirty (30) years from date of installation. This also includes protected PEX Press fitting in a slab.

4. Manifolds and panels used in the system will be free from manufacturing defect for a period of five (5) years.
5. Controls, mixing stations, or electrical components sold by manufacturer shall be free from manufacturing defect for a period of two (2) years from date of installation.

PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Viega LLC;Viega PEX Barrier or a comparable product by one of the following:

1. The FlorHeat Company.
2. Heat Innovations Inc.
3. Infloor Radiant Heating Inc.
4. IPEX USA LLC.
5. Uponor.

B. Pipe Material:

1. PEX tubing and fittings shall maintain a quality control program in accordance with ISO 9001 or NSF International in the manufacturing plant to assure that the tubing and fittings are continually being produced to the required standard.
2. Tubing shall be silane cross-linked high density polyethylene as per ASTM F876/F877 and CSA B137.5.
3. Tubing includes four layers.

    a. First layer: Cross-linked, high density polyethylene.
    b. Second layer: Adhesive.
    c. Third layer: Ethylene vinyl alcohol layer (EVOH oxygen barrier).
    d. Fourth layer: Polyethylene to protect the EVOH layer from damage.

4. Certified to NSF 14 and 61.
5. Tubing will have 6 month UV protection.
6. Certified to UL 263 ULC S101 for floor and wall assemblies.
7. Certified to ASTM E84 and ULC S102.2 Flame Spread (FS)/Smoke Developed (SD) (25/50).

C. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.

D. Bronze Fittings: PEX Press Fittings manufactured from UNS C83600 copper alloy, meeting the requirements of ASTM F 877 tested as a system with ViegaPEX Barrier tubing.

1. PEX Press Sleeve: Manufactured out of a 304 grade or better stainless steel, and have three view holes with an attached sleeve to ensure proper PEX tubing insertion.
2. Attached sleeve fitting will incorporate a tool locator ring that shall be in place while making a proper press connection.
3. PEX Press connection shall be made with a Viega supplied ratcheting PEX Press hand tool or PEX Press power tool.

E. Polymer Fittings: PEX Press Fittings manufactured from Radel-R® polymer, meeting the requirements of ASTM F 877 tested as a system with ViegaPEX Barrier tubing.

1. PEX Press Sleeve: Manufactured out of a 304 grade or better stainless steel and have three view holes with an attached sleeve to ensure proper PEX tubing insertion.
2. Fitting will include the Smart Connect feature providing quick easy identification of unpressed connections during the pressure testing process.
3. Unpressed connections are located by pressurizing the system to 0.5 psi to 100 psi.
4. Attached sleeve fitting will incorporate a tool locator ring that shall be in place while making a proper press connection.
5. PEX Press connection shall be made with a Viega supplied ratcheting PEX Press hand tool or PEX Press power tool.

F. Pressure/Temperature Rating: ViegaPEX Barrier High-Density Cross-linked polyethylene tubing shall meet the standard grade hydrostatic pressure ratings from the Plastic Pipe Institute in accordance with TR-4/03. The following three ratings are required:

1. 200 deg F at 80 psi.
2. 180 deg F at 100 psi
3. 73.4 deg F at 160 psi.

2.2 DISTRIBUTION MANIFOLDS

A. Stainless Manifold with Balancing Valves and Flow Meters: Minimum NPS 1 1/4.

1. Manifolds shall be made of 304 stainless steel with nickel-plate valve necks on select models.
2. Flow meters, balancing valves, and shut off valves are integrated on manifold.
3. Air bleeders and two purge valves are to be integrated on manifold.
4. Manifolds have 1 inch NPT removable end caps and 1 1/4 inch Union connections.
5. Galvanized steel bracket supplied by Viega.
6. Select manifold cabinet based on manifolds, accessories and fittings added.
7. Accept optional powerheads for individual zone control.
8. Manifold is suitable to receive all SVC connections.
9. Flow Meters for Stainless Manifolds:

    a. Visual Flow Indicator: Visible indication in a clear plastic cap at top of valve.
    b. Body Brass: Nickel plated.
    c. Internal Parts: Plastic, EPDM.
    d. Inlet Connection: NPS 1/2, 1/2 inch with O-ring.
    e. Measure range: 0 - 2 gpm.
    f. Handle Style: Rotating ring with lockable cap, no memory stop to retain set position if used for shut off.
    g. CWP Rating: 100 psi.

10. Thermometers:

    a. Mount on connection.
    b. Case: Stainless steel, 2 inch diameter.
    c. Element: Bimetal coil element.
    d. Movement: Mechanical, connecting element and pointer.

e. Dial: White aluminum, black lettering.
f. Pointer: Aluminum, black.
g. Window: Instrument glass, NS 33 polycarbonate.
h. Connector: Rigid, back type.
i. Accuracy: Plus or minus 2 percent of range.

11. Maximum Operating Pressure: 100 psi .
12. Maximum Operating Temperature: 180 deg F.

B. Stainless Manifolds with Balancing Valves: Minimum NPS 1 1/4.

1. Manifolds shall be made of 304 stainless steel with nickel-plate valve necks on select models.
2. Balancing valves and shut off valves are integrated on manifold.
3. Air bleeders and purge valves are to be integrated on manifold.
4. Manifolds have 1 inch NPT removable end caps and 1 1/4 inch NPT Union connections.
5. Use bracket supplied by Viega.
6. Select manifold cabinet based on manifolds, accessories and fittings added.
7. Accept optional powerheads for individual zone control.
8. Manifold circuit connections are suitable to receive all SVC connections.
9. Maximum Operating Pressure: 100 psi .
10. Maximum Operating Temperature: 180 deg F.

C. Balancing Valves for Stainless Manifolds:

1. Body: Brass, nickel plated.
2. Valve Spindle: Brass, EPDM.
3. Inlet Connection: NPS 1/2, 1/2 inch with O-ring.
4. Operator: Allen Wrench - 5 mm.
5. CWP Rating: 145 psi.
6. Maximum Operating Pressure: 100 psi .
7. Maximum Operating Temperature: 180 deg F .

D. Manual Air Vents:

1. Body: Brass, nickel-plated.
2. Operator: Key furnished with valve, or screwdriver bit.
3. Inlet Connection: NPS 1/2 .
4. Maximum Operating Pressure: 100 psi .
5. Maximum Operating Temperature: 180 deg F .

E. Main Shutoff Valves for Stainless Manifolds:

1. Field installed on supply and return connections.
2. Two-piece body.
3. Body: Brass nickel-plated body.
4. Ball: Full port chrome-plated brass.
5. Seals: PTFE.
6. Stem: Brass with 2 Buna-N O-rings and blowout proof assembly.
7. CWP Rating: 100 psig .
8. Maximum Operating Temperature: 180 deg F.

F. Powerheads (valve operator) for Stainless Manifolds (0-10 VDC):

1. Voltage: 24 VAC 50/60 Hz.
2. Control Voltage: 0-10 VDC.
3. Maximum Inrush Current: < 320 mA for 2 minutes maximum.
4. Operating Power 1 watt.
5. Actuating Force: 21 lbs
6. Stroke: 0.16 inch .
7. Fluid Temperature: 32 to 212 deg F.
8. Max Pressure Differential: 50 psi
9. Connecting Cable Length: 3 feet.

2.3 PIPING SPECIALTIES

A. Cable Ties:

1. Self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
2. Minimum Width: 0.17 inch.
3. Tensile Strength: 75 lb, minimum.

2.4 PREASSEMBLED STATIONS

A. Mixing Devices: specified in Section 230523 "General Duty Valves for HVAC" and Section 232123 "Hydronic Pumps".

B. Basis-of-Design Product: Subject to compliance with requirements, provide Viega LLC; or a comparable product by one of the following:
1. The FlorHeat Company.
2. Heat Innovations Inc.
3. Infloor Radiant Heating Inc.
4. IPEX USA LLC.
5. Slant/Fin Corp.

C. Hydronic Mixing Block:

1. Input Voltage/Current: 120 VAC ± 10% 60 Hz, 2A.
2. Sensors: (2) 10 K Ohms - 1 boiler sensor, 1 outdoor sensor.
3. Boiler Relay: 24 VAC 1.0 MAX AMPS.
4. Circulator Relay: 24 VAC 1.0 MAX AMPS.
5. Microprocessor: 8 Bit, 32 MHz.
6. Maximum Temperature: 203 deg F.
7. Pressure:
    a. Maximum Working Pressure: 45 psi
    b. Maximum Test Pressure: 100 psi
8. Weight: 10 lbs
9. Dimensions: 12.18 inches W x 10 inches H x 6.7 inches D
10. Listings:

a. Meets CSA C22.2 No. 24.
b. Meets UL Standard 873.
c. ETL Control No. 3068143.

D. Enhanced Mixing Station: (for reference only not used)

1. Enhanced Mixing Station Maximum Operating Pressure: 100 psi.
2. Enhanced Mixing Station Maximum Operating Temperature: 180 deg F
3. Connecting Options: Viega PEXPress, ProPress or Copper.
4. Mixing Station Piping Material: Type L Copper, ASTM B 88.
5. Circulator:

a. Circulator Material: Cast iron.
b. Circulator Flow Range: 0 - 17.5 U.S. GPM
c. Circulator Head Range: 0 - 19 ft.
d. Circulator Motor: Permanently magnetized circulator motor, Single Phase, 120 V.
e. Circulator Temperature Range: 36 to 230 deg F
f. Circulator Settings: 7 settings, 3 fixed speeds, 3 constant pressures, and 1 AutoADAPT™.
g. Circulator Maximum Discharge Pressure: 150 psi

6. Diverting Valve:

a. Diverting Valve Body: Bronze.
b. Diverting Valve Seals: EPDM.
c. Diverting Valve Maximum Differential Pressure: 7.3 psi
d. Diverting Valve Cv 7.6.

7. Ball Valve:

a. Ball Valve: Two piece bronze body.
b. Ball Valve Ball: 316 stainless steel ball, full port.
c. Ball Valve Seals: EPDM sealing elements.
d. Ball Valve Stem Seals: EPDM.
e. Ball Valve Press Ends: With engineered leak path.
f. Ball Valve Operating Temperature: 0 to 250 deg F
g. Ball Valve Maximum Operating Pressure: 200 psi
h. Ball Valve: 600 WOG.
i. Ball Valve Handles: Metal with standard sticker indicators for supply and return.

E. High Head Mixing Station:

1. High Head Mixing Station Maximum Operating Pressure: 100 psi.
2. High head Mixing Station Maximum Operating Temperature: 180 deg F
3. Connection Options: Viega PEX Press, ProPress or Copper.
4. Mixing Station Piping Material: Type L Copper, ASTM B 88.
5. Circulator:

a. Circulator Material: Cast iron.
b. Circulator Flow Range: 0 - 34 U.S. gpm.
c. Circulator Head Range: 0 - 30 ft

d. Circulator Motor: 2 Pole, Single Phase, 120 V.
e. Circulator Temperature Range: 36 to 230 deg F.
f. Circulator Maximum Working Pressure: 145 psi
g. Circulator Settings: 3 Speeds.

6. Diverting Valve:

a. Diverting Valve Body: Bronze.
b. Diverting Valve Seals: EPDM.
c. Diverting Valve Maximum Differential Pressure: 7.3 psi
d. Diverting Valve Cv: 7.6.

7. Ball Valve:

a. Ball Valve: Two piece bronze body.
b. Ball Valve Ball: 316 stainless steel ball, full port.
c. Ball Valve Seals: EPDM sealing elements.
d. Ball Valve Stem Seals: EPDM.
e. Ball Valve Press Ends: with engineered leak path.
f. Ball Valve Operating Temperature: 0 to 250 deg F.
g. Ball Valve Maximum Operating Pressure: 200 psi.
h. Ball Valve 600 WOG.
i. Ball Valve Handles: Metal with standard sticker indicators for supply and return.

2.5 CONTROLS

A. Temperature-control devices and sequence of operations are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Basis-of-Design Product: Subject to compliance with requirements, provide Viega LLC; or a comparable product by one of the following:

1. Andover controls.

C. Set Point Control:

1. Remote sensor unit with adjustable temperature range from minus 40 to 248 deg F.
2. Snap action; open-on-rise, 2 SPDT dry contacts, 1/2 hp @ 120 VAC, 9.8 FLA, 58.8 LRA.
3. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant-panel temperature.
4. Stop pump or close zone control valves if heated-panel setting is exceeded.
5. Corrosion-resistant, waterproof control enclosure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive radiant-heating piping for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Ensure that surfaces and pipes in contact with radiant-heating piping are free of burrs and sharp protrusions.
2. Ensure that surfaces and substrates are level and plumb.

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

3.2 APPLICATIONS

A. Install the following types of radiant-heating piping for the applications described:
1. Piping in Interior Reinforced-Concrete Floors: ViegaPEX Barrier.

3.3 INSTALLATION

A. Refer to manufacturer's most current installation instructions.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings or coordination drawings.

C. Install ViegaPEX Barrier at least 4 inches from edge of slabs, walls or other permanent objects.

D. Install ViegaPEX Barrier continuous from the manifold through the heated floor and back to the manifold without piping joints in heated panels. If coupling is required, use Viega PEX Press fitting and wrap in Viega's Coupling Repair Tape.

E. Avoid crossing tubing in slab unless minimum concrete thickness is met.

F. Square off ViegaPEX Barrier with approved PEX Cutters.

G. Connect ViegaPEX Barrier to manifold using approved Viega Manifold Adapters.

H. Use bend supports for pipe entering and exiting the slab.

I. Do not bend pipes in radii smaller than manufacturer's minimum bend radius.

J. Manifolds should be installed with brackets supplied by Viega LLC.

K. Install manifolds in accessible locations, or install access panels to provide maintenance access as required in Section 083113 "Access Doors and Frames."

L. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties" for pipes and connections to hydronic systems and for glycol-solution fill requirements.

M. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Section 078413 "Penetration Firestopping."

N. Piping in Interior Reinforced-Concrete Floors:

1. Secure piping by attaching pipes to reinforcement using approved fasteners from manufacturer.
2. Space fasteners a maximum of 24 inches and at center of turns and bends.
3. Maintain 2 inch minimum cover.
4. Install vapor barrier and insulation as per the radiant design. Ensure compression rating is suitable for structural engineer.
5. If pipe is being secured to insulation space fasteners a maximum of 24 inches and at center of turns and bends.
6. Install a sleeve of 3/8 inch thick, foam-type insulation PVC or PE pipe around tubing and extending for a minimum of 12 inches on each side of slab expansion joints to protect the tubing passing through expansion joints. Anchor sleeve to slab form at expansion joints to provide maximum clearance for saw cut.
7. If tube passes metal expansion joints pass tubing under the joint.
8. Maintain pressure test of a minimum 100 psig or 1.5 times system working pressure.
9. After initial pressurization, ensure pressure has not dropped after 20 minutes. Fluctuations may occur due to temperature fluctuations and tubing expansion. If a drop has occurred add pressure to the system. Carry out testing for a minimum of 1 hour.
10. Maintain pressure in piping during concrete and floor covering installation and continue for 24 hours after placement.

O. Piping in Concrete Floor (Not Reinforced):

1. Secure piping in concrete floors by attaching pipes to subfloor using approved fastener from manufacturer.
2. Space approved fasteners from manufacturer a maximum of 24 inches o.c. and at center of turns or bends.
3. Maintain 3/4 inch minimum cover.
4. Install insulation as per radiant design.
5. Install a sleeve of 3/8 inch-thick, foam-type insulation PVC or PE pipe around tubing and extending for a minimum of 12 inches on each side of slab expansion joints to protect the tubing passing through expansion joints. Anchor sleeve to slab form at expansion joints to provide maximum clearance for saw cut.
6. Maintain pressure test of a minimum 100 psig or 1.5 times system working pressure.
7. After initial pressurization, ensure pressure has not dropped after 20 minutes. Fluctuations may occur due to temperature fluctuations and tubing expansion. If a drop has occurred add pressure to the system. Carry out testing for a minimum of 1 hour.
8. Maintain pressure in piping during concrete and floor covering installation and continue for 24 hours after placement.

P. Piping in Ceiling:

1. Secure piping by attaching pipes to ceiling substrate using clamps or staples.
2. Space clamps or staples a maximum of 24 inches o.c. and at center of turns or bends.
3. Maintain 1-1/2-inch minimum thermal mass cover.
4. Maintain pressure test of a minimum 100 psig or 1.5 times system working pressure.
5. After initial pressurization, ensure pressure has not dropped after 20 minutes. Fluctuations may occur due to temperature fluctuations and tubing expansion. If a drop has occurred add pressure to the system. Carry out testing for a minimum of 1 hour.
6. Maintain pressure in piping during concrete and floor covering installation and continue for 24 hours after placement.

Q. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.

R. After system balancing has been completed, mark balancing valves to permanently indicate final position per design.

S. Perform the following adjustments before operating the system:

1. Open valves to fully open position.
2. Check operation of automatic valves.
3. Set temperature controls so all zones call for full flow.
4. Purge air from piping.

T. After concrete has cured, operate radiant-heating system as follows:

1. Start warm up after concrete has reached its final set (curing complete).
2. Set supply water temperature to 75 deg F for the first three days.
3. Increase supply water temperature to the set point in gradual increments for the next 4 days. Maximum of a 50 deg F increase in a period of 24 hour).

3.4 FIELD QUALITY CONTROL

A. Prepare radiant-heating piping for testing as follows:

1. Open all isolation valves and close bypass valves.
2. Open and verify operation of zone control valves.
3. Flush with clean water and clean strainers.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Radiant-heating piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Protect hydronic piping system from damage during construction.

END OF SECTION 238316

SECTION 23 84 16 VEHICLE EXHAUST SYSTEM

PART 1: GENERAL

1.01 RELATED DOCUMENTS

A. Conditions of the Contract and portions of Division One of this Project Manual apply to this Section as though repeated herein.

1.02 SUMMARY

HOSE REELS ON EXHAUST RAILS

This system shall include purchase, installation and start-up of seven, SER-850-AD Hose Reels with trolleys for mounting (two each) on three, 85-foot aluminum profile exhaust rails connected to Fan VEX-2 and one hose reel on a 60-foot aluminum profile hose rail connected to Fan VEX-1. The system shall be designed to allow for unlimited travel of the hose reel on the rail. The basis of design is the Plymovent system and or approved equal.

1.03 SYSTEM DESCRIPTION

This system shall include seven, SER-850-AD Hose Reels with trolleys for mounting (two each) on three, 85-foot aluminum profile exhaust rails connected to Fan VEF-2 and one hose reel on a 60-foot aluminum profile hose rail connected to Fan VEF-1. The system shall be designed to allow for unlimited travel of the hose reel on the rail. The basis of design is the Plymovent system and or approved equal.

1.04 SUBMITTALS

A. Product Data: Indicate manufacturer's model number, technical data, accessories, requirements for access, maintenance, weights and service-connections including dimensions.

B. Contractor to provide layout drawings showing field locations of all rails, hose reels, duct diameters and hanger details.

C. Closeout Submittals: Operation and Maintenance data manual including spare parts list.

1.05 QUALITY ASSURANCE

A. Engage an experienced installer to perform work of this Section who has specialized in installing hose storage systems, who has completed installations similar in design and extent to that indicated for this Project, and who has a record of successful in-service performance for a minimum of five years.

B. Engage a firm experienced in manufacturing hose storage systems similar to that indicated for this Project and with a record of successful in-service performance.

C. Conduct conference at Project site. Review methods and procedures related to hose storage system installation.
   1. Review access requirements for equipment delivery.
   2. Review equipment storage and security requirements.

3. Inspect condition of preparatory work performed by other trades.
4. Review structural loading limitations.

1.06 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading: Deliver hose storage system as a factory assembled unit with protective crating and covering. Store equipment in original protective crating and covering and in a dry location.

1.07 PROJECT/SITE CONDITIONS

A. Existing Conditions: Verify dimensions installation areas by field measurements.

1.08 COORDINATION

A. Coordinate layout and installation with other work, including light fixtures, HVAC equipment, overhead cranes, owner's representative and fire-suppression system components.

B. Coordinate location and requirements of service-utility connections.

C. Confirm product locations with owner's representative prior to installing equipment.

PART 2: PRODUCTS

2.01 MANUFACTURER

A. Plymovent Corporation
B. Monoxivent
C. Eurovac
D. Fume-A-vent

2.02 MANUFACTURED UNITS

Section Includes:

1. SER 850 Hose Reel
2. Hose Reel Trolley
3. Exhaust Rail for Hose Reel
4. Support Legs
5. Splicing joint
6. Hose
7. Nozzles
8. Fans VEX-1, VEX-2
9. VFD with pressure sensor and pitot tube for VEX-1 & 2
10. Wireless Receivers and Transmitters for Fan Start-Up
11. Ducting

A. Spring Operated Hose Reel: The Plymovent SER Spring Operated Hose Reel Hose Storage System shall be the following model: SER-850-AD-125 for 5" diameter hose. 33' long

All steel components shall be electro zinc plated steel except for the hose storage drum end plates, which will be powder coated yellow. The steel frame shall provide four angle clips, one at each corner for mounting reel to trolley.

The spring cassette must be a sealed enclosure to prevent the coiled spring from coming out of the enclosure if the spring needs to be exchanged. The spring cassette must be on the outside of the reel assembly (not in-between the hose reel side bracket and rotating drum) and held to the reel with four bolts.

Spring shall be a one-inch wide heavy-duty coil spring with a total lifting capacity of 42 lbs.

The frame shall include two adjustable side support tie bars that both connect the side plates together and acts as the hose stop bar. The bar shall be able to be field adjusted to match hose diameter used.

Two steel hose guides shall be provided to be bolted to the rotating drum of hose reel. Plastic tubing type hose guides are unacceptable.

The access panel in hose reel drum shall be covered with a sheet metal cover made from the same thickness steel as the drum. Exposed edges of drum access panel shall be covered with a heavy molded trim channel that covers the entire edge.

Provide, as part of the hose reel assembly, a rubber hose stop collar. This collar is installed around the hose and adjusted to control the amount of hose that hangs down off the reel when the hose is recoiled.

Provide a latch and lock feature on each hose reel. This feature allows an operator to pull the hose down to a convenient position and the reel will stay there until the hose is recoiled by pulling out a little more hose.

The hose reel must be designed to allow for future conversion from a spring recoil type reel to a motor activated reel via removal of the spring cassette and addition of the motor drive without complete disassembly of the reel.

B. Hose Reel Trolley: The hose reel trolley shall be constructed of tubular steel with welded construction. Four ball bearing rollers shall allow for the trolley to ride on the outside of the aluminum profile. The trolley shall be constructed to allow a metal transition to be bolted into place that convert from the 6.25” round hose reel inlet to a duct transition that will ride between the lips on the rail.

C. Exhaust Rail for Hose Reel: One-piece continuous extruded aluminum rail in a minimum length of 19 feet (580 mm). Construction Profile: Rectangular profile, rail height of 10 inches (254 mm) including the rubber seals, rail thickness of 0.20 inches (5mm), width of 8-½ inches (216 mm) id. Bottom Portion of Rail: Continuous slots to accept a rubber seal. Rubber Seals: Fitted into each side of the rail and shall join in the middle. Rail Material: Aircraft aluminum alloy Type AA-6063 (ASTM B209/B209M). Rail: Extruded as a one-piece design unit to maximize the structural integrity of the rail and to minimize joints which may add to possible leakage of dangerous exhaust gases.

D. Support Legs: Manufactured and provided by the supplier of primary exhaust removal system (Equipment Manufacturer). Support Leg Material: Aircraft aluminum alloy Type AA-6063

(ASTM B209/B209M). Supports: Standard in 19 feet lengths. A minimum of one support with appropriate bracing shall be provided for every 10 linear feet to 12 linear feet of rail profile. The support legs shall consist of a square outer profile with dimensions no less than 2-inch OD by 0.1 inch by with 0.4 inch (10 mm) fastening hardware provided. The vertical adjustable mounting foot shall be capable of attaching the leg assembly to a ceiling with a 30-degree pitch, complete with 3/8 of an inch (9.5 mm) hardware necessary for mounting the leg assembly to the top suspension mount. The support leg shall be equipped with round tubular zinc-plated steel knee brace with pressed ends in standard lengths of 20 inch, 30 inch and 72-inch. The angle shall be completely adjustable to the leg support and mounted perpendicular and parallel to direction of the rail. The typical support angle shall be 45 degrees from the centerline of the factory provided support leg. The standard leg shall be capable of meeting a Seismic Zone 4 requirement. Vertical support and bracing shall be provided to safely secure the rail profile in accordance with building code and seismic standards which may apply. A minimum of one support with appropriate bracing shall be provided for every 10 lineal feet to 12 linear feet of rail profile.

E. Rail Splicing Joint: Formed steel fitting equal to the internal diameter of the suction rail profile. The splice shall have a wall thickness of no less than 0.190 inch in thickness and a length of no less than 8 inches from end to end. Rail Splicing: Safely secured by no less than 16-3/8 inches by 1-½ inch bolts, nuts and lock washers. Each bolt shall pass through the exterior of the rail profile and splicing joint and shall be secured on the inside by a lock washer and nut. Self-tapping bolts or screws are not acceptable.

Hose: Plymovent SNF-2 hose. A light-weight high temperature two ply exhaust hose for use on vehicle exhaust capture systems with double-ply fabric and an iron oxide silicone coated fiberglass inner layer & a silicone coated Nomex® outer layer. Reinforced with an internal spring steel wire helix and external filament fiberglass cord. The system shall hold 40 feet of 5" diameter exhaust hose that is rated for 550 degree continuous and can handle a spike up to 1250 degrees F and weighs no more than 0.6 lbs. per foot.

G1. STANDARD Nozzles: RUBBER VEHICLE EXHAUST NOZZLE, REG-125-160: Provide Plymovent Rubber Exhaust nozzles (REG series) for the hose reels. These nozzles are designed for truck, car and heavy equipment exhaust systems. The oval design allows these to be attached to both round and dual/parallel exhaust pipe systems. The rubber material of the nozzle shall be rated a minimum of 430 degrees F.

Each nozzle shall include the following:

1. A high temperature, molded, oval rubber sleeve to fit over the tailpipe(s). Include a heavy sheet metal elbow bend suitable to match the hose diameter on the hose reel. The nozzle shall have an oval opening of 8.3" x 4.6", which will open up to a 6.3" diameter.

2. A CO port for vehicle emissions testing. A rubber plug is included to close this port when not used.

3. A Vise Grip latch to attach this nozzle to the vehicle tailpipe. This Vise Grip shall have an adjusting screw to allow for different thickness tailpipes.

4. The rubber portion of the nozzle shall be attached to a sheet metal elbow bend via a stainless-steel hose clamp.

G2. STACKER Nozzles: Vertical Stacker: For overhead tailpipes. The Stacker connects to the vertical exhaust pipe of the vehicle once the exhaust extractor has been connected to the Stacker's pipe joint. The Stacker connects to the exhaust extractor's nozzle or the exhaust hose (via a hose clip). The Stacker consists primarily of two parts which are joined with a hose clip. 1.Reduced pipe joint with a mounting arm (adjustable through
360°) riveted on it. The mounting arm is positioned between two friction pads and can be easily locked into place by simply turning the knob. This provides maximum flexibility and can be adapted to the various angles and locations; exhaust pipes occupy on lorries.2. Metal joint with rubber protecting border. The metal joint has a center pin that guarantees and simplifies control and coupling to the exhaust pipe. The metal joint can be supplemented with a spring clip which can be used success-fully for both straight and looped rails, guaranteeing connection. The Stacker is operated by a telescopic handle (N.B. ordered separately). The length of the handle is adjustable from 1.7m-3.2m

H. Fans:

Fan shall be AMCA tested and test reports provided with approval documents

VEX-1: Plymovent - FUA 3000.
The Plymovent FUA-Series Fan shall be a high-pressure blower with standard AMCA type B construction and a backward inclined aluminum fan impeller. The housing material will be galvanized steel with an epoxy powder coated finish. It shall also include a 90-degree rotational discharge and rubber shaft seal and motor mounting support. The motor for this project is 2 HP, 3-phase, 230-460/60Hz Voltage and 3450 RPM.
Plymovent model # FUA 3000. Design Capacity: 600 CFM @ 9"static pressure w.g.

VEX-2: The Plymovent TEV-Series Fan shall be a high-pressure blower with standard AMCA type B construction and a backward inclined aluminum fan impeller. The housing material will be galvanized steel with an epoxy powder coated finish. It shall also include a 90-degree rotational discharge and rubber shaft seal and motor mounting support. The motor for this project is 10 HP, 3-phase, 230-460/60Hz Voltage and 3450 RPM. Plymovent model # TEV-745. Design Capacity: 3000 CFM @ 12" static pressure w.g..

VFD, VEX-2: VFD will have 6 programmable digital inputs, including one for static pressure sensor. Output Voltage capability of 0-100%, with a scan interval of 5ms.

VFD, VEX-1: VFD will have 6 programmable digital inputs, including one for static pressure sensor. Output Voltage capability of 0-100%, with a scan interval of 5ms.

Wireless Receivers and Transmitters
For VEX-2

2400 MHz Receiver with Six 10-Amp SPDT On-Board Relays, Integrated Code learning Decoder, 12-36 Volt DC or AC Operation with LE0D output indicators

IP-67 enclosure 2-Button Remote Control Transmitter for 2400 MHz Transmitter. FCC Part 15 Certified.

For VEX-1

Receiver. 433 MHz Receiver with Three 10-Amp SPDT On-Board Relays, Integrated Code learning Decoder, 12-24 Volt DC or AC Operation with LED output indicators

NEMA IP-67 enclosure 2-Button Remote Control Transmitter for 433 MHz Transmitter. FCC Part 15 Certified.

I. Ducting: U.S. Duct Clampable Ducting Metal ducting utilizing one of several method to join the duct together. Methods include raw ends where duct is welded together, angle rings/flanges where the angle ring is welded to the duct in a fixed method, or angle rings/flanges where the ring is left loose so as to rotate freely on the duct 'behind' a van-stoned end (a 1/2" lip turned at 90 degrees) formed on the end of the duct. In this latter method, the van-stoned ends are pressed together between the joining flanges.

Material: Galvanized

Gauges: Components available in 8-24 gauge depending on diameter and radius of elbows. Elbows are typically 2 gauges heavier than the duct.

Sizes: 6" to 12"
Construction:
Pipe– Lock-seamed, welded seams and/or tubed based upon classification, gauge and material.

Elbows– Stitch welded pressed halves, Segmented 'gore' and then mechanically locked or welded, tubes. Any radius is available. Normally specified in Center Line Radius (CLR)

Branches– Spot welded or welded reducers with full welded laterals constructed with 45-degree laterals. Cut-offs- Aluminum with Galvanized blades

Application/Gauge/Welding Method Notes- Duct is built in accordance with SMACNA guidelines which are based upon operating pressures, abrasiveness relative to conveyed material and velocities. Angle ring/flanges are welded to the duct accordingly.

Hanging– Generally accepted methods include cable hangers and saddle hangers.

2.04 FABRICATION

A. Shop Assembly: Shop assemble hose reel to greatest extent possible for ease of shipment. Provide each hose reel with an adapter assembly to adapt the hose reel to the desired hose diameter. This adaptor kit includes the Hose Stop Collar used to limit how much hose hangs down from the reel when the hose is recoiled.

PART 3: EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, service-utility connections, and other conditions affecting installation and performance of food service equipment. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install system level and plumb, and in accord with manufacturer's written instructions, original design and referenced standards.
B. Hose reels must be mounted securely from the building steel or suitable structure.

3.03 ADJUSTING

A. Adjust system for proper operation. Replace any parts that prevent the system from operating properly.

3.04 CLEANING

A. Remove all debris caused by installation of the system. Clean all exposed surfaces to as fabricated condition and appearance.

3.05 DEMONSTRATION

A. Provide the end user a minimum of one hour of hands-on demonstration and operation of the system.

3.06 PROTECTION

A. Provide protection of the completed installation until completion of the project. Repair any damage at no additional cost to owner

3.07 WARRANTY

A. Provide a written warrantee for a period of one year from date of shipment for all components.

END OF SECTION 23 84 16

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

1.3 DEFINITIONS

A. VFC: Variable frequency controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

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

1. Alpha Wire Company.
2. Belden Inc.
3. Cerro Wire LLC.
4. Encore Wire Corporation.
5. General Cable Technologies Corporation.
6. General Cable; General Cable Corporation.
7. Senator Wire & Cable Company.
8. Southwire Company.

B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/THWN-2, Type XHHW-2 and Type SO.

D. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC mineral-insulated, metal-sheathed cable, Type MI and Type SO with ground wire.

E. VFC Cable:

1. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.
2. Type TC-ER with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.

2.2 CONNECTORS AND SPLICES

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

1. 3M.
2. AFC Cable Systems, Inc.
3. Gardner Bender.
4. Hubbell Power Systems, Inc.
5. Ideal Industries, Inc.
6. ILSCO.
7. NSi Industries LLC.
8. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
9. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

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

B. Comply with NFPA 70.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger, except VFC cable, which shall be extra flexible stranded.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway or Mineral-insulated, metal-sheathed cable, Type MI.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway, Metal-clad cable, Type MC or Mineral-insulated, metal-sheathed cable, Type MI.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway or Metal-clad cable, Type MC.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

I. VFC Output Circuits: Type TC-ER cable with braided shield.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

    a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    b. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

B. Test and Inspection Reports: Prepare a written report to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 260519

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SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency and testing agency's field supervisor.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

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

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Burndy; Part of Hubbell Electrical Systems.
2. ERICO International Corporation.
3. Galvan Industries, Inc.; Electrical Products Division, LLC.
4. Harger Lightning & Grounding.
5. ILSCO.
6. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
7. Siemens Power Transmission & Distribution, Inc.

2.2 SYSTEM DESCRIPTION

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 5/8 by 96 inches.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24 inches below grade.

C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

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

E. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare, tinned copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. For grounding electrode system, install at least two rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

D. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

F. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

G. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

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

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Manhole Grounds: 10 ohms.

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

a. Hangers.
b. Steel slotted support systems.
c. Trapeze hangers.
d. Clamps.
e. Turnbuckles.
f. Sockets.
g. Eye nuts.
h. Saddles.
i. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.

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

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation, A Member of the ABB Group.
f. Unistrut; an Atkore International company.

2. Material: Galvanized steel.
3. Channel Width: 1-5/8 inches.
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

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

        1) Hilti, Inc.
        2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
        3) MKT Fastening, LLC.
        4) Simpson Strong-Tie Co., Inc.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

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

        1) Cooper B-Line, Inc.; a division of Cooper Industries.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti, Inc.
        4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
        5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMTs, IMCs, and RMCs may be supported by openings through structure members, according to NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or

greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

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

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

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Surface raceways
5. Boxes, enclosures, and cabinets.
6. Handholes and boxes for exterior underground cabling.

1.3 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

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

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit.
3. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
4. Republic Conduit.
5. Southwire Company.
6. Thomas & Betts Corporation, A Member of the ABB Group.
7. Western Tube and Conduit Corporation.
8. Wheatland Tube Company.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. IMC: Comply with ANSI C80.6 and UL 1242.

E. EMT: Comply with ANSI C80.3 and UL 797.

F. FMC: Comply with UL 1; zinc-coated steel.

G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:

a. Material: Steel or die cast.
b. Type: Compression.

3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

I. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

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

1. AFC Cable Systems, Inc.
2. Arnco Corporation.
3. CANTEX INC.
4. CertainTeed Corporation.
5. Kraloy.
6. RACO; Hubbell.
7. Thomas & Betts Corporation, A Member of the ABB Group.

B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

D. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

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

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Hoffman; a brand of Pentair Equipment Protection.
3. MonoSystems, Inc.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.

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

a. Hubbell Incorporated; Wiring Device-Kellems.
b. MonoSystems, Inc.
c. Legrand/Wiremold
d. Panduit

2.5 BOXES, ENCLOSURES, AND CABINETS

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

1. Cooper Technologies Company.
2. EGS/Appleton Electric.
3. Erickson Electrical Equipment Company.
4. Hoffman; a brand of Pentair Equipment Protection.
5. Hubbell Incorporated.
6. MonoSystems, Inc.
7. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
8. RACO; Hubbell.
9. Thomas & Betts Corporation, A Member of the ABB Group.
10. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Metal Floor Boxes:

1. Material: Cast metal or sheet metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

K. Gangable boxes are allowed.

L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

M. Cabinets:

1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

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

a. Armorcast Products Company.
b. Carson Industries LLC.
c. NewBasis.
d. Oldcastle Precast, Inc.
e. Quazite: Hubbell Power Systems, Inc.
f. Synertech Moulded Products.

2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC.".
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC or IMC.
2. Concealed Conduit, Aboveground: GRC or IMC.
3. Underground Conduit: RNC, Type EPC-40-PVC or Type EPC-80-PVC.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.

3. Exposed and Subject to Severe Physical Damage: GRC or IMC. Raceway locations include the following:

    a. Loading dock.
    b. Mechanical rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC or IMC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use compression, steel or cast-metal fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Do not install aluminum conduits, boxes, or fittings.

F. Install surface raceways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inchesof enclosures to which attached.

I. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-footintervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from RNC, Type EPC-40-PVC to GRC or IMC before rising above floor.

J. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

M. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

N. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

O. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

P. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

Q. Surface Raceways:

1. Install surface raceway with a minimum 2-inch radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section.

Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

R. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

S. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

T. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

U. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    d. Attics: 135 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

V. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.

2. Use LFMC in damp or wet locations not subject to severe physical damage.

W. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to bottom of box unless otherwise indicated.

X. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Y. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

Z. Locate boxes so that cover or plate will not span different building finishes.

AA. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

CC. Set metal floor boxes level and flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

5. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
6. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install handholes with bottom below frost line, below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

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

   a. Advance Products & Systems, Inc.
   b. CALPICO, Inc.
   c. Metraflex Company (The).
   d. Pipeline Seal and Insulator, Inc.
   e. Proco Products, Inc.

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

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

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

   a. HOLDRITE.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

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

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

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

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 260544

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

B. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Raceways and Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

C. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.3 LABELS

A. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

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

a. Brady Corporation.
b. Champion America.
c. emedco.
d. Grafoplast Wire Markers.
e. LEM Products Inc.
f. Marking Services, Inc.
g. Panduit Corp.
h. Seton Identification Products.

B. Snap-Around Labels for Raceways and Cables Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceways they identify, and that stay in place by gripping action.

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

    a. Brady Corporation.
    b. Marking Services, Inc.
    c. Panduit Corp.
    d. Seton Identification Products.

C. Self-Adhesive Labels:

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

    a. A'n D Cable Products.
    b. Brady Corporation.
    c. Brother International Corporation.
    d. emedco.
    e. Grafoplast Wire Markers.
    f. Ideal Industries, Inc.
    g. LEM Products Inc.
    h. Marking Services, Inc.
    i. Panduit Corp.
    j. Seton Identification Products.

2. Preprinted, 3-mil-thick, polyester or vinyl flexible label with acrylic pressure-sensitive adhesive.

    a. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized to fit the cable or raceway diameter, such that the clear shield overlaps the entire printed legend.

3. Polyester or Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

    a. Nominal Size: 3.5-by-5-inch.

4. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
5. Marker for Tags: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 BANDS AND TUBES:

A. Snap-Around, Color-Coding Bands for Raceways and Cables: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters of raceways or cables they identify, and that stay in place by gripping action.

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

    a. Brady Corporation.
    b. Marking Services, Inc.
    c. Panduit Corp.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around cables they identify. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

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

    a. Brady Corporation.
    b. Panduit Corp.

2.5 TAPES AND STENCILS:

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

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

    a. Carlton Industries, LP.
    b. Champion America.
    c. Ideal Industries, Inc.
    d. Marking Services, Inc.
    e. Panduit Corp.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

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

    a. Brady Corporation.
    b. Carlton Industries, LP.
    c. emedco.
    d. Marking Services, Inc.

C. Tape and Stencil for Raceways Carrying Circuits 600 V or Less: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background that extends full length of raceway or duct and is 12 inches wide. Stop stripes at legends.

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

    a. LEM Products Inc.
    b. Marking Services, Inc.
    c. Seton Identification Products.

D. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

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

    a. Carlton Industries, LP.
    b. Seton Identification Products.

E. Underground-Line Warning Tape

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

    a. Brady Corporation.
    b. Ideal Industries, Inc.
    c. LEM Products Inc.
    d. Marking Services, Inc.
    e. Reef Industries, Inc.
    f. Seton Identification Products.

2. Tape:

    a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
    b. Printing on tape shall be permanent and shall not be damaged by burial operations.
    c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:

    a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
    b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
    c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

4. Tag:

    a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the

continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.

b. Width: 3 inches.
c. Overall Thickness: 5 mils.
d. Foil Core Thickness: 0.35 mil.
e. Weight: 28 lb/1000 sq. ft..
f. Tensile according to ASTM D 882: 70 lbf and 4600 psi.

F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.6 Tags

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Marking Services, Inc.
e. Seton Identification Products.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Grafoplast Wire Markers.
e. LEM Products Inc.
f. Marking Services, Inc.
g. Panduit Corp.
h. Seton Identification Products.

C. Write-On Tags:

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

a. Carlton Industries, LP.

b. LEM Products Inc.
c. Seton Identification Products.

2. Polyester Tags: 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment to raceway, conductor, or cable.
3. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 Signs

A. Baked-Enamel Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 7 by 10 inches.

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

a. Carlton Industries, LP.
b. Champion America.
c. emedco.
d. Marking Services, Inc.

B. Metal-Backed Butyrate Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 10 by 14 inches.

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

a. Brady Corporation.
b. Champion America.
c. emedco.
d. Marking Services, Inc.

C. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:

a. For signs up to 20 sq. inches, minimum 1/16-inch-
b. For signs larger than 20 sq. inches, 1/8 inch thick.
c. Engraved legend with black letters on white face.
d. Punched or drilled for mechanical fasteners.

e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Marking Services, Inc.

2.8 CABLE TIES

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

1. Ideal Industries, Inc.
2. Marking Services, Inc.
3. Panduit Corp.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

J. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

K. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

L. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.3 IDENTIFICATION SCHEDULE

A. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Snap-around labels. Install labels at 10-foot maximum intervals.

B. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl label. Install labels at 30-foot maximum intervals.

C. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "STANDBY POWER."
2. "POWER."
3. "UPS."

D. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
b. Colors for 208/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.

c. Colors for 480/277-V Circuits:

1) Phase A: Brown.
2) Phase B: Orange.
3) Phase C: Yellow.

d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

E. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.

F. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels.

G. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive, self-laminating polyester labels with the conductor or cable designation, origin, and destination.

H. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive, self-laminating polyester labels with the conductor designation.

I. Conductors To Be Extended in the Future: Attach marker tape to conductors and list source.

J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

K. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

L. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

M. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Metal-backed, butyrate warning signs.

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

a. Power-transfer switches.
b. Controls with external control power connections.

N. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

O. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

P. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm unless equipment is provided with its own identification.

1. Labeling Instructions:

a. Indoor Equipment: Engraved, laminated acrylic or melamine plastic label, punched or drilled for mechanical fasteners. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
d. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment To Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a engraved, laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchboards.
e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
f. Emergency system boxes and enclosures.
g. Enclosed switches.
h. Enclosed circuit breakers.
i. Enclosed controllers.
j. Variable-speed controllers.
k. Push-button stations.
l. Power-transfer equipment.
m. Contactors.
n. Remote-controlled switches, dimmer modules, and control devices.
o. Battery-inverter units.

p. Power-generating units.
q. Monitoring and control equipment.
r. UPS equipment.

END OF SECTION 260553

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SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Photoelectric switches.
   2. Indoor occupancy sensors.
   3. Switchbox-mounted occupancy sensors.

B. Related Requirements:

   1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

   1. Show installation details for the following:

      a. Occupancy sensors.

   2. Interconnection diagrams showing field-installed wiring.
   3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's warranties.

1.5 CLOSEOUT SUBMITTALS

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

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Faulty operation of lighting control devices.

2. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OUTDOOR PHOTOELECTRIC SWITCHES

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

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. Leviton Manufacturing Co., Inc.
4. NSi Industries LLC.
5. Tyco Electronics Corporation; a TE Connectivity Ltd. company.

B. Description: Solid state, with SPST dry contacts rated for 1000 W incandescent or 1800 VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A, and compatible with ballasts and LED lamps.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
3. Time Delay: Fifteen-second minimum, to prevent false operation.
4. Surge Protection: Metal-oxide varistor.
5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
6. Failure Mode: Luminaire stays ON.

2.2 INDOOR OCCUPANCY SENSORS

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

1. Bryant Electric.
2. Cooper Industries, Inc.
3. Hubbell Building Automation, Inc.

4. Leviton Manufacturing Co., Inc.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. Lutron Electronics Co., Inc.
7. NSi Industries LLC.
8. Philips Lighting Controls.
9. Sensor Switch, Inc.
10. Square D.
11. Watt Stopper.

B. General Requirements for Sensors:

1. Ceiling-mounted, solid-state indoor occupancy sensors.
2. Dual technology.
3. Separate power pack.
4. Hardwired connection to switch.
5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:

    a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

7. Sensor Output: Sensor is powered from the power pack.
8. Power: Line voltage.
9. Power Pack: Dry contacts rated for 20-A ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
10. Mounting:

    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet when mounted48 inches above finished floor.

2.3 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

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

1. Bryant Electric.
2. Cooper Industries, Inc.
3. Hubbell Building Automation, Inc.
4. Leviton Manufacturing Co., Inc.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. Lutron Electronics Co., Inc.
7. NSi Industries LLC.
8. Philips Lighting Controls.
9. Sensor Switch, Inc.
10. Square D.
11. Watt Stopper.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox using hardwired connection.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
4. Switch Rating: Not less than 800-VA ballast or LED load at 120 V, 1200-VA ballast or LED load at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor Tag WS1:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft..
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP.
4. Capable of controlling load in three-way application.
5. Voltage: Match the circuit voltage.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
9. Color: White.

10. Faceplate: Color matched to switch.

2.4 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

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

3.2 SENSOR INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.3 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.

C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

1. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Lighting control devices will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.

3.7 DEMONSTRATION

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

END OF SECTION 260923

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SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.

C. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Acme Electric Corporation.
2. Eaton.
3. General Electric Company.
4. Hammond Power Solutions Inc.
5. Powersmiths International Corp.
6. Siemens Industry, Inc., Energy Management Division.
7. Square D; by Schneider Electric.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.

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

C. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.
2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
3. Grounded to enclosure.

C. Coils: Continuous windings without splices except for taps.

1. Coil Material: Aluminum.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Bolted.

D. Enclosure: Ventilated.

1. NEMA 250, Type 2 or Type 3R: Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process to seal out moisture and air. Refer to plans for NEMA enclosure requirements of individual transformers.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
3. Wiring Compartment: Sized for conduit entry and wiring installation.

E. Taps for Transformers 3 kVA and Smaller: One 5 percent tap above normal full capacity.

F. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

H. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

I. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

J. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

K. Wall Brackets: Manufacturer's standard brackets.

L. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9.00 kVA and Less: 40 dBA.
2. 9.01 to 30.00 kVA: 45 dBA.
3. 30.01 to 50.00 kVA: 45 dBA.
4. 50.01 to 150.00 kVA: 50 dBA.
5. 150.01 to 300.00 kVA: 55 dBA.
6. 300.01 to 500.00 kVA: 60 dBA.
7. 500.01 to 700.00: 62 dBA.

2.4 IDENTIFICATION

A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
2. Ratio tests at rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at rated voltage connections.
4. No load losses, and excitation current and rated voltage at rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation-Resistance Tests:

    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.

9. Temperature tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

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

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.

B. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Secure transformer to concrete base according to manufacturer's written instructions.

D. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

E. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:

1. Visual and Mechanical Inspection.

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify the unit is clean.
e. Perform specific inspections and mechanical tests recommended by manufacturer.
f. Verify that as-left tap connections are as specified.
g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

a. Measure resistance at each winding, tap, and bolted connection.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

C. Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify the unit is clean.
e. Perform specific inspections and mechanical tests recommended by manufacturer.
f. Verify that as-left tap connections are as specified.
g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

a. Measure resistance at each winding, tap, and bolted connection.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence

of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.

c. Perform power-factor or dissipation-factor tests on all windings.
d. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
e. Perform an excitation-current test on each phase.
f. Perform an applied voltage test on all high- and low-voltage windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.
g. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

D. Remove and replace units that do not pass tests or inspections and retest as specified above.

E. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

F. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262213

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SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.3 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.

1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include schematic and wiring diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Routine maintenance requirements for switchboards and all installed components.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
5. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.9 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding 104 deg F.
    b. Altitude: Not exceeding 6600 feet.

1.10 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

2.2 SWITCHBOARDS

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

1. Eaton.
2. General Electric Company.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

I. Nominal System Voltage: 480Y/277 V.

J. Main-Bus Continuous: Refer to drawings for ampere ratings.

K. Indoor Enclosures: Steel, NEMA 250, Type 1.

L. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

M. Barriers: Between adjacent switchboard sections.

N. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

O. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

P. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks.

Q. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

R. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

S. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.
3. Copper feeder circuit-breaker line connections.
4. Ground Bus: 1/4-by-2-inch-hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
5. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
6. Disconnect Links:

    a. Isolate neutral bus from incoming neutral conductors.
    b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
7. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
8. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

T. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.3 SURGE PROTECTION DEVICES

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

1. Advanced Protection Technologies Inc. (APT).

2. Eaton.
3. General Electric Company.
4. Siemens Industry, Inc., Energy Management Division.
5. Square D; by Schneider Electric.

B. SPDs: Comply with UL 1449, Type 2.

C. Features and Accessories:
1. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
2. Indicator light display for protection status.
3. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
4. Surge counter.

D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 300 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V.
2. Line to Ground: 1200 V for 480Y/277 V.
3. Line to Line: 2000 V for 480Y/277 V.

F. SCCR: Equal or exceed 100 kA.

G. Nominal Rating: 20 kA.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
3. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
4. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.

c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
h. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
i. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.

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

a. Boltswitch, Inc.
b. Eaton.
c. Siemens Industry, Inc., Energy Management Division.
d. Square D.

2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
   a. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.

4. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
5. Service-Rated Switches: Labeled for use as service equipment.
6. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

   a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   b. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
   c. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).

7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

D. Fuses are specified in Section 262813 "Fuses."

2.5 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:

1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
d. Megawatts: Plus or minus 1 percent.
e. Megavars: Plus or minus 1 percent.
f. Power Factor: Plus or minus 1 percent.
g. Frequency: Plus or minus 0.1 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.6 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

2.8 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
3. Protect from moisture, dust, dirt, and debris during storage and installation.
4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

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

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Install filler plates in unused spaces of panel-mounted sections.

E. Install overcurrent protective devices, surge protection devices, and instrumentation.

F. Install spare-fuse cabinet.

G. Comply with NECA 1.

3.3 CONNECTIONS

A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

B. Support and secure conductors within the switchboard according to NFPA 70.

C. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Acceptance Testing:

    a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
    b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. Perform the following infrared scan tests and inspections, and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Instruments and Equipment:

        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.

4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
    b. Altitude: Not exceeding 6600 feet.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

    1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

E. Enclosures: Flush and Surface-mounted, dead-front cabinets.

    1. Rated for environmental conditions at installed location.

        a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
        b. Outdoor Locations: NEMA 250, Type 4.
        c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

    2. Height: 84 inches maximum.
    3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
    4. Finishes:

        a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.

b. Back Boxes: Galvanized steel.

F. Incoming Mains:

1. Location: Convertible between top and bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

G. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

a. Plating shall run entire length of bus.
b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.

H. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

I. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: 20 percent.

J. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.

2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 POWER PANELBOARDS

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

1. Eaton Electrical Sector; Eaton Corporation.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Energy.
4. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker or Lugs only.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

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

1. Eaton Electrical Sector; Eaton Corporation.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Energy.
4. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

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

1. Eaton Electrical Sector; Eaton Corporation.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Energy.
4. Square D; by Schneider Electric.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

    a. Inverse time-current element for low-level overloads.
    b. Instantaneous magnetic trip element for short circuits.
    c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
3. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
4. Subfeed Circuit Breakers: Vertically mounted.
5. MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Breaker handle indicates tripped status.
    c. UL listed for reverse connection without restrictive line or load ratings.
    d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
    e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
    f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
    h. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
    i. Multipole units enclosed in a single housing with a single handle.
    j. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

2.5 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NEMA PB 1.1.

D. Equipment Mounting:
1. Attach panelboard to the vertical finished or structural surface behind the panelboard.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Mount top of trim 90 inches above finished floor unless otherwise indicated.

G. Mount panelboard cabinet plumb and rigid without distortion of box.

H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

I. Mounting panelboards with space behind is recommended for damp, wet, or dirty locations. The steel slotted supports in the following paragraph provide an even mounting surface and the recommended space behind to prevent moisture or dirt collection.

J. Mount surface-mounted panelboards to steel slotted supports 1 1/4 inch in depth. Orient steel slotted supports vertically.

K. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

M. Install filler plates in unused spaces.

N. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

O. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers. Perform optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Instruments and Equipment:

        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

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

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.

3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262713 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes work to accommodate utility company revenue meters.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of meter.
2. For metering infrastructure components.
3. For metering software.

B. Shop Drawings: For electricity-metering equipment.

1. Include elevation views of front panels of control and indicating devices and control stations.
2. Include diagrams for power, signal, and control wiring.
3. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include series-combination rating data for modular meter centers with main disconnect device.

1.4 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Owner shall be notified and issued written permission no fewer than seven days in advance of proposed interruption of electrical service.

1.5 COORDINATION

A. Electrical Service Connections:

1. Coordinate with utility companies and utility-furnished components.

a. Comply with requirements of utility providing electrical power services.
b. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

B. Comply with UL 916.

2.2 UTILITY METERING INFRASTRUCTURE

A. Install metering accessories furnished by the utility company, complying with its requirements.

B. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.

C. Meter Sockets:

1. Comply with requirements of electrical-power utility company.
2. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written instructions. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Wiring Method:

1. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Minimum conduit size shall be 1/2 inch (13 mm).

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Series Combination Warning Label: Self-adhesive labels, with text as required by NFPA 70.

END OF SECTION 262713

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SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. USB charger devices.
3. Twist-locking receptacles.
4. Weather-resistant receptacles.
5. Snap switches.
6. Pendant cord-connector devices.
7. Cord and plug sets.
8. Floor service outlets and poke-through assemblies.

1.3 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

C. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.8 MAINTENANCE MATERIAL SUBMITTALS

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

1. Floor Service-Outlet Assemblies: One for every 10, but no fewer than one.
2. Poke-Through, Fire-Rated Closure Plugs: One for every five floor service outlets installed, but no fewer than two.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
2. Hubbell Incorporated; Wiring Device-Kellems.
3. Leviton Manufacturing Co., Inc.
4. Pass & Seymour/Legrand (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

2.3 USB CHARGER DEVICES

A. Tamper-Resistant, USB Charger Receptacles: 12 V dc, 2.0 A, USB Type A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 1310, and FS W-C-596.

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

    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
3. USB Receptacles: Dual, Type A.
4. Line Voltage Receptacles: Dual, two pole, three wire, and self-grounding.

2.4 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration as indicated on drawings, and UL 498.

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

    a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour/Legrand (Pass & Seymour).

2.5 PENDANT CORD-CONNECTOR DEVICES

A. Description:

1. Matching, locking-type plug and receptacle body connector.
2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
3. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.6 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.

2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 DECORATOR-STYLE DEVICES

A. Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, and UL 498.

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

a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

B. GFCI, Feed-Through Type, Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and UL 943 Class A.

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

a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

C. GFCI, Weather-Resistant Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and UL 943 Class A.

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

a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Pass & Seymour/Legrand (Pass & Seymour).

D. Toggle Switches, Square Face, 120/277 V, 20 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.

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

a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

E. Lighted Toggle Switches, Square Face, 120 V, 20 A: Comply with NEMA WD 1 and UL 20.

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

a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: With neon-lighted handle, illuminated when switch is "off."

F. All branch circuits rated at 15 amperes shall only have receptacles rated at 15 amperes connected to it.

2.8 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.9 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular, solid brass with satin finish.

D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

2.10 POKE-THROUGH ASSEMBLIES

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

1. Hubbell Incorporated; Wiring Device-Kellems.

2. Pass & Seymour/Legrand (Pass & Seymour).
3. Square D; by Schneider Electric.
4. Thomas & Betts Corporation, A Member of the ABB Group.
5. Wiremold / Legrand.

B. Description:

1. Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.
2. Comply with UL 514 scrub water exclusion requirements.
3. Service-Outlet Assembly: Pedestal type with services indicated.
4. Size: Selected to fit nominal 3-inch cored holes in floor and matched to floor thickness.
5. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
6. Closure Plug: Arranged to close unused 3-inch cored openings and reestablish fire rating of floor.
7. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, four-pair cables.

2.11 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:

a. Control circuits.
b. Switchboards.
c. Enclosed controllers.
d. Enclosed switches.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles. Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Coordination charts and tables and related data.
3. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017700 "Closeout Procedures," include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Bussmann; a division of Cooper Industries.
2. Edison; a brand of Cooper Bussmann; a division of Cooper Industries.
3. Littelfuse, Inc.
4. Mersen USA.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.
3. Type J: 600-V, zero- to 600-A rating, 200 kAIC.
4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Service Entrance: Class L, time delay.
2. Feeders: Class RK1, time delay.
3. Motor Branch Circuits: Class RK1, time delay.
4. Power Electronics Circuits: Class J, high speed.
5. Other Branch Circuits: Class J, fast acting.
6. Control Transformer Circuits: Class CC, time delay, control transformer duty.
7. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

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SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Shunt trip switches.
4. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

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

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.8 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

D. Comply with NFPA 70.

1.9 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.10 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

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

1. Eaton Electrical Sector; Eaton Corporation.
2. General Electric Company.
3. Siemens Industry, Inc.
4. Square D; by Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Lugs: Mechanical type, suitable for number, size, and conductor material.
6. Service-Rated Switches: Labeled for use as service equipment.
7. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.2 NONFUSIBLE SWITCHES

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

1. Eaton Electrical Sector; Eaton Corporation.
2. General Electric Company.
3. Siemens Industry, Inc.

4. Square D; by Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.
5. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.3 SHUNT TRIP SWITCHES

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

1. Eaton Electrical Sector; Eaton Corporation.
2. General Electric Company.
3. Siemens Industry, Inc.

B. General Requirements: Comply with UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.

C. Type HD, Heavy-Duty, Four Pole, Single-Throw Fusible Switch: 600-V ac, 100 A; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, with clips or bolt pads to accommodate specified fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Type HD, Heavy-Duty, Four Pole, Single-Throw Nonfusible Switch: 600-V ac, 100 A; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

E. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, pilot, indicating and control devices.

F. Accessories:
1. Oiltight key switch for key-to-test function.
2. Oiltight green ON pilot light.
3. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
4. Form C alarm contacts that change state when switch is tripped.

5. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.4 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 4.
3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in fusible devices.

D. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
    b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION 262816

SECTION 263213.14 - DIESEL ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes packaged engine generators used to supply non-emergency power, with the following features:

1. Diesel engine.
2. Diesel fuel-oil system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Outdoor engine generator enclosure.
7. Vibration isolation devices.
8. Finishes.

B. Related Requirements:
1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.3 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.
4. Include fuel consumption in gallons per hour at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.

6. Include airflow requirements for cooling and combustion air in cubic feet per minute at 0.8 power factor, with air-supply temperature of 95, 80, 70, and 50 deg F. Provide Drawings indicating requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for engine generators and functional relationship between all electrical components.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and manufacturer.

B. Source Quality-Control Reports: Including, but not limited to, the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.

C. Field quality-control reports.

D. Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
b. Operating instructions laminated and mounted adjacent to generator location.
c. Training plan.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.8 QUALITY ASSURANCE

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

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Caterpillar, Inc.; Electric Power Division.
2. Cummins Power Generation.
3. Generac Power Systems, Inc.
4. Kohler Power Systems.

B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. B11 Compliance: Comply with B11.19.

B. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.

C. UL Compliance: Comply with UL 2200.

D. Engine Exhaust Emissions: Comply with EPA Tier 4 requirements and applicable state and local government requirements.

E. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

F. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 104 deg F.
2. Altitude: Sea level to 1000 feet.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

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 use.

C. Power Rating: Industrial.

D. Power Factor: 0.8, lagging.

E. Frequency: 60 Hz.

F. Voltage: 480-V ac.

G. Phase: Three-phase, four wire, wye.

H. Induction Method: Turbocharged.

I. Governor: Adjustable isochronous, with speed sensing.

J. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

K. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

L. Engine Generator Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

    a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

    a. Provide permanent magnet excitation for power source to voltage regulator.

10. Start Time: 10 seconds.

M. Parallel Engine Generators:

1. Automatic reactive output power control and load sharing between engine generators operated in parallel.
2. Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.
3. Protective relays required for equipment and personnel safety.
4. Paralleling suppressors to protect excitation systems.
5. Reverse power protection.
6. Loss of field protection.

2.4 DIESEL ENGINE

A. Fuel: ASTM D975, diesel fuel oil, Grade 2-D S15.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid-mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
4. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.

    a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: 60 seconds.
4. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 to 140 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either

condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.

f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 30.

B. Piping: Fuel-oil piping shall be Schedule 40 black steel, complying with requirements in Section 231113 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

D. Fuel Filtering: Remove water and contaminants larger than 1 micron.

E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:

1. Tank level indicator.
2. Fuel-Tank Capacity: Minimum 133 percent of total fuel required for planned operation plus fuel for periodic maintenance operations between fuel refills.
3. Leak detection in interstitial space.
4. Vandal-resistant fill cap.
5. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.6 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Provide minimum run time control set for 30 minutes with override only by operation of a remote emergency-stop switch.

C. Comply with UL 508A.

D. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.

1. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6.

E. Control and Monitoring Panel:

1. Digital engine generator controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. AC voltmeter, connected to a phase selector switch.
    f. AC ammeter, connected to a phase selector switch.
    g. AC frequency meter.
    h. Generator-voltage adjusting rheostat.

3. Controls and Protective Devices: Controls, shutdown devices, and common alarm indication, including the following:

    a. Cranking control equipment.
    b. Run-Off-Auto switch.
    c. Control switch not in automatic position alarm.
    d. Overcrank alarm.
    e. Overcrank shutdown device.
    f. Low-water temperature alarm.
    g. High engine temperature pre-alarm.
    h. High engine temperature.
    i. High engine temperature shutdown device.
    j. Overspeed alarm.
    k. Overspeed shutdown device.
    l. Low fuel main tank.

        1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for duration required in "Fuel Tank Capacity" Subparagraph in "Diesel Fuel-Oil System" Article.

    m. Coolant low-level alarm.
    n. Coolant low-level shutdown device.
    o. Coolant high-temperature prealarm.
    p. Coolant high-temperature alarm.
    q. Coolant low-temperature alarm.
    r. Coolant high-temperature shutdown device.
    s. Battery high-voltage alarm.
    t. Low cranking voltage alarm.
    u. Battery-charger malfunction alarm.
    v. Battery low-voltage alarm.
    w. Lamp test.
    x. Contacts for local and remote common alarm.

y. Low-starting air pressure alarm.
z. Low-starting hydraulic pressure alarm.
aa. Remote manual stop shutdown device.
bb. Air shutdown damper alarm when used.
cc. Air shutdown damper shutdown device when used.
dd. Generator overcurrent-protective-device not-closed alarm.
ee. Hours of operation.
ff. Engine generator metering, including voltage, current, hertz, kilowatt, kilovolt ampere, and power factor.

F. Engine Generator Metering: Comply with Section 262713 "Electricity Metering."

G. Connection to Datalink:

1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.
2. Provide connections for datalink transmission of indications to remote data terminals via ModBus.

H. Remote Alarm Annunciator: An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Low water-temperature alarm.
3. High engine temperature pre-alarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low fuel main tank alarm.
8. Low coolant level alarm.
9. Low cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Lamp test.
18. Generator overcurrent-protective-device not-closed alarm.

I. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

J. Remote Emergency-Stop Switch: Flush; wall mounted unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.

B. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator output rating.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to, or integrated with, control and monitoring panel.

C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide six-lead alternator.

E. Range: Provide broad range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. Maintain voltage within 15 percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. Maintain frequency within 5 percent and stabilize at rated frequency within 2 seconds.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.9 OUTDOOR ENGINE GENERATOR ENCLOSURE

A. Description: Vandal-resistant, sound-attenuating, weatherproof steel housing; wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

1. Sound Attenuation Level: 2.

B. Hinged Doors: With padlocking provisions.

C. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.

D. Muffler Location: Within enclosure.

E. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Stormproof and drainable louvers prevent entry of rain and snow.

F. Interior Lights with Switch: Factory-wired, vaporproof luminaires within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.
2. DC lighting system for operation when remote source and generator are both unavailable.

G. Convenience Outlets: Factory-wired, GFCI. Arrange for external electrical connection.

2.10 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Standard neoprene separated by steel shims.

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch-thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment-mounting and -leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum Deflection: 1 inch.

C. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connector materials for steel piping.

D. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

E. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.11 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.12 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.

2. Test generator, exciter, and voltage regulator as a unit.
3. Full load run.
4. Maximum power.
5. Voltage regulation.
6. Transient and steady-state governing.
7. Single-step load pickup.
8. Safety shutdown.
9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
10. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

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

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. Install packaged engine generator with elastomeric isolator pads or restrained spring isolators having a minimum deflection of 1 inch on 4-inch-high concrete base. Secure enclosure to anchor bolts installed in concrete bases.

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
2. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
3. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."
4. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches of clearance from combustibles.

F. Drain Piping: Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
2. Drain piping valves, connectors, and installation requirements are specified in Section 232116 "Hydronic Piping Specialties."

G. Fuel Piping:

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."
2. Copper and galvanized steel shall not be used in the fuel-oil piping system.

H. Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.

C. Connect engine exhaust pipe to engine with flexible connector.

D. Connect fuel piping to engines with a gate valve and union and flexible connector.

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

G. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.4 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator system is a separately derived system and contains a neutral to ground bond.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.

    a. Visual and Mechanical Inspection:

        1) Compare equipment nameplate data with Drawings and the Specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify that the unit is clean.

    b. Electrical and Mechanical Tests:

        1) Perform insulation-resistance tests according to IEEE 43.

            a) Machines Larger Than 200 hp Test duration shall be 10 minutes. Calculate polarization index.
            b) Machines 200 hp or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.

        2) Test protective relay devices.
        3) Verify phase rotation, phasing, and synchronized operation as required by the application.
        4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
        5) Perform vibration test for each main bearing cap.
        6) Verify correct functioning of the governor and regulator.

2. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

    a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.

b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
c. Verify acceptance of charge for each element of the battery after discharge.
d. Verify that measurements are within manufacturer's specifications.

3. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
4. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
5. Exhaust Emissions Test: Comply with applicable government test criteria.
6. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
7. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
8. Noise Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

K. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels so terminations and connections are accessible to portable scanner.
1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

2. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 DEMONSTRATION

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

END OF SECTION 263213.14

SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes automatic transfer switches rated 600 V and less.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Include material lists for each switch specified.
3. Single-Line Diagram: Show connections between transfer switch, power sources, and load.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer-authorized service representative.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Features and operating sequences, both automatic and manual.

b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. Comply with NEMA ICS 1.

C. Comply with NFPA 110.

D. Comply with UL 1008 unless requirements of these Specifications are stricter.

E. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

F. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
1. Short-time withstand capability for three cycles.

G. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

H. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

I. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

J. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

K. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

L. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

M. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed shrinkable sleeve markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via rear and front access.

N. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated. Switches to be installed within main switchboard.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

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

1. Eaton.
2. Emerson.
3. GE Zenith Controls.
4. General Electric Company.
5. Hubbell Power Systems, Inc.
6. Russelectric, Inc.

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: Hard-drawn copper, 98 percent conductivity.
6. Main and Neutral Lugs: Mechanical type.
7. Ground Lugs and Bus-Configured Terminators: Mechanical type.
8. Ground bar.

9. Connectors shall be marked for conductor size and type according to UL 1008.

D. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

E. Electric Nonautomatic Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

F. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

G. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal and Alternate Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum. (One for permanent generator and one for temp roll up generator).
11. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency systems. Include results of test for the following conditions:

    a. Overvoltage.
    b. Undervoltage.
    c. Loss of supply voltage.
    d. Reduction of supply voltage.
    e. Alternative supply voltage or frequency is at minimum acceptable values.
    f. Temperature rise.
    g. Dielectric voltage-withstand; before and after short-circuit test.
    h. Overload.
    i. Contact opening.
    j. Endurance.
    k. Short circuit.
    l. Short-time current capability.
    m. Receptacle withstand capability.
    n. Insulating base and supports damage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.

1. Install transfer switches on cast-in-place concrete equipment base(s).
2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

3. Provide workspace and clearances required by NFPA 70.

B. Identify components according to Section 260553 "Identification for Electrical Systems."

C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

D. Comply with NECA 1.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

E. Route and brace conductors according to manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.

F. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches in length.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

1. After installing equipment, test for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:

a. Compare equipment nameplate data with Drawings and Specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and required clearances.
d. Verify that the unit is clean.
e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

f. Verify that manual transfer warnings are attached and visible.
g. Verify tightness of all control connections.
h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:

    1) Use of low-resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.

i. Perform manual transfer operation.
j. Verify positive mechanical interlocking between normal and alternate sources.
k. Perform visual and mechanical inspection of surge arresters.
l. Inspect control power transformers.

    1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
    2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
    3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

3. Electrical Tests:

    a. Perform insulation-resistance tests on all control wiring with respect to ground.
    b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
    c. Verify settings and operation of control devices.
    d. Calibrate and set all relays and timers.
    e. Verify phase rotation, phasing, and synchronized operation.
    f. Perform automatic transfer tests.
    g. Verify correct operation and timing of the following functions:

        1) Normal source voltage-sensing and frequency-sensing relays.
        2) Engine start sequence.
        3) Time delay on transfer.
        4) Alternative source voltage-sensing and frequency-sensing relays.
        5) Automatic transfer operation.
        6) Interlocks and limit switch function.
        7) Time delay and retransfer on normal power restoration.
        8) Engine cool-down and shutdown feature.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

    a. Check for electrical continuity of circuits and for short circuits.
    b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    c. Verify that manual transfer warnings are properly placed.
    d. Perform manual transfer operation.

5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.

    a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
    b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    c. Verify time-delay settings.
    d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    e. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
    f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

    a. Verify grounding connections and locations and ratings of sensors.

B. Coordinate tests with tests of generator and run them concurrently.

C. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

D. Transfer switches will be considered defective if they do not pass tests and inspections.

E. Remove and replace malfunctioning units and retest as specified above.

F. Prepare test and inspection reports.

G. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

END OF SECTION 263600

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SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes lightning protection system for ordinary structures.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Include roof attachment details, coordinated with roof installation.
5. Calculations required by NFPA 780 for bonding of metal bodies.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For lightning protection system to include in maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 017839 "Project Record Documents."
b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

B. Completion Certificate:

1. UL Master Label Certificate.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: UL-listed installer, category OWAY.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Advanced Lightning Technology, LTD.
2. East Coast Lightning Equipment Inc.
3. ERICO International Corporation.
4. Harger Lightning & Grounding.

2.2 PERFORMANCE REQUIREMENTS

A. UL Lightning Protection Standard: Comply with UL 96A requirements for Class I buildings.

B. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.3 MATERIALS

A. Air Terminals:

1. Aluminum unless otherwise indicated.

B. Air Terminal Bracing:

1. Aluminum.
2. 1/4-inch diameter rod.

C. Class 1 Main Conductors:

1. Aluminum: 98,600 circular mils in diameter.

D. Secondary Conductors:

1. Aluminum: 41,400 circular mils in diameter.

E. Ground Loop Conductor: Tinned copper**.**

F. Ground Rods:

1. Material: Copper-clad steel.
2. Diameter: 3/4 inch.
3. Rods shall be not less than 120 inches long.

G. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to UL 96A.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for concealed installations in UL 96A.

1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
2. Install conduit where necessary to comply with conductor concealment requirements.
3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: exothermic weld or high compression crimp.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Perform inspections as required to obtain a UL Master Label for system.

B. Prepare test and inspection reports and certificates.

END OF SECTION 264113

SECTION 264313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes:

1. Type 2 surge protective devices.
2. Enclosures.
3. Conductors and cables.

B. Related Requirements:

1. Section 262413 "Switchboards" for integral SPDs installed by switchboard manufacturer.

1.3 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: air of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. NRTL: Nationally recognized testing laboratory.

F. OCPD: Overcurrent protective device.

G. SCCR: Short-circuit current rating.

H. SPD: Surge protective device.

I. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.

J. Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.

K. Type 3 SPDs: Point of utilization SPDs.

L. Type 4 SPDs: Component SPDs, including discrete components, as well as assemblies.

M. Type 5 SPDs: Discrete component surge suppressors, such as MOVs that may be mounted on a printed wiring board, connected by its leads or provided within an enclosure with mounting means and wiring terminations.

N. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include electrical characteristics, specialties, and accessories for SPDs.
2. NRTL certification of compliance with UL 1449.

a. Tested values for VPRs.
b. Inominal ratings.
c. MCOV, type designations.
d. OCPD requirements.
e. Manufacturer's model number.
f. System voltage.
g. Modes of protection.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace SPDs that fail in materials or workmanship within five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TYPE 2 SURGE PROTECTIVE DEVICES (SPDs)

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

1. ABB Electrification Products.
2. Advanced Protection Technologies Inc. (APT).
3. Eaton.
4. Leviton Manufacturing Co., Inc.
5. Liebert; a brand of Vertiv.
6. Mersen USA.
7. Schneider Electric USA, Inc.
8. Siemens Industry, Inc., Energy Management Division.

B. Source Limitations: Obtain devices from single source from single manufacturer.

C. Standards:

1. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2.
2. Comply with UL 1283.

D. Product Options:

1. Include LED indicator lights for power and protection status.
2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include NEMA ICS 5, dry Form C contacts rated at 2 A and 24 V ac for remote monitoring of protection status.
4. Include surge counter.

E. Performance Criteria:

1. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
2. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 150 Insert value kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
3. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits must not exceed the following:

    a. Line to Neutral: 1200 V for 480Y/277 V.
    b. Line to Ground: 1200 V for 480Y/277 V.
    c. Neutral to Ground: 1200 V for 480Y/277 V.
    d. Line to Line: 2000 V for 480Y/277 V.

4. Protection modes and UL 1449 VPR for grounded wye circuits with 208Y/120 V, three-phase, four-wire circuits must not exceed the following:

    a. Line to Neutral: 700 V for 208Y/120 V.
    b. Line to Ground: 700 V for 208Y/120 V.
    c. Neutral to Ground: 700 V for 208Y/120 V.
    d. Line to Line: 1200 V for 208Y/120 V.

5. SCCR: Equal or exceed 100 kA.

6. Inominal Rating: 20 kA.

2.2 TYPE 3, TYPE 4, AND TYPE 5 SURGE PROTECTIVE DEVICES (SPDs)

A. Type 3, Type 4, and Type 5 SPDs are not approved for field installation.

2.3 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.

B. Outdoor Enclosures: NEMA 250, Type 3R.

2.4 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's written instructions.

C. Install leads between disconnects and SPDs short, straight, twisted, and in accordance with manufacturer's written instructions. Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
2. Do not exceed manufacturer's recommended lead length.
3. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Compare equipment nameplate data for compliance with Drawings and the Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. SPDs that do not pass tests and inspections will be considered defective.

C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Complete startup checks in accordance with manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests; reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 264313

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SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Interior solid-state luminaires that use LED technology.
2. Lighting fixture supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.

5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project.

    a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

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

B. Product Certificates: For each type of luminaire.

C. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

D. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.9 DELIVERY, STORAGE, AND HANDLING

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

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. Recessed Fixtures: Comply with NEMA LE 4.

D. Bulb shape complying with ANSI C79.1.

E. Lamp base complying with ANSI C81.61 or IEC 60061-1.

F. Rated lamp life of 35,000 hours.

G. Lamps dimmable from 100 percent to 0 percent of maximum light output.

H. Internal driver.

I. Nominal Operating Voltage: As indicated on Plans.

1. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

J. Housings:

1. Extruded-aluminum housing and heat sink.
2. powder-coat finish.

2.2 DOWNLIGHT

A. See Plans for manufacturers.

B. Minimum 1,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Universal mounting bracket.

D. Integral junction box with conduit fittings.

2.3 LINEAR INDUSTRIAL

A. See Plans for manufacturers.

B. Minimum 5,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Housing and heat sink rated to the following:
   1. NEMA 4X.
   2. IP 54.
   3. IP 66.
   4. Marine and wet locations.
   5. CSA C22.2 No 137.

2.4 RECESSED LINEAR

A. See Plans for manufacturers.

B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

C. Integral junction box with conduit fittings.

2.5 STRIP LIGHT

A. See Plans for manufacturers.

B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Integral junction box with conduit fittings.

2.6 SURFACE MOUNT, LINEAR

A. See Plans for manufacturers.

B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Integral junction box with conduit fittings.

2.7 SURFACE MOUNT, NONLINEAR

A. See Plans for manufacturers.

B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Integral junction box with conduit fittings.

2.8 SUSPENDED, LINEAR

A. See Plans for manufacturers.

B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

2.9 SUSPENDED, NONLINEAR

A. See Plans for manufacturers.

B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

C. Integral junction box with conduit fittings.

2.10 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. prismatic acrylic
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. powder-coat finish.

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

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI for all luminaires.

2.11 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.12 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount with two 5/32-inch-diameter aircraft cable supports adjustable to 120 inches in length.
2. Ceiling mount with pendant mount with 5/32-inch-diameter aircraft cable supports adjustable to 120 inches in length.
3. Ceiling mount with hook mount.

H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.

2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

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

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

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

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265119

SECTION 265219 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Emergency lighting units.
2. Exit signs.
3. Luminaire supports.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.

1. Include data on features, accessories, and finishes.
2. Include physical description of the unit and dimensions.
3. Battery and charger for light units.
4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.
   a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.

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

C. Product Schedule:

1. For emergency lighting units. Use same designations indicated on Drawings.
2. For exit signs. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of luminaire.

B. Product Test Reports: For each luminaire for tests performed by manufacturer and witnessed by a qualified testing agency.

C. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Luminaire-mounted, emergency battery pack: One for every 20 emergency lighting units. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

1.9 DELIVERY, STORAGE, AND HANDLING

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

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Power Unit Batteries: 5 years from date of Substantial Completion. Full warranty shall apply for the entire warranty period.
2. Warranty Period for Emergency Fluorescent Ballast and Self-Powered Exit Sign Batteries: Seven years from date of Substantial Completion. Full warranty shall apply for the entire warranty period.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

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

B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

D. Comply with NEMA LE 4 for recessed luminaires.

E. Comply with UL 1598 for fluorescent luminaires.

F. Lamp Base: Comply with ANSI C81.61 or IEC 60061-1.

G. Bulb Shape: Complying with ANSI C79.1.

H. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast.

1. Emergency Connection: Operate one lamp(s) continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.

2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
    b. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
    c. Humidity: More than 95 percent (condensing).
    d. Altitude: Exceeding 3300 feet.

4. Nightlight Connection: Operate lamp continuously at 40 percent of rated light output.
5. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.

    a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

6. Battery: Sealed, maintenance-free, nickel-cadmium type.
7. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
8. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

2.2 EMERGENCY LIGHTING

A. General Requirements for Emergency Lighting Units: Self-contained units.

B. Emergency Luminaires:

1. See Plans for manufacturers.

2. Emergency Luminaires: as indicated on Interior Lighting Fixture Schedule, with the following additional features:

    a. Operating at nominal voltage of 120 V ac or 277 V ac.
    b. Internal emergency power unit.
    c. Rated for installation in damp locations, and for sealed and gasketed luminaires in wet locations.

C. Emergency Lighting Unit:

1. See Plans for manufacturers.

2. Emergency Lighting Unit: as indicated on Interior Lighting Fixture Schedule.
3. Operating at nominal voltage of 120 V ac or 277 V ac.
4. Wall with universal junction box adaptor.
5. UV stable thermoplastic housing, rated for damp locations.
6. Two LED lamp heads.
7. Internal emergency power unit.

D. Remote Emergency Lighting Units:

1. See Plans for manufacturers.

2. Emergency Lighting Unit: as indicated on Interior Lighting Fixture Schedule.
3. Operating at nominal voltage of 120 V ac or 277 V ac.
4. Wall with universal junction box adaptor.
5. UV stable thermoplastic housing, rated for damp locations.
6. LED lamp heads.
7. External emergency power unit.

2.3 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. See Plans for manufacturers.
2. Operating at nominal voltage of 120 V ac or 277 V ac.
3. Lamps for AC Operation: Fluorescent, two for each luminaire; 20,000 hours of rated lamp life.
4. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
5. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.
6. Master/Remote Sign Configurations:

a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply and battery for power connection to remote unit.
b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

2.4 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.

3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. Prismatic acrylic.
2. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing and heat sink.
2. powder coat finish.

E. Conduit: Electrical metallic tubing or Flexible metallic conduit, minimum 3/4 inch in diameter.

2.5 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

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

3.2 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire and emergency power unit weight.
2. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.3 IDENTIFICATION

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

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service:

1. Charge emergency power units and batteries minimum of one hour and depress switch to conduct short-duration test.
2. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.

a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

2. Conduct short-duration tests on all emergency lighting.

END OF SECTION 265219

SECTION 265619 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Luminaire supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaire.
4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.

5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.

    a. Manufacturer's Certified Data: Photometric data certified by manufacturer?s laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.

6. Wiring diagrams for power, control, and signal wiring.
7. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. LEED Submittals:
1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

D. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of the following:

1. Luminaire.

B. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

C. Source quality-control reports.

D. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 100of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

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

1.9 DELIVERY, STORAGE, AND HANDLING

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

1.10 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.

B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Structural failures, including luminaire support components.
    b. Faulty operation of luminaires and accessories.
    c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

2.2 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. UL Compliance: Comply with UL 1598 and listed for wet location.

D. Lamp base complying with ANSI C81.61 or IEC 60061-1.

E. Bulb shape complying with ANSI C79.1.

F. CRI of minimum 70. CCT of 4000 K.

G. L70 lamp life of 50,000 hours.

H. Lamps dimmable from 100 percent to 0 percent of maximum light output.

I. Internal driver.

J. Nominal Operating Voltage: 277 V ac.

K. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

L. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

A. Area and Site:

1. See Plans for manufacturers.
2. Luminaire Shape: Square.
3. Mounting: Building.
4. Luminaire-Mounting Height: As indicated on architectural plans.
5. Distribution: Type IV.
6. Diffusers and Globes: Prismatic acrylic.
7. Housings:

a. Extruded-aluminum housing and heat sink.
b. powder-coat finish.

2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

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

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

G. Housings:

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

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

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage and coating.
c. CCT and CRI for all luminaires.

2.5 FINISHES

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

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

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

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

a. Color: As indicated on plans.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls for suitable conditions where luminaires will be installed.

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

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Install lamps in each luminaire.

C. Fasten luminaire to structural support.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.

F. Wiring Method: Install cables in raceways. Conceal raceways and cables.

G. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

H. Coordinate layout and installation of luminaires with other construction.

I. Adjust luminaires that require field adjustment or aiming.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 BOLLARD LUMINAIRE INSTALLATION:

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 IDENTIFICATION

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

3.7 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

a. IES LM-5.
b. IES LM-50.
c. IES LM-52.
d. IES LM-64.
e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION

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

3.9 ADJUSTING

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

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265619

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SECTION 280513 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. 50/125-micrometer, multimode optical-fiber cabling.
2. Fire alarm wire and cable.
3. Identification products.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. IDC: Insulation displacement connector.

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

D. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

E. RCDD: Registered Communications Distribution Designer.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordinate layout and installation of electronic safety and security cabling with Owner's telecommunications and LAN equipment and service suppliers.

B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Installation data for optical-fiber cables as specified in TIA 569-C-1.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics, including the following:

    a. Cross-connects.
    b. Patch panels.
    c. Patch cords.

5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical-fiber cable to determine the continuity of the strand, end to end. Use optical-fiber flashlight or optical loss test set.
2. Test optical-fiber cable on reels. Use an optical time domain reflectometer to verify the cable length, and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

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.

2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels in Section 061000 "Rough Carpentry."

2.3 OPTICAL-FIBER CABLE

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

1. AMP NETCONNECT; a TE Connectivity Ltd. company.
2. Belden Inc.
3. Berk-Tek Leviton; a Nexans/Leviton alliance.
4. CommScope, Inc.
5. Corning Cable Systems.
6. Draka Cableteq USA; a Prysmian Group company.
7. General Cable Technologies Corporation.
8. Mohawk; a division of Belden Networking, Inc.
9. Superior Essex Inc.
10. West Penn Wire.

B. Description: Multimode, 50/125-micrometer, 24-fiber, nonconductive, tight buffer, optical-fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAB for detailed specifications.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

    a. General Purpose, Nonconductive: Type OFN or Type OFNG, or Type OFNR, Type OFNP.
    b. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
    c. Riser Rated, Nonconductive: Type OFNR or Type OFNP, complying with UL 1666.

5. Conductive cable shall be aluminum armored type.
6. Maximum Attenuation: 3.50 db/km at 850 nm; 1.5 db/km at 1300 nm.
7. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

C. Jacket:

1. Jacket Color: Aqua for 50/125-micrometer cable.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.4 OPTICAL-FIBER CABLE HARDWARE

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

1. 3M.
2. ADC.
3. American Technology Systems Industries, Inc.
4. AMP NETCONNECT; a TE Connectivity Ltd. company.
5. Belden Inc.
6. Berk-Tek Leviton; a Nexans/Leviton alliance.
7. Corning Cable Systems.
8. Hubbell Incorporated.
9. Leviton Manufacturing Co., Inc.
10. Molex Premise Networks.
11. West Penn Wire.

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.

D. Cable Connecting Hardware: Comply with the Fiber Optic Connector Intermateability Standard (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA-604-12. Comply with TIA-568-C.3.

1. Quick-connect, simplex and duplex, Type SC, Type ST, Type LC or Type MT-RJ connectors. Insertion loss not more than 0.75 db.
2. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.5 FIRE ALARM WIRE AND CABLE

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

1. Allied Wire & Cable Inc.
2. CommScope, Inc.
3. Comtran Corporation.
4. Draka Cableteq USA; a Prysmian Group company.
5. Genesis Cable Products; Honeywell International, Inc.
6. Rockbestos-Suprenant Cable Corp.
7. Superior Essex Inc.
8. West Penn Wire.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, not less than 16 AWG.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire alarm and cable tray installation, plenum rated.

2.6 IDENTIFICATION PRODUCTS

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

1. Brady Corporation.
2. HellermannTyton.
3. Kroy LLC.
4. Panduit Corp.

B. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Comply with requirements in Section 260553 "Identification for Electrical Systems."

2.7 SOURCE QUALITY CONTROL

A. Factory test optical-fiber cables on reels according to TIA-568-C.1.

B. Factory test multimode optical fiber cables according to TIA-526.14-B and TIA-568-C.3.

C. Cable will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for installation of supports for cables.

3.2 WIRING METHOD

A. Install wiring in metal pathways and wireways.

1. Minimum conduit size shall be 3/4 inch. Control and data-transmission wiring shall not share conduits with other building wiring systems.

B. Install cable, concealed in accessible ceilings, walls, and floors when possible.

C. Wiring on Racks and within Enclosures:

1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM's "Cabling Termination Practices" chapter. Cable ties shall not be excessively tightened such that the transmission characteristics of the cable are altered.
2. Install lacing bars and distribution spools.
3. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer.
4. Install conductors parallel with or at right angles to sides and back of enclosure.
5. Connect conductors associated with intrusion system that are terminated, spliced, or interrupted in any enclosure onto terminal blocks.
6. Mark each terminal according to system's wiring diagrams.
7. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1 and NFPA 70.

B. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.

C. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.

D. Install UTP, optical-fiber, and coaxial cables and connecting materials after spaces are complete and dry, and HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

E. General Requirements for Cabling:

1. Comply with TIA-568-C.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels. Leave a minimum of 6 inches of slack at outlet terminations and coil loosely into box after termination on outlet fitting.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Maintain minimum cable bending radius during installation and termination of cables.

6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions. Do not exceed manufacturer's rated cable-pulling tension.
9. Riser Cable: Riser cable support intervals shall be in accordance with manufacturer's recommendations.
10. Comply with Section 280544 "Sleeves and Sleeve Seals for Electronic Safety and Security Pathways and Cabling."

F. Optical-Fiber Cable Installation:

1. Comply with TIA-568-C.3.
2. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.

G. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart. Cable supports shall be fastened to structural members or floor slabs in accordance with Section 260529 "Hangers and Supports for Electrical Systems."
3. Cable shall not be run in contact with pipes, ducts, or other potentially damaging items. Cables shall not be run through structural members or use structural members, pipes, ducts, or equipment as a support.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-C recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communication cables or cables in nonmetallic pathways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communication cables in grounded metallic pathways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between cables in grounded metallic pathways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or hp and Larger: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 FIRE ALARM WIRING INSTALLATION

A. Comply with NECA 1 and NFPA 72.

B. Wiring Method:

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Cables and pathways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
3. Fire-Rated Cables: Use of two-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is permitted.
4. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or pathway as signaling line circuits.

C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

E. Color Coding: Color code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm circuit wiring and another for supervisory circuits. Color code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

F. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.

G. Wiring to Remote Alarm Transmitting Device: 1-inch conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.5 POWER AND CONTROL-CIRCUIT CONDUCTORS

A. 120-V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.

B. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No. 14 AWG.
2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.6 CONNECTIONS

A. Comply with requirements in Section 283111 "Digital, Addressable Fire-Alarm System" for connecting, terminating, and identifying wires and cables.

3.7 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-C, "Firestopping" Annex A.

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.8 GROUNDING

A. For communication wiring, comply with J-STD-607-A and with BICSI TDMM's "Grounding, Bonding, and Electrical Protection" chapter.

B. For low-voltage wiring and cabling, comply with requirements in Section 280526 "Grounding and Bonding for Electronic Safety and Security."

3.9 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.10 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visually inspect UTP and optical-fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations to confirm color coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.

    a. Test instruments shall comply with or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

4. Optical-Fiber Cable Tests:

    a. Test instruments shall comply with or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.
        2) Attenuation test results for links shall be less than 2.0 db. Attenuation test results shall be less than that calculated according to equation in TIA-568-C.1.

C. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 280513

SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Heat detectors.
5. Notification appliances.
6. Magnetic door holders.
7. Remote annunciator.
8. Addressable interface device.
9. Digital alarm communicator transmitter.
10. Network communications.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

E. PC: Personal computer.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Locate detectors according to manufacturer's written recommendations.

12. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; Level III minimum.
    c. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

1.6 Sample Warranty: For special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Record copy of site-specific software.
g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

h. Manufacturer's required maintenance related to system warranty requirements.
i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.8 MAINTENANCE MATERIAL SUBMITTALS

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

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
3. Smoke Detectors, Heat Detectors, and Carbon Monoxide Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
5. Keys and Tools: One extra set for access to locked or tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
8. Provide all necessary hardware and programming to provide the client with 20% spare capacity on all initiating and indicating circuits.
9. Provide as part of the base contract all labor and materials to install fifteen (15) additional fire alarm devices during construction. The fifteen (15) fire alarm device can be but not limited to smoke detector, heat detector, door holder, duct detector, fan shutdown, tamper switches, flow switches, etc. Include all labor and materials including wire, boxes, conduit, terminations, hardware, software, programming and testing.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.10 PROJECT CONDITIONS

A. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Owner's written permission.

B. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.11 SEQUENCING AND SCHEDULING

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

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Noncoded, UL-certified addressable system, with multiplexed signal transmission and horn/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

E. 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.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Automatic sprinkler system water flow.
6. Fire-extinguishing system operation.
7. Dry system pressure flow switch.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances in building fire-alarm signal has originated from. Building 1 elevator lobby, Building 2, Building 3 and Building 4 are treated as one building.
2. Identify alarm and specific initiating device at fire-alarm control unit, connected network control panels, off-premises network control panels, and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
9. Recall elevators to primary or alternate recall floors.
10. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. High or low air pressure switch and low temperature of a dry-pipe or preaction sprinkler system.
3. Carbon monoxide detector.
4. Elevator shunt-trip supervision.
5. Independent fire-detection and –suppression systems.
6. User disabling of zones or individual devices.
7. Loss of communication with any panel on the network.
8. Carbon monoxide monitoring panel, low level and high level alarm.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit, connected network control panels, off-premises network control panels, and remote annunciators.
3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
4. Transmit system status to building management system.

F. Elevator shaft or elevator machine room heat detector signal shall initiate the following actions in addition to the action indicated above:
   1. Activate elevator shunt trip. There shall be a delay in the activation of the power shunt trip. This delay will be the time it takes the elevator to travel from the top of the hoist way to the lowest recall level.

G. Signal from carbon monoxide detector shall initiate the following actions:

   1. Initiate supervisory signal to system and records at the main panel and remote annunciator.
   2. Transmits a (supervisory) carbon monoxide signal to central station.
   3. Continuously operate sounder base associated with the carbon monoxide detector.
   4. Continuously operate carbon monoxide alarm audio/visual notification device in the main office.

2.3 FIRE-ALARM CONTROL UNIT

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

   1. Gamewell - FCI by Honeywell.
   2. GE UTC Fire & Security; A United Technologies Company.
   3. Notifier.
   4. Siemens Industry, Inc.; Fire Safety Division.

B. General Requirements for Fire-Alarm Control Unit:

   1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.

      a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
      b. Include a real-time clock for time annotation of events on the event recorder.
      c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
      d. The FACP shall be listed for connection to a central-station signaling system service.
      e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

   2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
   3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, three line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class B.
2. Pathway Survivability: Level 0.
3. Install no more than 100 addressable devices on each signaling-line circuit.
4. Serial Interfaces:

    a. One dedicated RS 485 port for central-station operation using point ID DACT.
    b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
    c. One USB port for PC configuration.

E. Notification-Appliance Circuit:

1. FIRE ALARM: Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. CARBON MONOXIDE ALARM: Audible appliances shall sound in a four-pulse temporal pattern, as defined in NFPA 72, or a constant tone. Carbon monoxide alarm sound shall be different than the fire alarm sound.
3. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
4. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

F. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:

    a. Elevator lobby detectors except the lobby detector on the designated floor.
    b. Smoke detector in elevator machine room.
    c. Smoke detectors in elevator hoistway.

2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
3. Heat detectors in an elevator shaft and elevator machine room shall shut down elevators associated with the location. There shall be a delay in the activation of the power shunt trip. This delay will be the time it takes the elevator to travel from the top of the hoist way to the lowest recall level.

G. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values.

H. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

I. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals and supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

J. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium.

K. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 MANUAL FIRE-ALARM BOXES

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

1. Gamewell - FCI by Honeywell.
2. GE UTC Fire & Security; A United Technologies Company.
3. Notifier.
4. Siemens Industry, Inc.; Fire Safety Division.
5. System Sensor.
6. Wheelock; a brand of Eaton.

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.

3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

2.5 SYSTEM SMOKE DETECTORS

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

1. Gamewell - FCI by Honeywell.
2. GE UTC Fire & Security; A United Technologies Company.
3. Notifier.
4. Siemens Industry, Inc.; Fire Safety Division.

B. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be two-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

    a. Multiple levels of detection sensitivity for each sensor.
    b. Sensitivity levels based on time of day.

C. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

3. Each sensor shall have multiple levels of detection sensitivity.
4. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

2.6 CARBON MONOXIDE DETECTORS

A. General: Carbon monoxide detector listed for connection to fire-alarm system.

1. Mounting: Adapter plate for outlet box mounting.
2. Testable by introducing test carbon monoxide into the sensing cell.
3. Detector shall provide alarm contacts and trouble contacts.
4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
5. Comply with UL 2075.
6. Locate, mount, and wire according to manufacturer's written instructions.
7. Provide means for addressable connection to fire-alarm system.
8. Test button simulates an alarm condition.
9. Provide with sounder bases for local audio annunciation.

2.7 MULTICRITERIA DETECTORS

A. Mounting: Twist-lock base interchangeable with smoke-detector bases.

B. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Automatically adjusts its sensitivity by means of drift compensation and smoothing algorithms. The detector shall send trouble alarm if it is incapable of compensating for existing conditions.

D. Test button tests all sensors in the detector.

E. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

1. Primary status.
2. Device type.
3. Present sensitivity selected.
4. Sensor range (normal, dirty, etc.).

F. Sensors: The detector shall be comprised of four sensing elements including a smoke sensor, a carbon monoxide sensor, an infrared sensor, and a heat sensor.

1. Smoke sensor shall be photoelectric type as described in "System Smoke Detectors" Article.
2. Carbon monoxide sensor shall be as described in "Carbon Monoxide Detectors" Article.
3. Heat sensor shall be as described in "Heat Detectors" Article.
4. Each sensor shall be separately listed according to requirements for its detector type.

2.8 HEAT DETECTORS

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

1. Gamewell - FCI by Honeywell.
2. GE UTC Fire & Security; A United Technologies Company.
3. Notifier.
4. Siemens Industry, Inc.; Fire Safety Division.

B. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

C. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.9 NOTIFICATION APPLIANCES

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

1. GE UTC Fire & Security; A United Technologies Company.
2. Siemens Industry, Inc.; Fire Safety Division.
3. System Sensor.
4. Wheelock; a brand of Eaton.

B. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

D. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.

1. Rated Light Output:

a. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate:
   a. Fire alarm unit: Factory finished, red with “FIRE” in white letters.
   b. Carbon monoxide unit: Factory finished, blue with “CARBON MONOXIDE” in white letters.

2.10 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.

B. Material and Finish: Match door hardware.

2.11 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.12 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.

2.13 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.

4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.14 NETWORK COMMUNICATIONS

A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.

B. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

1. Connect new equipment to existing control panel in existing part of the building.
2. Connect new equipment to existing monitoring equipment at the supervising station.
3. Expand, modify, and supplement existing control and monitoring equipment as necessary to extend existing control and monitoring functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

E. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
5. HVAC: Locate detectors not closer than 60 inches from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

F. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

I. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

J. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

L. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 PATHWAYS

A. Pathways above recessed ceilings and in nonaccessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches above the floor shall be installed in EMT.

B. Exposed EMT shall be painted red enamel.

3.4 CONNECTIONS

A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Magnetically held-open doors.
3. Electronically locked doors and access gates.
4. Alarm-initiating connection to elevator recall system and components.
5. Supervisory connections at valve supervisory switches.
6. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
7. Supervisory connections at elevator shunt-trip breaker.
8. Data communication circuits for connection to building management system.
9. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.

3.5 IDENTIFICATION

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

B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

3.8 DEMONSTRATION

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

END OF SECTION 283111

SECTION 31 10 00 SITE CLEARING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work of this section shall include but not be limited to the clearing and disposal of:

1. Trees, stumps, shrubbery growth, and other vegetation.

2. Asphalt millings, stones, boulders, construction debris, and other miscellaneous foreign and undesirable materials. Stones and other material within the project area may be reused as fill material in locations designated on the Contract Documents if deemed acceptable by the Engineer.

3. Existing guide rail, debris, trash within project area.

1.2 RELATED SECTIONS

A. Section 31 20 00 – Grading, Excavating and Backfilling

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 CLEARING AND GRUBBING

A. Unless otherwise indicated on Construction Drawings, remove trees, shrubs, grass, other vegetation, improvements, or obstructions interfering with installation of new construction. Removal includes digging out stumps and roots. Depressions caused by clearing and grubbing operations shall be filled to subgrade elevation to avoid ponding of water.

B. Remove grass, trees, plant life, stumps, and other construction debris from site to dump site that is suitable for handling such material according to state laws and regulations.

C. Cut heavy growths of grass from areas before stripping and topsoil removal and remove cuttings with remainder of cleared vegetative material.

D. All existing drainage structures on the site that are to be abandoned shall have the castings removed and shall be filled with flowable fill. All existing drainage pipes to be abandoned shall be filled with flowable fill.

3.2 EXISTING PROPERTY

A. Contractor shall store at a site designated by the Rockland County Highway Department items in reusable condition as determined by the Engineer.

3.3 CLEAN UP

A Remove and legally dispose of construction debris and other items having no value to approved disposal site.

END OF SECTION 31 10 00

SECTION 31 20 00 GRADING, EXCAVATING AND BACKFILLING

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included

1. Under this section, the Contractor shall provide all labor, equipment and materials necessary to do all grading excavation, backfilling and compacting complete in place, and as shown on the drawings and approved by the Engineer.

2. In General, work to be included under this section shall include, but not be limited to the following:

   a. Unclassified excavation

   b. Removal of unsuitable excavation

   c. Rock excavation

   d. Dewatering

   e. Sheeting and bracing

   f. Disposal of excess and unsuitable material

   g. Importing of classified fill material required to construct the structure of the project including buildings, pipelines, roadways, etc.

   h. Placement of fills

   i. Backfilling and compacting

   j. Rough and final grading of the site

B. Related Work Described Elsewhere

1. Erosion and Sediment Control Section 31 25 00

1.2 SUBMITTALS

A. General

1. Submit shop drawings in accordance with 01340 – "Submittals".

B. Design Calculations

1. For excavations more than 5 feet deep that are required to be sheeted and shored, submit working drawings and calculations for the design of the sheeting and shoring. The drawings and calculations shall be certified by an Engineer registered in the State of New York.

C. Borrow Material

1. Thirty (30) pound samples in airtight containers or gradation and certification of aggregate material for each material source to be used as fill shall be submitted to the Construction Manager /or Engineer ten (10) working days prior to commencing filling operations. This material shall not be used as a fill until approved by the Owner and/or Engineer.

2. Submit name of each material supplier and specify type and source of material. For sources pre-approved by NYSDOT, submit proof of NYSDOT certification.

1.3 QUALITY ASSURANCE

A. Testing:

1. All earthwork operations shall be carried out under the direct control of the Construction Manager and Engineer retained by the Owner at the Owner's expense. The Engineer will have technical personnel on the site during the earthwork operations, who will conduct as many tests as they feel necessary to insure proper control of the moisture, density, compaction and other qualities of Work. The Contractor shall abide by the results of such tests and the recommendations of the Engineer in the full conduct of the Work and in the correction of conditions which are unsatisfactory and not in accordance with the Drawings and Specifications. Work will not be accepted by the Owner until certified by the Engineer to be in compliance with the Drawings and Specifications.

B. Allowable Tolerances:

1. All subgrade surfaces, prior to fine grading for pavement and building construction, shall be graded to within one-tenth (0.1) foot for building and two-tenths (0.2) foot for pavement of the required subgrade surface elevations.

2. Complete and finish fill slopes to plus or minus 6 inches of the slope line shown.

C. Allowable Codes:

1. New York State Department of Labor – Board of Standards and Appeals, Rule No. 23 of the Industrial Code.

2. Occupational Safety and Health Administration (OSHA) Safety and Health Regulations for Construction.

D. Reference Standards

1. American Association of State Highways and Transportation Officials (ASSHTO):

a. M145 Classification of Soils and Soil-Aggregate Mixture for Highway Construction Purposes

b. T11 Amount of Material Finer than No. 200 Sieve in Aggregate.

c. T27 Sieve Analysis of Fine and Coarse Aggregate.

d. T89 Determining the Liquid Limit of Soils.

e. T90 Determining the Plastic Limit and Plasticity Index of Soils.

f. T92 Determining the Shrinkage Factors of Soils.

g. T180 Moisture-Density Relations of Soils Using a 10-lb Rammer and an 18-inch Drop.

h. T191 Density of Soil In-Place by the Sand-Cone Method.

i. T205 Density of Soil In-Place by the Rubber-Balloon Method.

2. New York State Department of Transportation

a. The New York State Department of Transportation Standard Specifications (NYS-DOT Specifications) for Construction and Materials, Latest Revision,

plus addenda when referred to, shall become part of this specification for materials and construction requirements. The measurement and payment section of the NYS-DOT Specification shall not apply as all work under this Section shall be included in the Contractor's lump sum bid for this Contract. Where the New York State DOT Specifications cite requirements differing from those included or specified elsewhere in these Contract Documents, the more stringent, highest quality requirement shall apply.

1.4 PRODUCT HANDLING

A. Protection

1. Use all means necessary to protect the materials of this Section before, during and after installation and to protect installed work and materials of other trades.

B. Replacement

1. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Owner.

1.5 JOB CONDITIONS

A. Prevent water from accumulating in the excavation.

B. For all excavation deeper than 5 feet and where required for performance of the construction involved, secure the sides of excavations against movement in accordance with the following:

1. Install sheet piling or sheeting held in place by waling and bracing members.

2. Do not excavate below the bottom of sheet piling or sheeting except as necessary to install piling or sheeting.

3. Fill voids behind piling or sheeting immediately with approved material.

4. Comply with all other provisions of specifications that may impose additional or stricter requirements.

5. Dewater excavation as necessary to obtain an excavation free of water.

C. Do not place, spread, roll or compact frozen and thawing fill.

D. The Contractor shall inform the Engineer of all excavation activities at least forty-eight hours in advance.

E. Subsurface Information

1. Subsurface investigations have been performed at the site. The location of each exploration and the information obtained is shown on boring lots and is attached as part of the contract Documents.

2. Permission may be granted to the Bidder upon request, to drill borings or dig test pits for the purpose of verifying conditions at the site. The locations and size of such exploratory holes will be subject to approval by the Owner and the cost of such explorations shall be borne by the Bidder.

3. Bidders shall examine the site as well as all available information and then decide for themselves the character of materials to be encountered. Attention is directed to the fact that subsurface conditions at other than the boring, probe and test pit locations may include different soils, hard or soft strata, obstructions that may be either natural or manmade, or other conditions different from those shown in the borings, probes and test pits. The boring logs make no representations or warranties either as to the presence or absence of such different conditions or as to their nature and extent. The Bid should include the influence of such features, and it shall be deemed to include all consideration for the risks involved.

4. The groundwater levels shown in the borings and test pits were measured during or shortly after drilling. The groundwater may rise during wet weather or fall during dry weather. The Bidder is hereby advised that varying groundwater levels are to be expected and that this may affect any construction operations involving earthwork.

F. Site Conditions not Guaranteed

1. Neither the Construction Manager, Engineer nor the Owner guarantees that materials disclosed by the borings, probes and test pits will actually be encountered. The data is supplied only for general information and is not guaranteed.

2. The subsurface information referred to herein is made available to the Bidders in good faith and so that they may have access to the same information utilized for design and estimating purposes, and is not intended as a substitute for personal investigation, interpretations and judgment of the Bidder.

3. Submission of a Proposal binds the Bidder thereto to accept the actual site conditions and to provide a completed condition at no additional cost to the Owner, except as specifically provided herein

PART 2 - PRODUCTS

2.1 FILL AND BACKFILL MATERIALS

A. If practicable, use materials removed from excavation as fill and backfill and if those materials satisfy requirements specified herein, as determined by the Engineer. Approved onsite materials must meet the proper moisture content.

B. All material excavated shall be classified as "Unclassified Excavation", and this material shall be further classified as "Suitable Material" or "Unsuitable Material" as follows:

1. Unclassified Excavation shall be defined as removal of all material of any nature, including topsoil, rock and earth.

2. Suitable Material shall be defined as material whose composition is satisfactory for use in formation of fill section, subgrade, embankment, etc construction. In general, any mineral (inorganic) soil, blasted or broken rock, free of organic and deleterious materials, and particles with a diameter not greater than six (6) inches, shall be considered Suitable Material.

3. Unsuitable Material shall be defined as any material containing vegetation or organic matter, such as muck, peat, organic silt, topsoil sod, deleterious material, and particles greater than six (6) inches in diameter, which is not satisfactory for use in embankment construction or for support of permanent structures. Materials located below the groundwater table may not be used as fill.

C. Classification of all material excavated will be made by the Engineer whose decision shall be final and binding upon the Contractor.

D. Should the Contractor encounter unusual material he shall immediately notify the Construction Manager and/or Engineer, who will examine the material, classify it and advise the Contractor as to the method of handling. Unauthorized removal of material before it has been classified is performed at the Contractor's risk.

2.2 REPLACEMENT FOR UNSUITABLE MATERIAL:

A. Shall have characteristics of material that will be superimposed on the replacement.

2.3 TRENCH BACKFILL MATERIAL

A. Standard Backfill - Onsite material approved by the Engineer. Should there be a deficiency of proper onsite material for backfilling, the Contractor shall furnish additional proper backfill material, at no additional cost to the Owner.

B. Select Granular Backfill - Soil material which meets the requirements of Section 733-11 of the NYSDOT Specifications.

D. All backfill material shall be free from large stones (6 inches or larger), clods, topsoil, sod, frozen earth, wood or any other objectionable material.

E. Unless otherwise specified, Standard Backfill shall be used.

2.4 BORROW:

A. Obtain borrow materials from sources outside the project site, at the Contractor’s option. Materials shall conform to the requirements for fill and backfill. Fill supplied by the Contractor from an offsite source shall be granular fill, free of organic or other deleterious material with a maximum particle size of 6 inches, with less the 15% passing the No. 200 sieve.

B. This borrow material shall meet with the approval of the Owner and/or Engineer, and shall generally be consistent with onsite material approved for fill areas.

C. The contractor shall be responsible for complying with all NYSDEC SPDES and local erosion control permitting requirements for all offsite borrow-operations.

PART 3 - EXECUTION

3.1 SURFACE PREPARATION

A. Topsoil: Strip existing topsoil from the site where excavation or grading is indicated and stockpile separately from the other excavated material in accordance "New York Guidelines for Urban Erosion and Sediment Control", August 2005. Locate topsoil such that the material can be used readily for the finished grading.

B. Dispose excess or unsuitable topsoil offsite. If suitable topsoil is not available, the Contractor shall supply additional topsoil at no additional cost.

3.2 EXCAVATION

A. Excavate in a manner which will preserve material below the outside indicated lines of excavation. If solid rock, loose rock, or hardpan, or combinations thereof, exist at subgrade elevation, excavate not less than 12 inches into that rock or hard pan, or both, across the width and length of that excavation. Remove unsuitable subgrade material to depth required by the Engineer. Allow adequate working space to install forms and ensure safety of personnel. Place excavated material at distance from edge not less than one-half the final depth of excavation. Excavation for the convenience of Contractor shall conform to limits set by the Engineer.

B. It is recommended that the Contractor follow the following procedure for excavation and preparation of the building subgrade:

1. Excavate to 1.5 feet above subgrade elevation. Then excavate the remaining 1.5 feet by reaching out with a backhoe.

2. Immediately proof roll, compact and place building subgrade material. As an option, the contract may place ¾ inch clean, crush stone to provide a working mat.

3. Should the subgrade become saturated, compaction, undercutting of unacceptable material and meeting the specification included herein shall be the responsibility of the Contractor.

B. Stability of Excavation: The Contractor shall be responsible at all times for carrying out of all excavation operations in a safer and prudent manner so that the workers, the public, and the adjacent private property will be protected from unreasonable hazard. Details and requirements shall conform to all applicable local, State and/or Federal requirements. Shore and brace where sloping is not possible because of space

restrictions or stability of material excavated. Maintain sides and slopes of excavation in a safe condition until completion of backfilling.

C. Dewatering: Prevent surface water and subsurface or groundwater from flowing into excavations and from flooding work site and surrounding area.

1. Furnish, install and operate any and all additional machinery, appliances, and equipment necessary to keep excavations continuously free from water during construction as deemed necessary. Dispose of water under the terms of all applicable Federal and State permits obtained for this project.

2. Design and operate dewatering systems so as to prevent removal of the natural soils. The dewatering system shall be designed using accepted and professional methods of design and engineering consistent with the best modern practice.

3. Control surface runoff so as to prevent entry or collection of water in excavations or in other isolated areas of the site.

4. Within thirty (30) calendar days after Notice of Award, submit for review and approval by the Engineer drawings and complete design data showing methods and equipment to be utilized in dewatering and in maintaining the excavation in a dewatered and hydrostatically relieved condition.

5. The Contractor shall be responsible for taking all reasonable precautions necessary to ensure continuous and successful operation of the system. This includes adequate marking of all well, pump, and pipeline locations.

6. Maintain on-site sufficient equipment and materials to ensure continuous and successful operation of the dewatering system.

7. Dewatering shall be a continuous operation and interruptions due to outages or any other reason shall not be permitted. The Contractor shall be responsible for all damages to accepted work in the excavation area and for damages to any other area caused by failure to maintain and operate the system. Any damage shall be repaired at no cost to the Owner.

8. All dewatering operations shall discharge to a sediment control facility.

D. Material Storage:

Stockpile suitable excavated materials until required for backfill or fill. Place, grade and shape stockpiles for proper drainage.

1. Locate and retain soil materials away from edge of excavations.

2. Site soils may be rendered unusable due to excess exposure to rain. Protect all material stockpiles from adverse weather.

2. Dispose of excess soil material and waste materials in a legal manor.

E. Excavation for Structures:

Conform to elevations and dimensions shown on the drawings within a tolerance of plus or minus 0.10 foot and extending a sufficient distance from footings and foundations to permit placing and removal of concrete form work, other construction, and inspection.

3.3 PREPARATION SUBGRADE

A. Subgrade is the lowest elevation of excavation required to accommodate the indicated construction.

B. Do not place spread, roll, nor compact material which is saturated, devoid of moisture, frozen, or thawing.

C. Adhere to the following for areas on which fill will be placed:

1. Remove vegetation, debris, unsatisfactory or deleterious soil materials and obstructions from ground surface prior to placement of fills. Bench sloped surfaces steeper than 1 vertical to 4 horizontal. Bench width shall be determined by construction equipment. Minimum height of bench is 3 feet.

2. When existing ground surface has a density less than that specified under Article 3.07 Compaction, for the particular area classification, break up the ground surface and compact to required depth as directed by the Engineer.

D. Proof Rolling of Subgrade Surface

1. All subgrade surfaces, including areas requiring removal of existing fill, shall be proof-rolled by means of heavy rollers to locate and permit timely correction of subgrade deficiencies, which will adversely affect the performance of the pavement structure. Equipment capable of providing a minimum weight of ten (10) tons shall be available as required by the Engineer.

2. In cut sections, proof-rolling of the subgrade surface shall be performed to determine the location and extent of areas below subgrade surface that may require subgrade undercutting. Should any portion of the cut subgrade surface fail to provide satisfactory support for the proof-rolling operation, the Owner and/or Engineer may order corrective undercut and backfill performed.

Payment for such corrective work shall be as specified elsewhere herein in the Contract Documents.

3. In embankment sections, proof-rolling of the subgrade surface shall be performed to determine the uniformity of the compaction below the subgrade surface and to locate subgrade deficiencies requiring corrective work. Any deficiencies discovered during proof-rolling operations shall be corrected in a manner satisfactory to the Owner and/or Engineer. After all corrective work has been completed, the surface shall be proof-rolled again. Corrective work shall not be considered complete and acceptable until the embankment shows satisfactory and uniform response to the proof-rolling operations. All Work necessary and required to correct subgrade deficiencies in embankment sections shall be at the Contractor's expense.

E. Removal of Fill Material in Building Areas

1. Existing fill material encountered within building footprint areas shall be removed. The removal of existing fill shall extend from a point 5 feet outside of the footing line downward at 45 degrees to the underlying sand strata or material determined acceptable by the Engineer.

2. The base material shall be proof-rolled and approved by the Engineer.

3. Backfill with acceptable fill material in accordance with the specifications herein.

3.4 EMBANKMENTS AND FILL

A. Fill sections and embankments shall be acceptable material and defined herein and deposited in successive lifts with a loose thickness of each lift not be more than twelve (12) inches before compaction.

B. The size of rock particles within the fill in building areas and in the upper three (3) feet of paved areas shall not exceed six (6) inches. The maximum size of rock particles below the upper three (3) feet in paved areas may be increased to twelve (12) inches provided that the larger rock particles are well choked and blended with the finer soils.

C. Embankments shall be pitched to provide drainage at the close of each day's operations. In no case shall the slope of fill construction exceed a ratio of 2 horizontal to 1 vertical.

3.5 STRUCTURAL BACKFILL

A. Backfill excavations as promptly as work permits but not until completion of the following:

1. Acceptance by the Engineer of construction below finish grade including, where applicable, underdrain installation, damp proofing, waterproofing and perimeter insulation.

2. Removing of trash and debris.

B. Structure Backfill.

1. Backfill concrete structures only if those structures have cured.

2. Place structure backfill in horizontal, parallel layers not thicker than 8 loose inches across full width of cross-section, where practicable. Maintain uniform thickness in each layer with plate tampers, jumping jacks or other equipment approved by the Engineer.

3. Dry excessively wet material, and moisten dry material with potable water to facilitate compaction.

4. Backfill shall not contain stones and rock in excess of 6-inches and shall be placed in a manner which preclude the forming of voids.

3.6 EXCAVATING AND BACKFILLING APPURTENANCES

A. Excavated materials not required for suitable for backfill shall be removed from the project site. Provide sheeting and shoring as necessary for protection of work and safety of personnel. Remove water from excavation by pumping or other approved method.

3.7 TRENCH EXCAVATION AND BACKFILL

A. Preparation of Bottom of Trench- The bottom of the trenches shall be prepared to conform to the grade of the pipe and the bottom of the foundation of structures. The bottom of trenches shall be shaped as shown on the details of the drawings and recessed for pipe bells. Precautions shall be exercised to insure that pipes, when installed, will not rest on rock, masonry or any other materials which would present a nonuniform foundation. Where two or more pipes are to be laid in the same trench, the Contractor will excavate the trench so that all pipes are laid on undisturbed material.

B. Unsuitable Material at Bottom of Trench - When the material at the bottom of a trench is unsuitable, as determined by the Owner /or Engineer, it shall be removed to

such depth as directed, and backfilled with suitable granular material obtained from the project excavation, or from borrow excavation if it is not available within the project. Payment for removal and replacement of this unsuitable material shall in accordance with the Contract provisions.

C. Backfill for pipe and ducts shall be placed evenly and carefully around and over the pipe in six (6) inch maximum layers. Each layer shall be thoroughly and carefully compacted until one (1) foot of cover exists over the pipe. The remainder of the backfill shall then be placed and compacted in maximum one (1) foot layers. Each layer shall be compacted by approved mechanical tamping machines to a density equal to that of adjacent original material, but not less than 92% of the maximum dry density.

D. Backfill areas which settle shall be corrected

3.8 COMPACTION

A. General: Control soil compaction during construction providing minimum percentage of density specified for each area classification.

B. Percentage of Maximum Density Requirements:

1. Compact soil to not less than the following percentages of maximum dry density determined in accordance with AASHTO T180, Method D.

a. Proposed buildings - To a point ten (10) feet outside the exterior footing and sloping downward at a 45 degree angle, and in roadway and parking areas, the soil shall be compacted to a density not less than 95% of the maximum dry density

b. Landscape Areas - Unless otherwise noted, the soil shall be compacted to not less than 90% of the maximum dry density.

a. Structure Backfill: Compact top 8 inches of subgrade and each layer of backfill material at 95 percent of maximum dry density.

C. Maintain the moisture content of fill material as it is being placed within plus or minus 2 percent of the optimum moisture content of the material as determined by the laboratory tests herein specified.

D. Determination of the optimum water content will be made by the Engineer on representative samples of soil proposed by the Contractor for use in compacted fill.

3.9 MAINTENANCE

A. Protection of Graded Areas: Protect newly graded areas from construction traffic and erosion. Keep free of trash and debris and provide temporary drainage as required. Repair and reestablish grades in settled, eroded and rutted areas to specified tolerances.

B. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, and compact to required moisture and density prior to further construction. Remove saturated or softened soil as directed by the Engineer.

1. Make one field density test or subgrade at each component location. In each compacted fill layer, make one field density test at each compaction location.

2. Backfill: Take one field density test at each backfill location as directed.

3.10 DISPOSAL OF EXCESS, UNSUITABLE AND WASTE MATERIALS

A. Remove waste materials, including unsuitable or excess excavated material, excavated stumps, trash and debris, and legally dispose of it off Owner’s property. Provide the Owner with evidence of satisfactory disposal.

END OF SECTION 31 20 00

SECTION 31 25 00 EROSION AND SEDIMENT CONTROL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work of this Section includes all labor, materials, equipment and services necessary to complete the temporary erosion control measures as shown on the Drawings or as ordered by the Engineer during the life of the Contract.

The Contractor shall provide and maintain temporary vegetation of all areas disturbed by construction.

B. Vegetative Measures

1. Topsoil

2. Mulching

C. Temporary Structural Measures

1. Earth Dike

2. Temporary Swale

3. Perimeter Dike/Swale

4. Temporary Storm Drain Diversion

5. Pipe Slope Drain

6. Straw Bale Dike

7. Silt Fence

8. Storm Drain Inlet Protection

9. Sediment Trap

10. Portable Sediment Tank

11. Sediment Basin

12. Stabilized Construction Entrance

13. Construction Road Stabilization

14. Dust Control

15. Sump Pit

1.2 RELATED WORK

A. Grading, Excavation and Backfill	Section 31 20 00
B. Site Drainage	Section 33 40 00
C. Drainage Structures	Section 33 49 13

1.3 QUALITY ASSURANCE

A. The Contractor shall perform all operations in accordance with the rules, regulations and ordinances of those governing bodies having jurisdiction.

B. NYSDEC General Permit GP-0-15-002

1. The project will be subject to the New York State Department of Environmental Conservation (NYSDEC) SPDES General Permit for Stormwater Discharges from Construction Activity, Permit No. GP-0-15-002. The Owner will file a Notice of Intent (NOI) with the NYSDEC in accordance with the General Permit.

2. A Storm Water Pollution Prevention Plan has been prepared in accordance with the SPDES General Permit. The SWPPP is a part of the Contract Documents and the Contractor shall conform to the Chapter on Soil Erosion and Sediment Control in addition to the requirements of this Specification.

3. The Contractor(s) and Subcontractor(s) will be responsible for implementing all sediment control measures during construction. All contractors and subcontractors that will be performing excavations on the site must sign a copy of the certification statement before undertaking any construction or activity at the site. The certification must include the name and title of the person providing the signature; the name, address and telephone number of the contracting firm; the address (or other identifying description) of the site; and the date the certification was made.

Contractor Certification Statement

"I certify under penalty of law that I understand and agree to comply with the terms and conditions of the Storm Water Pollution Prevention Plan (SWPPP) for the construction site identified in such SWPPP as a condition of authorization to discharge stormwater. I also understand that the operator must comply with the terms and conditions of the New York State Pollutant Discharge Elimination System ("SPDES") general permit for stormwater discharges from construction activities and that it is unlawful for any person to cause or contribute to a violation of water quality standards."

4. In the event of conflict between the requirements of these Project Specifications and the pollution control laws, rules or regulations of Federal, State or Local agencies, the more restrictive laws, rules or regulations shall govern.

5. In accordance with the NYSDEC General Permit, the project is limited to a maximum disturbed area of 5.0 acres. The Contractor may alter the construction sequence only with prior approval by the Engineer. Areas covered with gravel, building subbase material or temporary emulsion or stabilization shall considered as stabilized.

6. Temporary stabilization must be maintained at all times. The Contractor is responsible for maintaining records to insure the 5 acre disturbance limit is meet.

7. Providing and maintaining all temporary stabilization to meet the NYSDEC requirements shall be included in the Contract price. The Contractor shall maintain throughout the entire construction contract.

1.4 SUBMITTALS

A. Submit shop drawings in accordance with Section 01340-Submittals.

B. Manufacturers' specifications and other data required to demonstrate compliance with specific requirement of this Section.

1.5 DELIVERY, STORAGE & HANDLING (NOT USED)

1.6 JOB CONDITIONS

A. The Contractor shall provide all necessary safeguards as may be required to prevent damage to property beyond the Work area or adjacent property.

B. Area of Work

1. In accordance with the NYSDEC General Permit, the project is limited to a maximum disturbed area of 5.0 acres. The Contractor may alter the construction sequence only with prior approval by the engineer. Areas covered with gravel, building subbase material or temporary emulsion or stabilization shall considered as stabilized.

2. The Construction Manager or Engineer shall have the authority to increase or decrease the surface area of erodible earth material exposed by clearing and grubbing, and/or excavation and fill operations, and to direct the Contractor to provide immediate permanent or temporary pollution control measures to prevent contamination of adjacent streams or other watercourses, lakes, ponds or other areas of water impoundment.

C. Temporary Erosion Control Measures

1. Temporary erosion control measures shall be used to correct conditions that develop during construction that are needed prior to installation of permanent control features, or that are temporarily needed to control erosion that develops during normal construction practices, but which are not associated with permanent control features on the Project. All slopes and stockpile areas that will remain undisturbed and/or not topsoiled and seeded for a period of fourteen (14) days shall be temporarily seeded as specified on Drawings.

D. Permanent Erosion Control Measures

2. The Contractor shall incorporate all permanent erosion control features into the Project at the earliest practical time as outlined in the Project Schedule.

PART 2 – PRODUCTS

2.1 GENERAL

A. All materials shall be in accordance with the items specified on the Drawings and/or contained in the "New York State Standards and Specifications for Erosion and Sediment Control", November 2016.

2.2 SILT FENCE

A. Fence post shall be at least 36 inches long. Wood posts shall be of hardwood with a minimum cross section area of 4 inches. Steel posts shall be standard "T" of "U" sections and should weigh no less than one (1) pound per linear foot.

B. Additional support shall be provided by a woven wire fence. Woven wire fence shall be at least 14-gauge with 2" x 4" openings. Plastic netting may be used in lieu of woven wire fence. The plastic netting shall be sewn on top of the geotextile filter fabric. Plastic netting shall have the following minimum properties.

Netting Property	Minimum Acceptable Value
Tensile Strength (lbs/ft)	185
Elongation (%)	11

C. The geotextile filter fabric shall have the following minimum material properties.

Geotextile Property	Minimum Acceptable Value	Test Method
Grab Tensile Strength (lbs)	90	ASTM D1682
Elongation at Failure (%)	50	ASTM D1682
Mullen Burst Strength (psi)	190	ASTM D3786
Puncture Strength (lbs)	40	ASTM D751(mod)
Slurry Flow Rate (gal/min/sf)	0.3	
Apparent Opening Size (AOS)	40-80	US Std Sieve CW-02215
Ultraviolet Radiation Stability	90	ASTM G26

2.3 STABILIZED CONSTRUCTION ENTRANCE

A. The geotextile filter fabric shall have the following minimum material properties.

Geotextile Property	Minimum Acceptable Value	Test Method
Grab Tensile Strength (lbs)	200	ASTM D1682
Elongation at Failure (%)	50	ASTM D1682
Mullen Burst Strength (psi)	190	ASTM D3786
Puncture Strength (lbs)	40	ASTM D751(mod)
Apparent Opening Size (AOS)	40-80	US Std Sieve CW-02215

B. Stone size shall be a minimum of two (2) inches conforming to AASHTO M-43, Size no. 1.

2.4 DUST CONTROL

A. Spray adhesives for use on mineral soils shall be as specified in the Table below.

Material	Water Dilution	Type of Nozzle	Apply Gallons/Acre
Acrylic Polymer	7:1	Course Spray	500
Latex Emulsion	12.5:1	Fine Spray	235
Resin in Water	4:1	Fine Spray	300
Polyacrylamide (PAM) Spray on or Dry Spread	Apply according to manufacturer's instructions.		
Acidulated soy bean soap stick	None	Course Spray	1200

B. Tillage- to roughen surface and bring clods to the surface. This is a temporary emergency measure which should be used before soil blowing starts. Begin plowing on windward side of site. Chisel-type plows spaced about 12 inches apart, and spring-toothed harrows are examples of equipment which may produce the desired effect.

C. Sprinkling - site is sprinkled until the surface is wet.

D. Barriers - solid board fences, snow fences, burlap fences, crate walls, bales of hay, and similar material can be used to control air currents and soil blowing.

E. Calcium chloride- shall be in the form of loose, dry granules or flakes fine enough to feed through commonly used spreaders at a rate that will keep surface moist but not cause pollution or plant damage. If used on steeper slopes, then use other practices to prevent washing into streams, or accumulation around plants.

F. Stone – shall be crushed stone or coarse gravel conforming to AASHTO M-43, Size no. 57.

2.5 MULCH

A. Mulch Materials

Material	Quality Standard	Application Rate per 1,000 s.f.	Depth of application
Small Grain Straw	Air dried; free of undesirable seeds and coarse material	90 to 100 lbs.	Cover about 90% of surface
Wood chips or Shavings	Green or air dried; free of objectionable coarse material	500 to 900 lbs	--

Jute Twisted Yarn	Undyed, unbleached plain weave. Warp 78 ends per yd. Weft 41 ends per yd. 60-90 lbs/roll	48" x 50 yards 48" x 75 yards	--
Gravel, crushed stone or slag	Washed: AASHTO M-43, Size no. 2. AASHTO M-43, Size no. 3.	9 cubic yards	Use Size no. 3 where subject to traffic

1. Alternate mulch materials as described in the "New York State Standards and Specifications for Erosion and Sediment Control", November 2016.may be utilized with prior written approval of the Engineer.

B. Mulch Anchoring

1. Mulch anchoring should be accomplished immediately after placement to minimize loss by wind or water. Anchoring may be done by one of the following methods, depending upon the size of the area, steepness of slopes, and costs.

2. Peg and Twine - Drive 8 to 10 inch wooden pegs to within 2 to 3 inches of the soil surface every 4 feet in all directions. Stakes may be driven before or after applying mulch. Secure mulch to soil surface by stretching twine between pegs in a criss-cross and a square pattern. Secure twine around each peg with two or more round turns.

3. Mulch Nettings - Staple the light weight paper, jute, cotton, or plastic nettings to the soil surface. Mulch netting shall be biodegradable.

4. Crimper (mulch anchoring tool) - A tractor-drawn implement, somewhat like a disc-harrow especially designed to push or cut some of the broadcast long fiber mulch 3 to 4 inches into the soil so as to anchor it and leave part standing upright. This technique is limited to areas traversable by a tractor, which must operate on the contour of slopes. Straw mulch rate must be 3 tons per acre. No tackifying or adhesive agent is required.

5. Liquid Mulch-Binders - May be used to anchor salt hay or straw mulches.

   a. Applications should be heavier at edges where wind catches the mulch, in valleys, and at crests or banks. Remainder of area should be uniform in appearance.

   b. Use one of the following:

1) Emulsified asphalt - (SS-l, CSS-l, CMS-2, MS-2, RS-l, RS-2, CRS-l, and CRS-2). Apply 0.04 gallons per sq. yd. or 194 gallons per acre on flat slopes less than 8 feet high. On slopes 8 feet high or more use 0.075 gallons per sq. yd. or 363 gallons per acre.

2) Cutback asphalt - rapid curing (RC-70, RC-250, and RC-800) or medium curing (MC-250 or MC-800). Apply 0.04 gallons per sq. yd. or 194 gallons per acre on flat areas and on slopes less than 8 feet high. On slopes 8 feet or more high, use 0.075 gallons per sq. yd. or 363 gallons per acre.

3) Synthetic or Organic binders - binders such as Curasol, DCA-70, Petro-set and Terra-Tack, or equal, may be used at rates recommended by the manufacturer to anchor mulch materials.

PART 3 - EXECUTION

3.1 INSPECTION

A. The Owner will retain an engineer to conduct on-site inspections every 7 days and within 24 hours of 0.5 inches or greater of rainfall for general compliance with the SWPPP and the General Permit. Inspection reports will be provided to the Owner and Contractor within 24 hours of the field inspection. Any problem areas of areas in need of additional stabilization will require immediate attention and correction by the Contractor.

B Examine the areas and conditions where Erosion Control Measures are to be installed and notify the Construction Manager or Engineer of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected by the Contractor in a manner acceptable to the Construction Manager or Engineer.

3.2 GENERAL REQUIREMENTS

A. The Contractor shall conduct his operations to minimize erosion of soils and to prevent silting and muddying of streams, rivers, irrigation systems, impoundments (lakes, reservoirs, etc.) and lands adjacent to or affected by the Work, in accordance with the approved Sequence of Construction, Drawings and these Project Specifications.

B. Construction of drainage facilities and performance of other Work that will contribute to the control of erosion and sedimentation shall be carried out in conjunction with earthwork operations or as soon thereafter as practical.

C Where erosion is likely to be a problem, clearing and grubbing operations shall be scheduled so that grading operations and permanent erosion control features can follow immediately thereafter, if the Project conditions permit; otherwise, temporary erosion control measures may be required between successive construction stages. The area of bare soil exposed at any one time by construction operations shall be kept to a minimum.

D. Throughout all operations covered by this Section, the Contractor shall provide all necessary measures to control dust through the use of water, calcium chloride or other material in accordance with the approval of the Construction Manager or Engineer, at such locations and during such periods as he may direct, or as may be required by Local Ordinance or Authorities.

3.3 TEMPORARY EROSION CONTROL MEASURES

A. Temporary erosion control measures shall be used to correct conditions that develop during construction that are needed prior to installation of permanent control features, or that are temporarily needed to control erosion that develops during normal construction practices, but which are not associated with permanent control features on the Project.

B. The Contractor shall install all temporary sediment and erosion control measures in accordance with the Details and as described herein.

3.4 DUST CONTROL

A. Throughout all operations covered by this Section of the Project Specifications, the Contractor shall provide all necessary measures to control dust through the use of water, resin-in-water emulsion or other material in accordance with the approval of the Construction Manager or Engineer, at such locations and during such periods as he may direct, or as may be required by Local Ordinance or Authorities.

B. Any disturbed areas that are left exposed more than 14 days, and are not subject to construction traffic, will immediately receive a temporary seeding. If the season prevents the establishment of a temporary cover, the disturbed areas will be mulched with straw or equivalent material.

C. Application of spray-on adhesive (resin-in-water emulsion) shall be applied at a rate of 300 gallons per acre. The resin-in-water emulsion shall be diluted at a ratio of 4:1 and shall be applied with a fine spray nozzle. The treated soil shall not be used for travel.

D. Watering equipment shall consist of pipelines, tanks, tank trucks or other approved devices capable of applying a uniform spread of water over the surface. A suitable device for regulating the flow and positive shut-off of the water shall be provided for

positive control by the operator.

E. The Construction Manager or Engineer will advise the Contractor of any unsatisfactory procedures for dust control. If the unsatisfactory procedures are not corrected promptly, the Construction Manager or Engineer may suspend the performance of any or all construction until the condition has been corrected.

3.5 TEMPORARY SEEDING

A. Fertilizer shall be applied at the rate of 14 lbs. per 1000 square foot or 600 lbs. per acre, using 5-10-10 or equivalent.

B. Annual ryegrass shall be applied at the rate of 30 lbs. per acre, or other select mixture described in the standards.

C. Small grain straw mulch shall be applied at a rate of 90 lbs. per 1000 square foot or 2 tons per acre, to be applied and anchored according to the standards.

D. All slopes and stockpile areas that will remain undisturbed and/or not topsoiled and seeded for a period of fifteen (15) days shall be temporarily seeded as specified on Drawings.

3.6 SEDIMENTS AND POLLUTANTS

A. Water from operations containing sediment shall be treated by filtration, settling basins or other approved means sufficient to reduce the sediment content to no more than that of the stream into which it is discharged.

B. Pollutants such as fuels, lubricants, bitumens, raw sewage and other harmful materials shall not be discharged into or near rivers, streams, and impoundments or into natural or manmade channels leading thereto. Wash water or waste from concrete mixing operations shall not be allowed to enter live streams.

3.7 PERMANENT EROSION CONTROL MEASURES

A. The Contractor shall incorporate permanent erosion control features into the Project at the earliest practical time as outlined in his accepted schedule.

B. No area shall receive permanent seeding prior to approval by the Construction Manager or Engineer.

3.8 CONCRETE WASTE

A. Discharge of excess or waste concrete and/or wash water from Concrete Ready-Mix Trucks will be allowed on the construction site, but only in specifically designated

diked areas that have been prepared to prevent contact between the concrete and/or wash water and storm water that will be discharged from the site or in locations where waste concrete can be placed into forms to make riprap or other useful concrete products. The cured residue from the concrete washout diked areas shall be disposed in accordance with applicable state and federal regulations. The Contractor is responsible for assuring that these procedures are followed.

3.9 TEMPORARY FUEL TANKS

A. Temporary on-site fuel tanks for construction vehicles shall meet all state and federal regulations. Tanks shall have approved spill containment with the capacity required by the applicable regulations. The tank shall be in sound condition free of rust or other damage that might compromise containment. Hoses, valves, fittings, caps, filler nozzles, and associated hardware shall be maintained in proper working condition at all times.

END OF SECTION 31 25 00

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SECTION 32 16 00 PAVEMENTS, WALKWAYS & CURBS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Work Included

1. Under this Section the Contractor shall provide all labor, equipment and material necessary to furnish and install pavement, sidewalks, curbs and markings complete in place, and as shown on the drawings, specified herein and approved by the Engineer.

2. In general, work to be included under this section shall include, but not be limited to, the following:

   a. Asphalt Pavement

   b. Concrete Sidewalk

   c. Concrete Curb

   d. All Pavement Markings

B. Related Work Described Elsewhere

1.	Grading, Excavation and Backfilling	Section 31 20 00
2.	Cast-In-Place Concrete	Section 03 30 00

1.2 QUALITY ASSURANCE

A. Standards

1. All equipment and labor furnished under this Section shall:

   a. Comply with ASTM, AA, NEC, ANSI and all other applicable Federal, State and Municipal codes and regulations including revisions to date of contract.

   b. In all cases where a device or part of the equipment is referred to in this Section in the singular (such as “motor”), it is intended that such references shall apply to as many such devices as are required to complete the installation.

c. Referenced specifications: The New York State Department of Transportation Standard Specifications (NYS-DOT Specifications) for construction and materials, January 1 2019, plus addenda when referred to, shall become a part of this specification for material and construction requirements. A referenced New York State (NYS) Pay Item Number shall serve to describe the required work for this project providing materials and construction conforming to all applicable requirements under the NYS-DOT Specifications for that New York State Item, except for measurement and payment. The measurement and payment section of the NYS-DOT Specification shall not apply as all work under this section shall be included in the Contractor's price bid for this Contract. Where the New York State DOT Specifications site requirements differing from those included in these specifications, the more stringent, highest quality requirement shall apply.

B. Qualifications of Suppliers

1. Products used in the work of this section shall be produced by those who are regularly engaged in the production and/or supply of similar items for at least five (5) years and which have a history of successful production, acceptable to the Engineer.

C. Qualifications of Installers

1. Use adequate number of skilled workmen who are thoroughly trained and experienced in the specified requirements and the methods needed for proper performance of the work of this Section.

1.3 SUBMITTALS

A. General

1. Submit shop drawings in accordance with Section 01340 – "Submittals".

B. Product Data

1. Manufacturer's specification and other data required to demonstrate compliance with specific requirements.

2. Complete shop drawings of all work of this Section, showing dimensions and locations of all items including supporting structures and clearance requirements.

1.4 PRODUCT HANDLING

A. Protection

1. Use all means necessary to protect materials of this Section before, during and after installation and to protect installed work and materials of all other trades.

B. Replacements

1. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Owner.

PART 2 – PRODUCTS

2.1 ASPHALT PAVEMENT

A. All asphalt pavement courses and base material shall be hot mix asphalt pavement conforming to material requirements of Sections 300 and 400 of the NYS-DOT Specifications and in accordance with the typical sections shown on the plans.

2.2 CONCRETE SIDEWALKS AND CURBS

A. All sidewalks and curb to be installed or replaced shall be in conformance with Section 608 and 609 of the NYSDOT Specifications and in accordance with the typical sections shown on the plans.

2.3 PAVEMENT MARKINGS

A. Pavement markings shall be latex pavement marking paint conforming to Federal Specification TT-P-1952D Type II as manufactured by Safety Coatings Inc., of Foley, AL or Ennis Paint, Inc. of Ennis, TX or approved equal.

B. Where reflectorized pavement markings are required, the markings shall be in conformance with the requirements of the Section 640 of the NYSDOT Specifications.

2.4 CONCRETE CURB

A. All concrete curb to be installed or replaced shall be in conformance with Section 609 of the NYSDOT Specifications and as shown on the drawings.

PART 3 – EXECUTION

3.1 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.

B. After the subgrade and/or existing pavement surfaces have been prepared as specified herein, the Contractor shall check all frames, covers, grates, water valve boxes and all other miscellaneous castings that are located in the proposed pavement areas to insure that all such items have been accurately positioned and set to the proper slope and elevation. All covers and grates are to be set flush with the required finished pavement surface. No depressions or mounds will be permitted in the pavement to accommodate inaccuracies in the setting of these appurtenances.

3.2 ASPHALT PAVEMENTS

A. Shall be constructed on approved compacted subgrades in accordance within the in conformance with the lines, grades, thicknesses and typical sections shown on the Drawings and with the requirements of the referenced New York State DOT Specifications, for each Item Number specified. These shall include all requirements for equipment, weather, placement, spreading, tolerances, temperature, protection testing, and all related and incidental construction requirements for each component of the pavement structure.

B. Surface shall be smooth, free of roller marks, trowel marks or depressions and when tested with water shall not contain any irregularities that would impede water flow or ponding including in the area of drainage inlets.

END OF SECTION 32 16 00

SECTION 32 31 11 GATE OPERATORS

PART 1-GENERAL

1.1 SECTION INCLUDES

A. The work in this section shall include furnishing all labor, materials, equipment and appliances necessary to complete a Cantilever Slide Gate required for this project in strict accordance with this specification section and drawings.

1.2 REFERENCES

A. Underwriters Laboratory Gate Operator Requirements (UL 325).

B. ASTM F2200-05 – Standard Specification for Automated Vehicular Gate Construction.

C. ASTM F 1184 Standard Specification for Industrial and Commercial Horizontal Slide Gates, Type II, Class 2.

D. American Welding Society AWS D1.2 Structural Welding Code.

E. ASTM F 1043 Standard Specification for Strength and Protective Coatings on Steel Industrial Chain Like Fence Framework.

F. ASTM 123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel.

1.3 SUBMITTAL

A. Product Data:

1. Provide manufacturer's catalog cuts with printed specifications and installation instructions.

2. Furnish detailed sequence of operation (description of system).

3. Furnish operation and maintenance in accordance with specification section.

B. Shop Drawings:

1. Shop drawings shall be in accordance with section 1340.

2. Include complete details of gate construction, gate height, gate operator, and post spacing dimensions.

C. Certifications:

1. Gate in compliance with ASTM F2200-05, Standard Specification for Automated Vehicular Gate Construction.

D. Operation and Maintenance Manuals

1. Within thirty (30) days after shop drawing approval, and as a condition of its acceptance, deliver to the Engineer the materials compiled in accordance with the provisions of Specification Section 1390.

PART 2 PRODUCTS

2.1 CANTILEVER SLIDE GATE MANUFACTURERS

A. The cantilever sliding gate system shall be manufactured by a professional in the field that has more than five (5) years experience in the manufacturer of gates with automated openers.

B. Gate manufacturer shall certify gate is manufactured in compliance with ASTM F2200-05, Standard Specification for Automated Vehicular Gate Construction.

2.2 GATE DIMENSIONS

A. The gate will have an open clearance of 32 feet.

B. The gate will be consistent in height with the approaching side and not less than 6’ 0” as measured from one inch above the curb to top of fence.

2.3 GATE CONSTRUCTION DETAILS

A. Gate frame

1. The gate frame shall be fabricated from schedule 40 Steel Piping that comply with ATSM F 1083. The Top and Bottom Members will be 2.875 inch outside diameter, 4.64 lb per linear foot.

2. All sections of the gate including counterbalance sections will have a Z cross bracing of steel piping 2 inch outside diameter.

3. Sections of the gate will not be wider than 5’ unless approved by the Engineer.

B. The gate frame shall have a separate semi-enclosed “keyed” track. The track member is to be located on only one side of the top primary.

C. The gate frame is to be supported from the track by two (2) swivel type, self-aligning, 4-wheeled, sealed lubricant, ball-bearing truck assemblies with stainless steel races. Each truck is to be attached to a hot dipped, galvanized steel hanger bracket that in turn is to be attached to a 6.625” O.D. support post. The bottom of each support post is to be equipped with a pair of 3” guide wheels.

D. Diagonal "Z" bracing of 2" minimum diameter galvanized steel tube be installed to brace the gate panels and to provide a ready means of vertical adjustment.

E. The gate shall be completed by installation of approved filler as specified. The gate filler will be chain link as defined.

1. Chain Link The material is be specified as shown on the detail drawing of the fencing and is in accordance with specification section 02445. Gate filler shall extend the entire length of the gate (including the clear opening and counterbalance) and shall be secured at each end of the gate frame by standard fence industry tension bars and tied at each 2" x 2" (51mm x 51mm) vertical member with standard fence industry ties.

2.4 POSTS

A. All posts shall be minimum 6.625 O.D. Schedule 80 round galvanized steel in accordance with ASTM F 1043. All posts shall have a concrete footer that is 24" in diameter and 42" deep.

2.5 FINISH

A. Gate to be black, thermally fused vinyl coated over galvanized steel.

B. All hardware, miscellaneous material accessories shall be black, thermally fused vinyl coated over galvanized to match framework and fence.

C. Gate Posts/steel shapes to be Galvanized in accordance with ASTM A-123, 2,0 oz zinc per square foot and then primes and painted black or thermally fused vinyl coated.

2.6 GATE OPENING EQUIPMENT

A. The Operator will be a minimum of 1HP total power with chain driven operation.

B. The duty cycle will be classified as continuous UL 325 classification of Type 2.

C. It will be 208 Volt supply power. This will be coordinated with the Electrical Contractor at no additional cost to the owner.

D. Rated for a carrying capacity of 1800 pounds.

2.7 GATE OPENING CONTROLS

A. The gate manufacturer shall provide an integrated control system to open and close the gate from both a local and remote position. Key elements of the gate controls shall include the following:

a. Gate Control Panel

b. 10-digit keypad for opening with intercom to the administration building that allows for opening from that remote location approximately 2000 ft away.

c. 2 beam optic sensors for automatic opening for exiting traffic.

B. The control system design will have a soft stop on opening and closing and a reverse on contact mode.

C. Manual release function and manual operate function.

D. Gate Control Panel

a. The gate control panel shall be supplied pre-wired, complete and ready for installation and operation, and shall include all components, controls, etc. necessary the proper and safe operation of the gate.

b. The gate control panel enclosure shall carry a NEMA 4X rating

c. Panel Controls: The gate control panel shall be provided with the following controls as a minimum:

1. Main Circuit Breaker/Disconnect Switch

2. LOCAL-OFF-REMOTE (L-O-R Selector Switch

3. OPEN-CLOSE Selector Switch or Pushbuttons

4. Ready Light (Green)

5. Run Light (Green)

d. Description of Operation

1. With the Gate Control Panel Main Circuit Breaker/Disconnect Switch in the “OFF” position, all electrical power shall be disconnected for the gate operator and control, and the panel door be permitted to open.

2. With the Gate Control Panel Main Circuit Breaker/Disconnect Switch in the ON position, the panel door shall be locked closed and the panel electrical components to be energized causing the panel “READY” light to glow and permitting panel/gate operation as described below

3. Placing the “LOCAL-OFF-REMOTE” (L-O-R) Selector Switch in the “LOCAL” position shall electrically connect the gate operator to the “OPEN-CLOSE” Selector Switch. Placing the L-O-R Switch in the “REMOTE” position shall electrically connect the gate operator to the:

a) Remote Keypad for operation from that device

b) The Gate Open/Close Controls in the Building No. 1

c) Exit Optic Sensor

4. With the L-O-R Selector Switch in the “LOCAL” position, the gate operator shall open or close the gate depending on the position selected on the OPEN-CLOSE” Selector Switch.

5. With the L-O-R Selector Switch in the “REMOTE” position, the gate operator shall:

   a) Open the gate on command from the Keypad Operator once the proper entry code has been entered. The gate shall remain in the open position until the exit point has been cleared for a period of 15 seconds.

   b) Open or close the gate on command from the Gate Open/Close Controls in Building No. 1.

   c) Open the gate when the Exit Optic Sensor senses that a vehicle is present at the exit point. The gate shall remain in the open position until the exit point has been cleared for a period of 15 seconds.

   d) The delay on gate close shall be user adjustable for a minimum span of 5 – 30 seconds.

6. Panel control logic shall be such that the gate shall always complete the direction of travel cycle (gate shall fully open or fully close) when the L-O-R Selector Switch is in the “REMOTE” position.

7. When the gate operator is in operation, the “READY” light shall be de-energized and the “RUN” light shall glow.

2.7 GATE ACCESSORIES

A. The Contractor shall furnish and install one (1) each of the following signs as manufactured by Seton Products Inc. of Branford, CT or approved equal.

1. Sign No. 1

Seton Style Number:	86293
Size:	18” x 18”
Color:	Red/White/Black
Wording:	CAUTION
	GATE WILL ALLOW
	ONLY ONE VEHICLE AT A TIME
	DO NOT TAILGATE
Location:	Gate Exterior

2. Sign No. 2

Seton Style Number:	86294
Size:	18” x 18”
Color:	Red/White/Black
Wording:	CAUTION
	AUTOMATIC
	GATE
	NO
	PLAYING OR CLIMBING
	ON OR AROUND GATE
Location:	Gate Exterior

3. Sign No. 3

Seton Style Number:	17286
Size:	14” x 10”
Color:	Red/White/Black
Wording:	VEHICLES MUST COME TO A COMPLETE STOP BEFORE PROCEEDING
Location:	Gate Interior

PART 3 EXECUTION

3.1 INSTALLATION

Final grades and installation conditions shall be examined. Installation shall not begin until all unsatisfactory conditions are corrected.

A. Equipment in this section shall be installed in strict accordance with the company’s printed instructions unless otherwise shown on the contract drawings.

B. The gate system is to be automated and installation shall also comply with ASTM F2200-05 and UL 325.

C. The system will be set up to be integrated with the site security system. At a minimum the gate will be able to operate with a key pad with a intercom system to the Administration building #1, remotely from the Administration building #1 and manually. In addition there will be an off mode that secures power.

3.2 SYSTEM VALIDATION

A. The complete system shall be adjusted to assure it is performing properly.

B. The system shall be operated for a sufficient period of time to determine that the system is in proper working order.

C. For operated gate systems - test and explain safety features:

1. Each system feature and device is a separate component of the gate

2. Read and follow all instructions for each component.

3. Ensure that all instructions for mechanical components, safety devices and the gate operator are available for everyone who will be using the

gate system.

4. The warning signs shipped with the gate operator must be installed in prominent positions on both sides of the gate.
5. Ensure the owner is clear with regard to the safety points concerning basic operational guidelines of the safety features of the gate operator system. These safety points are listed in the gate operator manual and must be read prior to system use.

3.3 EXTRA EQUIPMENT

A. In addition to the standard additional equipment, provide four (4) 10 feet length of chain with master link connectors.

3.4 SECURE CONTRACT

A. Provide a 2 year parts and labor guarantee service Contract with a response time of 12 hours or less. This Contract should be extendable in yearly increments.

END OF SECTION 32 31 11

SECTION 32 31 13 CHAIN LINK FENCES

PART 1 - GENERAL

1.1 DESCRIPTION

A. The Contractor shall provide all labor, materials, equipment, and services necessary for, and incidental to, the installation of chain link fence, as shown on the Drawings and as specified herein.

B. Fence installed along the NYSDOT/Thruway right-of-way shall conform to the requirements in Section 607 of the NYSDOT Standard Specifications, January 1, 2019 and NYSDOT Standard Sheets group ID 607.

1.2 QUALITY ASSURANCE

A. Comply with standards of the Chain Link Fence Manufacturer's Institute.

B. Provide steel fence gates as a complete system produced by a single manufacturer, including necessary erection accessories, fittings and fastenings.

C. Comply with ASTM F-1083 for requirements of Schedule 40 steel piping.

D. Perimeter Fence height shall be as indicated on drawings measured from the top of concrete wall or top of concrete footing to the top of post. Retention basin fencing shall be 4'-0" high. Other fencing shall be 6'-0" high, unless otherwise noted.

E. Posts and rails shall be continuous without splices.

1.3 SUBMITTALS

A. Shop Drawings will be in accordance with Section 1340 of the contract specifications.

B. Product Data: Manufacturer's catalog cuts, with printed specifications, and installation instructions.

C. Samples: One sq. ft. minimum of fence fabric, and one lock and one each size post tops.

PART 2 - PRODUCTS

2.1 STEEL FRAMEWORK

A. End Posts, Center Posts, Pull Posts and Line Posts:

1. Class B Steel Tubing: 2.875 inches OD, 4.64 lb. per linear ft.

2.2 STEEL FABRIC

A. One-piece widths for fence heights up to 12’-0”.

B. Chain Link, No. 9 gauge, 2 inch mesh.

C. Selvages: Top side knuckled and bottom side knuckled.

2.3 MISCELLANEOUS MATERIALS AND ACCESSORIES

A. Rails and Post Braces:

1. Class B Steel Tubing: 1.660 inches OD, 1.84 lb. per linear ft.

B. Post Tops:

1. Steel, wrought iron, or malleable iron.

C. Stretcher Bars:

1. One piece equal to full height of fabric, minimum cross-section 3/16 inch x 3/4 inch.

D. Metal Bands (for stretcher bars):

1. Steel, wrought iron, or malleable iron, to secure stretcher bars to end, corner, pull and gate posts.

E. Wire Ties:

1. For tying fabric to line posts, rails and braces: 9 gauge steel wire.

2. For tying fabric to tension wire: 11 gauge steel hog rings.

F. Tension Wire:

1. 7 gauge coiled spring steel wire.

G. Base Plate:

1. ASTM A-36.

H. Bolts and Nuts:

1. ASTM A-307, Grade A.

I. Manual Gates:

1. Provide number of gates as shown on drawing.

2. A 2” outside diameter Z cross bracing shall be provided.

3. The gate post will be a 4” outside diameter schedule 40 galvanized steel post with a 24” diameter X 36’ concrete footing.

4. A hasp and lock system will be provided by the contractor. Provide locks that are Master Lock Weather Tough Locks Model 6121 KALJ or equal all keyed the same.

5. Provide two (2) additional locks than the number of gates called for in the plans.

6. Double Swing Gates (as provided in the retention pond areas) will have a central locking mechanism that is anchored in a 1.5’ by 1.5’ X 2’ deep pour concrete block.

2.4 FINISHES

A. Steel Framework:

1. Pipe: Hot-dipped galvanized in accordance with ASTM F-1043, 2.0 oz. zinc per sq. ft.

2. Class “B” Steel Tubing: Exterior; 1.0 oz. zinc per sq. ft. plus a coating of chromate and polyurethane. Interior; zinc rich organic coating.

3. All steel framework shall be galvanized steel.

B. Steel Fabric:

1. Galvanized steel.

C. Fence Hardware, Miscellaneous Materials, Accessories:

1. Wire Ties: Galvanized Finish, ASTM A-90 2.0 oz. zinc per sq. ft.

2. Hardware, Bolts, Nuts and Other Miscellaneous Items: Galvanized Finish, ASTM A-153 (Table 1).

3. Steel Shapes: Galvanized in accordance with ASTM A-123, 2.0 oz zinc per sq. ft.

4. All hardware, miscellaneous materials and accessories shall be galvanized steel to match framework and fence.

D. Tension Wire:

1. Aluminized Finish: ASTM A-585 Class 2, 0.30 per sq. ft.

PART 3 - EXECUTION

3.1 PREPARATION

A. Remove any existing fence if necessary and perform necessary surface preparation including surface leveling or debris/concrete removal as needed for the installation of the chain link fence.

3.2 INSTALLATION

A. Space posts equidistant in the fence line with a maximum of 10 feet on center. All posts shall be set vertically. Cutting of the tops of the posts will be allowed only with the approval of the Engineer.

B. Install concrete for the placement of the anchor rods as shown on the drawings.

C. Locate corner posts at corner and at changes in direction. Use pull posts at all abrupt changes in grade and at intervals no greater than 100 feet. On runs over 100 feet, space pull posts evenly between corner or end posts. On long curves, space pull posts so that the strain of the fence will not bend the line posts.

D. Install top rail continuously through post caps or extension arms, bending to radius for cured runs. Install expansion couplings as recommended by fencing manufacturers.

E. Install intermediate rails in one piece between posts and flush with post on fabric side using special offset fittings where necessary.

F. Diagonally brace corner posts, pull posts, and terminal posts to adjacent line posts with truss rods and turnbuckles.

G. Attach fabric to outside of fence. Maintain a 2 inch clearance above finished grade except when indicated otherwise. Thread stretcher bars through fabric using one bar for each end post and two for each corner and pull post. Pull fabric tight so that the maximum deflection of fabric is 2 inches when a 30 pound pull is exerted perpendicular to the center of a panel. Maintain tension by securing stretcher bars to posts with metal bands spaced 15 inches oc. Fasten fabric to steel framework with wire ties spaced 12 inches oc for line posts and 24 inches o.c. for rails and braces. Bend back wire ends to prevent injury. Tighten stretcher bar bands, wire ties, and other fasteners securely.

H. Position bolts for securing metal bands and hardware so nuts are located opposite the fabric side of fence. Tighten nuts and score excess threads.

1. Secure post tops, extension arms, and caps with one-way cadmium plated steel screws.

I. Tension wire: Support bottom edge of fabric with coil spring tension wire. Weave tension wire through fabric or fasten with hog rings spaced 24 inches oc. Tie tension wire to posts with 9 gauge wire ties.

END OF SECTION 32 31 13

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SECTION 32 39 00 MISCELLANEOUS SITE IMPROVEMENTS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Work included: Under this section, the Contractor shall provide all labor, equipment and material necessary to furnish and install miscellaneous site improvements complete in place, and as shown on the drawings, specified herein and approved by the Engineer. This section includes but is not limited to the following types signs, sign components, bollards, guard rails, and flagpoles, as indicated on the contract drawings.

1) Parking and traffic signs (Reflectorized)

2) Hydrant Out-of-Service signs

3) Corrugated guard rail

4) Flagpole and flag

B. Remove, salvage and relocate existing signs where directed by the Documents, providing re-installations that comply with requirements for new installations. Fabricate and install the Work of this Section, including graphics for signage, in strict conformance with the latest edition of the Manual on Uniform Traffic Control Devices or New York State Department of Transportation design manual whichever is more restrictive.

C. Correlation of Contract Documents

1. Refer to Supplementary Conditions for additional requirements affecting the interpretation of Drawings and Specifications and affecting the Work of this Section.

1.2 QUALITY ASSURANCE

A. Regulatory Requirements

1. Comply with local, state and Federal UFAS and ADA accessibility requirements for mounting heights, reflectivity, and raised lettering (Braille) when required.

B. Installer Qualifications

1. Firm experienced in the installation of sign and flagpoles units of the types indicated and employing the installation methods required for this project, with a record of 5 years of successful installations, and having sufficient staff to install required items without causing delay in the Work.

1.3 SUBMITTALS

A. Submit shop drawings in accordance with Section 01340 – "Submittals"

1. Product data for each type of sign specified, including details of construction relative to materials, dimensions of individual components, profiles, and finishes.

B. Shop drawings showing fabrication, plans, elevations, and large-scale sections of typical members and other components. Show anchors, grounds, layout, reinforcement, accessories, and installation details.

1. Provide message list for each sign required, including details of wording and lettering layout.

2. Provide shop drawings for the flagpole including a foundation design that is approved by a NYS licensed professional engineer.

1.4 RELATED DOCUMENTS

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

2. Referenced specifications: The New York State Department of Transportation Standard Specifications NYS–DOT specifications) for Construction and Materials, January 1, 2019, plus addenda when referred to, shall become part of this specification for materials and construction requirements. A referenced New York State (NYS) Pay Item Number shall serve to describe the required work for this project providing materials and construction conforming to all applicable requirements under the NYS-DOT Specifications for that New York State Item, except for measurement and payment. The measurement and payment section of the NYS-DOT Specification shall not apply as all work under this section shall be included in the Contractor's lump sum bid for this Contract. Where the New York State DOT Specifications cite requirements differing fro those included in these specifications, the more stringent, highest quality requirement shall apply.

1.5 PROJECT CONDITIONS

A. Field Measurements

1. Take field measurements prior to preparation of shop drawings and fabrication to ensure proper fittings. Show recorded measurements on final shop drawings. Coordinate fabrication schedule with construction progress to avoid delay.

PART 2 – PRODUCTS

2.1 TRAFFIC CONTROL SIGNS

A. All material shall be in accordance with Manual of Uniform Traffic Control Devices and New York State Department of Transportation Specification Section 645 Signs

2.2 HYDRANT OUT-OF-SERVICE SIGNS

A. Signs shall be sized to fit the pumper nozzle of the hydrant out-of-service hydrant.

B. Hydrant "out-of-service" signs shall be equivalent to the "Hydra-Sign" as manufactured by Rodan Corp. of St. Charles, Illinois or approved equal.

2.3 CORRUGATED GUIDE RAIL

A. Shall conform to details indicated on the drawings and shall conform to the Requirements of NYSDOT Item 606.16. Guide rails shall be fitted with end sections at appropriate locations. All steel posts plates connector bolt rods and any other materials needed for assembly shall be in accordance with NYSDOT Item 606.16.

2.4 FLAGPOLE AND FLAG

A. Furnish and erect, where shown on the plans new cone tapered aluminum flagpoles, complete with all standard fittings, as listed below, made by American Flagpole, Division of Kearney-National, Inc. or approved equal. Install concrete foundation in accordance with manufacturer's standard details. Flagpole to be ground set, standard type with exposed height above ground as specified in the drawings. Outside butt diameter shall be six inches and outside top diameter 3-1/4 inches.

B. Flagpole shall have wall thickness throughout of not less than .25 in. and shall have uniform conical taper. Pole shall be machine-made of 6063-T6 seamless extruded aluminum. Pole shall have smooth uninterrupted exterior surface without visible joints or offsets. Exterior surface of pole shall have genuine Ultrasheen finish. Pole color shall be polished silver. All exposed parts to match.

C. Before shipment, pole shall be heavily spiral-wrapped with waterproof polyethylene, covered with burlap, wood-stripped, and steel-banded for protection during transit.

D. Painting: Unexposed portion of flagpole below ground shall receive heavy coat of black asphaltum inside and outside before shipment.

E. Ball shall be 6 inches diameter constructed of 14-ga. Aluminum, having flush seam and genuine Ultrasheen finish, mounted on 5/8 inch dural rod attached to truck.

F. Truck shall be double 2-3/8 in. dia. Sheaves, same material as pole.

G. Cleats shall be two 9-inch length made of aluminum having the same color as the pole.

H. Halyard shall be internal halyard system including a heavy-duty winch with removable crank, a halyard of stainless steel braided aircraft cable, and a concealed revolving truck assembly. The mechanism is to be serviced through a flush hinged access door with a continuously reinforced periphery. Door shall pivot on a heavy duty piano hinge and be secured with a cylinder lock. The halyard device shall permit a flag to be raised, lowered and flown from any position on the pole without entanglement or slippage.

I. The winch shall be a manually operated geared unit with control stop arrangement to permit positive locking of flag at any position on the pole.

J. The flag attachment arrangement shall consist of a nylon braided sling encircling the pole and a counterweight to assure descent of flag in all weather conditions, excluding hurricane force winds.

K. Foundation tube shall be made of 16-gauge galvanized corrugated steel of proper length and diameter for this size pole foundation tube. Include welded steel bottom plate, lower welded steel internal centering wedges, steel lightning ground spike, steel plate support, all galvanized and as detailed.

L. Metal base shall be a standard cast aluminum base, design number 2000 having genuine Ultrasheen finish. Provide recess in top for waterproof caulking to flagpole after erection.

M. Flags

1. Provide two first quality 4’ x 6’ outdoor nylon flag (United States) made from bunting woven to meet Federal Specifications and dyed in brilliant colors for maximum color brightness. All seams and hems shall be stitched with heavy nylon thread. The fly and seam shall be reinforced with extra stitching.

2. Provide two first quality 4’ x 6’ outdoor nylon flag (New York State) made from bunting woven to meet New York State Specifications and dyed in brilliant colors for maximum color brightness. All seams and hems shall be stitched with heavy nylon thread. The fly and seam shall be reinforced with extra stitching.

PART 3 - EXECUTION

3.1 TRAFFIC CONTROL SIGNS

A. Installation shall be in accordance with the NYS DOT Specification Section 645-Signs and NYS-DOT Standard Details

3.2 HYDRANT OUT-OF-SERVICE SIGNS

A. Hydrant “Out-of-Service” signs shall be provided and installed.

1. At all existing hydrants removed from service.

2. At all new hydrants.

B. Hydrant “Out-of-Service” signs shall remain in place until the “Out-of-Service” hydrant is placed in service.

C. Hydrant “Out-of-Service” signs shall be maintained by the Contractor for the duration of the project.

D. The Contractor shall replace, at his own expense, any hydrant “Out-of-Service” sign which is lost, stolen, damaged or defaced.

E. Hydrant “Out-of-Service” signs shall become the property of the County of Rockland upon completion of their use.

3.3 GUARD RAIL

A. Installation will be in accordance with the New York State Department of Transportation specification section 606 Guide Railing and NYS-DOT standard details

3.4 FLAGPOLES AND FLAGS

A. Flagpole shall be set plum level, at the height indicated and centered in concrete footing.

B. The Contractor shall insure that the pole is in good working order and has cleaned with surfaces free from distortion or other defects in appearance.

C. Installation will be in accordance with manufacturer's written instruction. If during installation in the opinion of the Engineer the installer is not installing the flagpole in accordance with manufacturer instruction a representative of the manufacturer will be required to field verify the correct installation. This site visit will be at no cost to the owner.

D. Remove and replace the pole if in the opinion of engineer the defect or repairs to the pole are unacceptable

END OF SECTION 32 39 00

SECTION 323910 - SITE FURNISHINGS AND COURTYARD AMENITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division - 1 Specification sections apply to work of the Section.

B. Related Work specified elsewhere:

1. Section 312000 Grading, Excavating and Backfilling
2. Section 033000 Cast-In-Place Concrete
3. Section 329300 Landscape
4. Section 221413 Piping
5. Section 265619 Exterior Lighting
6. Section 260519 Low Voltage Electrical Power Conductors and Cables
7. Section 262213 Low- Voltage Distribution Transformers
8. Section 334000 Site Drainage
9. Section 334913 Drainage Structures

1.2 SUMMARY

A. Furnish all labor, materials, tools, equipment, and services necessary for and reasonably incidental to complete the site furnishings as shown on the drawings, or specified, including, but not limited to the following:

1. Cedar Spilt Rail Fence

2. Washed River Round Stone Border

3. Yard Drains

4. Landscape Lighting

1.3 SUBMITTALS

A. Submit manufacturer's product data for each type if factory fabricated item required showing size, materials, and installation procedures to the Landscape Architect.

B. Submit shop drawings for each custom fabrication showing materials, dimensions and installation procedures to the Landscape Architect.

C. Submit sample of each indicated finish to the Landscape Architect.

1.4 PROJECT CONDITIONS

A. Do not begin site furnishings and courtyard amenity work until final grading and surfacing is complete.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cedar Split Rail Fence: Furnish and install fence as shown on plans as follows:

Manufacturer: Walpole Outdoors or Approved Equal.

Model: Wood: Clear Grade Northern Red Cedar

Finish: Manchester Natural

Size: 3'-6" Height- 3 Rail System

Installation: Secured to concrete footing according to manufacturer's specs.

B. Washed River Round Stone Border: Furnish and install stone border as follows:

1. Washed Grey natural toned stones- 3" – 5" round. Submit sample for approval: 4" depth.

2. Filter fabric non-woven geotextile as supplied by MIRAFI Construction Products or approved equal; 140 N series to be installed over compacted subgrade below washed stones.

3. Steel Edge: As manufactured by Border Concepts or approved equal 1800-845-3343. Border King Series (1/4" Thick x 5" Height) with super stake staking system (3/16" Thick x 24" Long). Edging to be painted with manufacturer's standard black enamel paint.

C. Yard Drains: Furnish and install yard drains at lawn courtyard at Building 1.

1. Yard Drain: Catch Basin Kit as manufactured by NDS or approved equal. 1800-726-1994/559-562-9888. Catalog N^6. 900 MTLKIT.

2. 9" x 9" Galvanized Steel Grate.

3. 6" Storm pipe connecting each basin as supplied by manufacturer

D. Landscape Lighting: Furnish and Install landscape lighting at main entrance to Building

1. Lighting at stone wall: As manufactured by Vista Professional Outdoor Lighting or approved equal. 718- 361-9150/ 800-766-8478. Model GR-5105-Z-2-W-FR.

2. Uplighting at birch trees: As manufactured by Vista Professional Outdoor Lighting or approved equal. 718-361-9150/ 800-766-8478. Model GR-5014i-Z-2.5-W-MF-FR.

3. Stainless Steel Transformer with mechanical timer: As manufactured by Vista Professional Outdoor Lighting or approved equal. 718-361-9150/ 800-766-8478. Model ES-15OT.

PART 3 - EXECUTION

3.1 PREPARATION

A. Examine subgrades and finish surfaces prior to beginning work. Do not install site furnishings and courtyard amenities until final surface is complete.

B. Remove loose and extraneous material from bare surface before placing site furnishings and courtyard amenities.

C. Prepare trenching for all wiring and conducts as per applicable electrical sections of project specifications.

D. Prepare subgrades and trenching for all connecting storm piping as per applicable earthwork and storm drainage sections of project specifications.

3.2 INSTALLATION

A. Install all manufactured products per manufacturer's instructions.

B. Install all wiring, conduits, and fixtures as per applicable electrical sections of project specifications.

C. Install all piping and yard drains as per applicable earthwork and storm drainage sections of specifications.

D. Erect plumb and secure.

D. Repair all surfaces damaged during installation.

3.3 CLEAN UP

A. Perform cleaning during installation of work and upon completion of work. Remove from site all excess materials, debris and equipment.

END OF SECTION 323910

SECTION 329200- MEADOW SEEDING (SEED MIX 'C')

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division - 1 Specification sections apply to work of this Section.

B. Related Work Specified Elsewhere:

1. Landscaping 329300

1.2 DESCRIPTION OF WORK

A. Furnish all labor, materials, tools, equipment, and services necessary for and reasonably incidental to complete the installation of seeded areas (Mix C) as shown on the drawings, or specified, including, but not limited to the following:

1. Soil preparation
2. Installation of meadow planting
3. Establishment period
4. Guarantee

B. All meadow installations specified in this section and on the drawings shall be in addition to lawn types A & B and installation performed for soil erosion, dust control, or construction stabilization purposes during construction of the project. Contractor shall provide the specified slope stabilization plantings and meadows in a fully established condition for all areas of the project within the contract limit line and areas of disturbance.

1.3 QUALITY ASSURANCE

A. Installation of meadows and related work shall be performed by a firm with a minimum of five years' experience specializing in this type of work.

B. Contractor shall be responsible for obtaining all permits and owners approval with regards to the application of any herbicides and removals.

1.4 SUBMITTALS

A. Provide and pay for soil tests for representative site soil samples and topsoil to be used. Tests shall show pH factor, mechanical analysis, percentage of organic content, recommendations on type and quantity of additives to establish the required pH factor and recommendations for any additional soil additives that are necessary to establish the meadows. Furnish all test results and recommendations to Landscape Architect prior to beginning work. All testing to be done by a qualified testing service laboratory.

B. Submit soil test results to seed supplier: Amend seed mixture as recommended by supplier based on test results.

C. Submit seed vendor's certification for all required seed mixtures, indicating percentage by weight, and percentages of purity, germination, and weed seed for each grass and cover crop species.

1.5 PROJECT CONDITIONS

A. Work Notification: Notify Landscape Architect at least ten (10) calendar days prior to start of meadow planting installation operations.

B. Protect existing utilities, paving, and other facilities from damage caused by MEADOW installation operations.

C. Perform meadow installation work only after planting and other work affecting ground surface has been completed.

D. Seed: Deliver seed in original sealed, labeled, and undamaged containers.

E. Restrict traffic from meadows until seeded areas are established. Erect signs and barriers as required.

F. Review site conditions with Landscape Architect to determine dry and moist areas surrounding basin for meadow planting.

1.6 REVIEW AND ACCEPTANCE

A. Final Review and Acceptance:

1. Review to determine final acceptance of meadow area will be made by the Landscape Architect, upon Contractor's written request. Provide notification at least five (5) calendar days before requested review date. Meadow areas will be acceptable provided all requirements, including the establishment period have been complied with, and a healthy, uniform, close stand of the specified grass is established free of weeds, undesirable grass species, disease, and insects. Upon final acceptance, the Owner will assume meadow maintenance.

1.7 GUARANTEE

A. All meadow areas shall be guaranteed for one year or until final acceptance whichever is longer.

B. The Contractor shall provide a uniform stand of meadow that is healthy, even colored, free of weeds, undesirable grass species, disease, and insects.

C. The Contractor shall repair or reseed without cost to the Owner, all planting areas that are not in the specified acceptable condition. Repair method shall be the same as originally specified.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Refer to Engineer's drawings and specifications for bio-retention soil specifications at basins where meadow seeding will occur.

B. Topsoil: ASTM D 5268, pH range of 5.5 to 7.0, 4 percent organic material minimum,20% maximum, free of stones 1 inch (25 mm) or larger in any dimension, and other extraneous materials harmful to plant growth including invasive weeds.

1. Imported topsoil from offsite sources shall be obtained from naturally well-drained sites where topsoil occurs at least 4 inches (199 mm) deep; do not obtain from bogs or marshes.

2.

Mechanical Analysis Screen Size	**% By Weight Passing**
1"	100
¼"	97-100
No. 200	20-65

3. Topsoil in which more than 65% of the material passing a No. 200 sieve as determined by the Bouyoucous Hydrometer or by the decantation method, shell be rejected. All percentages based on the dry weight of the samples.

4. On-site topsoil if required may be used for meadow areas if, when amended, its physical and nutrient properties meet the requirements of these specifications.

5. All topsoil suitable shall be kept separate from other material, stored and stocked piled on the site in locations approved by the Owner's field representatives.

C. Lime: Lime material shall be ground agricultural limestone that contains at least 50% total oxides calcium oxide plus magnesium oxide. Ground limestone shall be ground to such a fineness that at least 50% will pass through a 100-mesh sieve and 98 to 100% will pass through a 20-mesh sieve. Lime shall be applied at rates as recommended by seed supplier and as determined by soil testing.

D. Fertilizer: No fertilizers shall be added to meadows unless specifically called out by seed supply company after analysis of soil samples. All fertilizers shall be uniform in composition, free flowing, and suitable for application with approved equipment. Fertilizers shall be delivered to the site fully labeled according to applicable State Fertilizer Laws and shall bear the name, trade name, or trademark and warranty of the producer. Fertilizer should not be typical Lawn Food, but a Low nitrogen fertilizers recommended by the seed supply company for meadow establishment.

E. Seed (Mix C) for Meadows: Seed shall be delivered in original sealed packages bearing the producer's guaranteed analysis for percentages of mixtures and pure live seed. Seed shall be labeled in conformance with U.S. Department of Agricultural rules and regulations under the Federal Seed Act. Seed that has become wet, moldy, or otherwise damaged will not be acceptable. Shall be

supplied by Ernst Conservation Seeds, Inc., 8884 Mercer Pike, Meadville, PA 16335 (1-800-873-3321) or approved equal.

Seed mix for Seed Mix ‘C’ 'Moisture Tolerant Mix: Mix shall be supplied by Ernst Conservation Seeds, Inc., 8884 Mercer Pike, Meadville, PA 16335 (1-800-873-3321), or approved equal.

1. Seed Mixture C shall be as follows:

Puccinellia distans 'Fults' (Alkaligrass)	20.0%
Panicum clandestinum 'Tioga' (Deertongue)	19.0%
Elymus virginicus PA Ecotype (Virginia Wildrye)	19.0%
Agrostis stolonifera (Creeping Bentgrass	18.0%
Carex vulpinoidea, PA Ecotype (Fox Sedge)	15.0%
Juncus effusus (Soft Rush)	5.0%

F. Inoculants: Provide proper fresh rhizobium inoculum supplied by Preferred Seed Company, Inc., or approved equal.

G. Mulch and Binders:

1. Provide straw mulch over new meadows per New York State Department of Transportation item 713-19. Provide air-dry, clean, mildew, and seed free, salt hay or threshold straw of wheat, rye, oats or barley.

2. Wood Cellulose Fiber Mulch: Degradable green dyed wood cellulose fiber or 100% recycled long fiber pulp, free from weeds or other foreign matter toxic to seed germination and suitable for hydromulching. Acceptable products include Conwed Hydromulch, Conwed Corp., St. Paul, Minn., Cellin Hydromulch, Cellin Manufacturing, Inc., Lorton, VA or approved equal.

3. Tackifier: Liquid concentrate diluted with water forming a transparent three-dimensional film-like crust permeable to water and containing no agents toxic to seed germination. Acceptable products include Polybind DLR, Celtite, Inc. Cleveland, Ohio; Curasol AK, American Hoechst Corp., Elk Grove, Illinois.

PART 3-EXECUTION

3.1 INSTALLATION SEASON

A. Installation of meadows shall be done only within the following dates:

1. Mix for dry sites can be applied at any time of the year. Mix for moist sites shall be sown between March 15th and May 1st or between August 21st and October 15th with a light mulching of weed free straw to conserve moisture.

3.2 SOIL PREPARATION

A. Examine finish surfaces and grades. Work shall proceed only after subgrade is within 0.10' of final grade, allowing for topsoil depth.

Grades on the areas where plantings are to be established shall be maintained in a true and even grade.

B. Loosen subgrade of slope stabilization plantings areas to a MINIMUM DEPTHOF 4". Remove stones over 1-1/2" in any dimension and sticks, roots, rubbish, and other extraneous matter. Limit preparation to areas that will be planted promptly after preparation.

C. Place approximately ½ the thickness of topsoil if required. Work into top of loosened subgrade to create a transition layer and then spread remainder of topsoil to meet lines, grades, and elevations shown, after light rolling and natural settlement.

D. Apply lime, at a rate determined by a soil test, to adjust the pH of the soil to not less than 6.5 and not more than 7.0. Distribute evenly over the soil and fully incorporate into the soil by tilling.

E. Apply low nitrogen fertilizer, at a rate determined by a soil test, to the soil. Distribute evenly over the soil and fully incorporate into the soil by tilling. Fertilizer application may be incorporated into hydroseeding procedure.

F. Grade slope stabilization plantings areas to a smooth, even surface with loose uniform fine texture. Roll and rake and remove ridges and fill depressions. Restore slope stabilization plantings areas to specified condition if eroded or otherwise disturbed after fine grading and prior to installation of plantings.

3.3 INSTALLATION OF MEADOW

A. Existing on site topsoil may be utilized for meadow areas if test results indicate soil is suitable based on supplier’s recommendations. Contractor to add amendments as required. Follow supplier’s instructions ridgley for installation of all meadow seed mixes.

1. Provide a freshly rototilled seedbed free of rocks or dirt clumps greater than two inches in diameter.

2. Apply 10-10-10 fertilizer as recommended by seed supplier.

3. Divide the mixture in half and broadcast one half of the seed evenly over site using seed spreader. Apply the second half of the seed evenly over the site in a perpendicular direction. Seed at rates as recommended by

seed supplier

4. Cover the seed with one eighth to one fourth inch of soil using a rake, drag, or piece of chain link fence.

5. Roll lightly and water with fine spray.

6. Mulch the designated planting area with approximately one inch of weed-free straw.

B. The Contractor shall provide at his own expenses protection against trespassing and damage to meadow areas. If any areas are damaged, they shall be restored at the Contractor's expense.

3.4 STABLISHMENT OF MEADOWS

A. Establishment shall begin immediately after plantings are installed and shall continue until final acceptance. The establishment period is intended to insure that the project is delivered to the Owner with all slope stabilization plantings installed and in full, vigorous health.

B. Maintain seeded areas for a period of 60 days or until final acceptance, whichever is longer. Establishment shall begin after completed installation. Maintain seeding and work incidental thereto by performing the following and all other operations of care for the promotion of growth so that all work meets specifications throughout the establishment period.

1. Watering: Provide all labor and materials for watering operations required for maintenance. During the first week, perform daily watering to keep soil moist at all times and to maintain moist topsoil to a depth of at least four inches. During subsequent weeks, water the seeded areas to maintain adequate moisture in the upper four inches of soil necessary for the promotion of deep root growth. Minimum precipitation rate shall be one inch per week.

2. Mowing: Mow meadow at intervals recommended by the seed supplier.

3. Reseeding: During the establishment period, replace seeded areas that are dead, or are in an unhealthy, unsightly, or badly impaired condition as soon as possible during the specified planting season. Make such replacements in the same manner as specified for the original seeding at no additional cost to the

3.5 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of it off the Owner's property.

END OF SECTION 329200

SECTION 329300- LANDSCAPING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related work specified elsewhere

1. Section 329200 Meadow Seeding

1.2 SUMMARY

A. This Section includes the following:

1. Trees, Shrubs, & Ground covers.

2. New Lawn - Seed Mix A (General) & Seed Mix B (Lawn)

3. Hydroseeding

4. Topsoil and soil amendments

5. Planting Mixes Fertilizers and mulches.

6. Stakes and guys.

7. Mulches, binders, and erosion control blankets.

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 certificates signed by manufacturers certifying that their products comply with specified requirements.

1. Manufacturer's certified analysis for standard products.

2. Analysis for other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

3. Label data substantiating that plants, trees, shrubs, and planting materials comply with specified

requirements.

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 packing.

D. 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.

E. 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.

F. Manufacturer’s and suppliers test reports and product data for all mulches, binders and erosion control blankets.

1.4 QUALITY ASSURANCE

A. Standards: Comply with latest specifications and recommendations of New York State Department of Transportation for seeding.

B. Installer Qualifications: Engage an experienced Installer who has completed landscaping work including hydroseeding similar in material, design, and extent to that indicated for this Project and with a record of successful landscape, lawn and meadow establishment.

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on the Project site during times that landscaping is in progress.

C. Provide quality, size, genus, species, and variety of trees and shrubs indicated, complying with applicable requirements of ANSI Z60.1 "American Standard for Nursery Stock."

D. Topsoil Analysis: Furnish a soil analysis made by a qualified independent soil-testing agency stating percentages of organic matter, inorganic matter (silt, clay, and sand), deleterious material, pH, and mineral and plant-nutrient content of topsoil.

1. Report suitability of topsoil for growth of applicable planting material. State recommended quantities of nitrogen, phosphorus, and potash nutrients and any limestone, aluminum sulfate, or other soil amendments to be added to produce satisfactory topsoil.

E. Measurements: Measure trees and shrubs according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches (150 mm) above ground for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above

ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in containers showing weight, analysis, and name of manufacturer. Protect materials from deterioration during delivery and while stored at site.

B. Seed: Deliver seed in original sealed, labeled, and undamaged containers.

C. Trees and Shrubs: Deliver freshly dug trees and shrubs. Do not prune before delivery, except as approved by the Landscape Architect. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind- tie trees or shrubs in such a manner as to destroy natural shape. Provide protective covering during delivery. Do not drop trees and shrubs during delivery.

D. Handle balled and burlapped stock by the root ball.

E. Deliver trees, shrubs, ground covers, and plants after preparations for planting have been completed and install immediately. If planting is delayed more than 6 hours after delivery, set planting materials in shade, protect from weather and mechanical damage, and keep roots moist.

1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.

2. Do not remove container-grown stock from containers before time of planting.

3. Water root systems of trees and shrubs stored on site with a fine- mist spray. Water as often as necessary to maintain root systems in a moist condition.

1.6 PROJECT CONDITIONS

A. Prior to submitting bid, contractor shall visit and familiarize himself with site and scope of work to be done by others. He is advised to examine all existing conditions not shown on drawings or mentioned in specifications, which would affect the cost of work required under the Contract, and to judge for himself conditions which will exist when he carries out his Contract, as he will not be allowed extra compensation for any additional work required thereby.

B. The Contractor shall review the plans showing approximate location of existing and proposed utilities and underground and surface structures. He shall acquaint himself with these features and any damage to them by reason of his performance of work will be his responsibility and shall be repaired at his expense to the satisfaction of the Landscape Architect.

C. Percolation Test: Prior to any tree or shrub planting, the Contractor shall fill a minimum of 25% of the planting pits with water and observe the rate of percolation. If in the opinion of the Contractor,

slow percolation indicates a soil condition might endanger the health of materials to be planted, he shall contact the Landscape Architect to establish a mutually acceptable method of providing adequate drainage. Compensation for any necessary drainage provisions shall be at a negotiated price. No claims for additional compensation arising from the loss of plant material due to ground water problems will be accepted unless this procedure is followed.

D. Protection: The Contractor shall provide at his own expense protection against trespassing and damage to all planted and seeded areas. If any areas are damaged, they shall be restored at the Contractor's expense. The Landscape Architect shall approve any means of protection prior to its erection.

1.7 COORDINATION AND SCHEDULING

A. Coordinate installation of planting materials during specified planting seasons for each type of plant material required.

1.8 WARRANTY

A. Warrant material and workmanship in accordance with Contract Documents for a period of one year after acceptance or for not less than two full planting seasons, whichever period is greater.

B. During the warranty period, the Contractor shall replace any plant which, for any reason has died or is in a dying condition, or which has failed to flourish in such a manner or to such a degree that its usefulness or appearance has been impaired, and he shall further make good any other damage, loss, impairment or defect in materials or work where the loss, impairment, destruction, or failure to flourish sufficiently is the result of inferior or defective materials of workmanship, or unfavorable weather conditions. The decision of the Landscape Architect as to the necessity of replacing any plants or materials or repair any defects in workmanship or of the cause of any destruction, loss, impairment, or failure to flourish shall be conclusive and binding upon the Contractor. The Contractor shall also make good all damage to persons or property caused by defective workmanship or materials or by the work required to remedy such defects.

C. During the warranty period, the contractor shall from time to time, inspect the maintenance operations carried on by the owner and promptly report to the Landscape Architect any methods, practices or operations which he considers unsatisfactory, and not in accord with his interests or good horticultural practices. The failure of the Contractor to so inspect or report shall be construed as an acceptance by him of the Owner's maintenance operations, and he shall not thereafter claim or assert that any defects which may later develop are the results of such methods, practices or operations.

D. Replacements: All trees, shrubs and ground cover found to be unacceptable, during the warranty period, shall be removed from the site and replaced, with material as originally specified, during the immediate planting season following the Landscape Architect's notification.

E. Lawn Warranty: Warrant all lawn areas for a period of one year after acceptance. At the end of the warranty period, all areas that are in a dead or dying or have not germinated condition shall be replaced.

1.9 TREE AND SHRUB ESTABLISHMENT

A. Maintain trees and shrubs by pruning, cultivating, watering, weeding, fertilizing, restoring planting saucers, tightening and repairing stakes and guy supports, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray as required to keep trees and shrubs free of insects and disease. Maintain trees and shrubs until owner acceptance.

1.10 GROUND COVER AND PLANT ESTABLISHMENT

A. Maintain ground cover and plants by watering, weeding, fertilizing, and other operations as required to establish healthy, viable plantings until owner acceptance.

1.11 LAWN ESTABLISHMENT

A. Begin maintenance of lawns immediately after each area is planted and continue until acceptable lawn is established, but for not less than the following periods:

1. Seeded Lawns: 60 days or until Substantial Completion whichever is longer.

a. 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 lawns by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth lawn.

C. Watering: Provide and maintain temporary piping, hoses, and lawn- watering equipment to convey water from sources and to keep lawns uniformly moist to a depth of 4 inches (100 mm).

1. Water lawn at the minimum rate of 1 inch (25 mm) per week.

D. Mow lawns as soon as there is enough top growth to cut with mower set at specified height for principal species planted. Repeat mowing as required to maintain specified height without cutting more than 40 percent of the grass height. Remove no more than 40 percent of grass- leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet.

E. Postfertilization: Apply fertilizer to lawn after first mowing and when grass is dry.

1. Use fertilizer that will provide actual nitrogen of at least 1 lb per 1000 sq. ft. (0.5 kg per 100 sq. m) of lawn area.

1.12 ACCEPTANCE

A. Acceptance: Upon completion of the planting operations, the contractor shall request, in writing, an inspection by the Landscape Architect. If all work is acceptable the Landscape Architect will issue a certificate of acceptance and the one year warranty will begin. If any work is found to be defective or incomplete, the Contractor will not be issued an acceptance certificate.

B. Final Acceptance: At the end of the warranty period, the Contractor shall request an inspection by the Landscape Architect. If all work is found to be acceptable, the Landscape Architect shall authorize payment of the 10% retention. If replacements and/or remedial work are found to be necessary, this work will be completed by the Contractor and approved by the Landscape Architect prior to final payment.

PART 2 - PRODUCTS

2.1 SLOW RELEASE WATER BAGS

A. Slow release watering bags placed at each tree- Treegater as manufactured by Spectrum Products or approved equal.

2.2 TREE AND SHRUB MATERIAL

A. Inspection: All plants shall be subject to inspection and approval by the Landscape Architect. Plants shall be inspected and tagged at the place of growth prior to digging. Inspection and tagging at the place of growth before shipment shall not affect the right to reject such plants if damage has occurred during digging, handling or delivery. Inspection will be for quality and size, variety and color, all other requirements are the responsibility of the Contractor.

The Contractor or his authorized representative shall be present during inspections.

The Contractor shall make a written request to the Landscape Architect ten working days in advance for all inspections at the various nurseries and collecting grounds. State the location of the nursery or collecting grounds and list the particular plants which are to be inspected as well as the sizes and quantities of such plants.

If the plants and materials to be inspected are located outside a 20 mile radius of the project site, the cost of inspection shall be paid for by the Contractor at a per diem rate plus travel, lodging and other out-of- pocket expenses.

B. General: Furnish nursery-grown trees and shrubs conforming to ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully-branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

C. Grade: Provide trees and shrubs of sizes and grades conforming to ANSI Z60.1 for type of trees and shrubs required. Trees and shrubs of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.

D. Label a minimum of one tree and one shrub of each variety with a securely attached waterproof tag bearing legible designation of botanical name and common name. These labels shall remain on plant material until Final Review for Warranty Conformance.

2.3 PLANT MATERIAL

A. General: Refer to the PLANT SCHEDULE on the drawings for specific types and quantities of plants to be furnished.

1. Plants shall be nursery grown in accordance with good horticultural practices and grown under climatic conditions similar to those in the locality of the project for at least two years. They shall have been root pruned within the last two years.

2. Plants shall be freshly dug. No heeled-in plants or plants from cold storage will be accepted.

3. Unless specifically noted otherwise, all plants shall be of specimen quality, exceptionally heavy, symmetrical, tightly-knit plants, so trained or favored in their development and appearance as to be unquestionably and outstandingly superior in form, number of branches, compactness, and symmetry.

4. Plants shall be sound, healthy and vigorous, well-branched and densely foliated when in leaf, free of disease, insect pests, eggs or larvae, and shall have healthy, well-developed root systems. They shall be free from physical damage or adverse conditions that would prevent thriving with the specified result.

5. Plants shall be true species and variety and shall conform to measurements specified in the plant schedule except that plants larger than specified may be used if acceptable to the Landscape Architect. Use of such plants shall not increase the contract price. If larger plants are accepted the ball of earth shall be increased in proportion to the size of the plant.

6. Container grown stock shall have been grown in a container long enough for the root system to have developed sufficiently to hold its soil together.

2.4 GRASS MATERIALS

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.

2.5 TOPSOIL

A. .Topsoil: ASTM D 5268, pH range of 5.5 to 7.0, 4 percent organic material minimum,20% maximum, free of stones 1 inch (25 mm) or larger in any dimension, and other extraneous materials harmful to plant growth including invasive weeds.

1. Imported topsoil from offsite sources shall be obtained from naturally well-drained sites where topsoil occurs at least 4 inches (199 mm) deep; do not obtain from bogs or marshes.

2.

Mechanical Analysis Screen Size	**% By Weight Passing**
1”	100
¼”	97-100
No. 200	20-65

3. Topsoil in which more than 65% of the material passing a No. 200 sieve as determined by the Bouyoucous Hydrometer or by the decantation method, shell be rejected. All percentages based on the dry weight of the samples.

4. No on-site topsoil may be used for planting mixture backfill for tree or shrub planting pits or for perennial beds. On-site topsoil may be used for lawn areas if, when amended, its physical and nutrient properties meet the requirements of these specifications.

5. All topsoil suitable shall be kept separate from other material, stored and stocked piled on the site in locations approved by the Owner’s field representatives.

6. If there is not a sufficient quantity of topsoil present on the site the Contractor shall supply from off-site sources the necessary quantity of topsoil to complete the topsoil operations as specified here in or shown on the drawings. All such topsoil shall be furnished and spread as part of the contract sum. No claim for extra compensation by the Contractor will be allowed.

2.5 PLANTING MIXES

A. All planting mixes shall be prepared prior to delivery to site.

1. Planting Mix for Tree and Shrub Pit Planting Mix shall be as follows:

3 parts screened topsoil

1 part clean washed coarse sand

1 part peat humus

5 lbs. super phosphate per cubic yard of mix.

Submit certification of Planting Mix from soil distributor to the Landscape Architect for approval.

Certification shall verifying composition of soil after mixing.

2.6 SOIL AMENDMENTS

A. Lime: ASTM C 602, Class T, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent, with a minimum 99 percent passing a No. 8 (2.36 mm) sieve and a minimum 75 percent passing a No. 60 (250 micrometer) sieve.

1. Provide lime in the form of dolomitic limestone.

B. Aluminum Sulfate: Commercial grade, unadulterated.

C. Sand: Clean, coarse, ungraded, meeting ASTM C33 requirements for mason's sand free of toxic materials.

D. Humus: Shall be FS Q-P-166E Type IV natural domestic reed peat or sedge peat, but not peat-moss, free from sticks, stones, weeds, roots or other foreign matter and when delivered from stock piles containing between 35-50% moisture, suitable for mulch and of composition to provide ample water holding capacity and retention of plant food. Dark brown or black in color. Provide humus of the following analysis:

1. Maximum moisture content 70% by weight.

2. pH 5.0 to 7.5.

3. Water absorbing capacity not less than 300% of its own weight (oven dried basis)

4. Organic matter shall test 80% on a dry weight basis (samples dried at 100 degrees C)

5. Humus with organic matter of 75%-80% may be accepted, the deficiency to be made up in the quantity.

6. Low in content of woody material, iron and sulphur. Ash, on dry basis shall not be more than 20%.

E. Herbicides: EPA registered and approved, of type recommended by manufacturer.

F. Water: Potable.

2.7 FERTILIZER

A. Bonemeal: Commercial, raw, finely ground; minimum of 4 percent nitrogen and 20 percent phosphoric acid.

B. Superphosphate: Commercial, phosphate mixture, soluble; minimum of 20 percent available phosphoric acid.

C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea-form, phosphorous, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

D. Slow-Release Fertilizer: Granular fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

E. Natural Organic Fertilizer: Similar to Milorganite, produced by the Sewerage Commission, Milwaukee Wisconsin having the following analysis:

1. Total Nitrogen (6.5% water insoluble nitrogen) 6.0%
Available Phosphoric Acid 2.0%
Soluble Potash 0.0%
Iron (Fe) 3.0%

2.8 MULCHES

A. Organic Mulch: Organic mulch, free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Shredded cedar bark for all plants. Fibrous texture and uniform dark brown color. Material shall be partially decomposed, of a consistency that not more than 25% will pass through a 1/2" sieve, 1 1/2" max. size with an organic content of not less than 90% and white wood content not exceeding 8%. "Cedar Scape" Decorative Shredded Cedar Bark by Atlantic Forest Product, Edenton, NC 27932 is an approved product.

B. Straw mulch for lawns.

1. Provide straw mulch over new lawns per New York State Department of Transportation item 713-19. Provide air-dry, clean, mildew, and seed free, salt hay or threshold straw of wheat, rye, oats or barley.

C. Mulch, Binders, and Erosion Control Blankets for Lawn Areas

1. Wood Cellulose Fiber Mulch: Degradable green dyed wood cellulose fiber or 100% recycled long fiber pulp, free from weeds or other foreign matter toxic to seed germination and suitable for hydromulching. Acceptable products include Conwed Hydromulch, Conwed Corp., St. Paul, Minn.,

Cellin Hydromulch, Cellin Manufacturing, Inc., Lorton, VA. or approved equal.

2. Tackifier: Liquid concentrate diluted with water forming a transparent three-dimensional film-like crust permeable to water and containing no agents toxic to seed germination. Acceptable products include Polybind DLR, Celtite, Inc. Cleveland, Ohio; Curasol AK, American Hoechst Corp., Elk Grove, Illinois. or approved equal.

3. Erosion Control Blanket (slopes greater than 3:1) : Biodegradable made of curled wood excelsior with 80% six- inch fiber or greater. Material shall not contain any weed seed or chemical additives. Acceptable products include Curlex Single Net (Curlex 1), Green Color, as manufactured by American Excelsior Company, Arlington Texas or approved equal.

2.1 STAKES AND GUYS

A. Upright and Guy Stakes: Sound white cedar 3 to 3 1/2" inches in diameter by length indicated, pointed at one end.

B. Guy and Tie Wire: ASTM A 641 (ASTM A 641M), Class 1, galvanized- steel wire, 2-strand, twisted, 0.106 inch (2.7 mm) in diameter.

C. Hose Chafing Guard: Reinforced rubber hose at least 1/2 inch (13 mm) in diameter, black, cut to lengths required to protect tree trunks from damage.

D. Flags: Standard surveyor's plastic flagging tape, white, 6 inches (150 mm) long.

2.2 MISCELLANEOUS MATERIALS

A. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's instructions.

PART 3 – EXECUTION

3.1 PREPARATION

A. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, and secure Landscape Architect's acceptance before the start of planting work. Make minor adjustments as may be required.

3.2 PLANTING SOIL PREPARATION

A. Before mixing, clean topsoil of roots, plants, sods, stones, clay lumps, and other extraneous materials harmful to plant growth.

B. Contractor shall have planting mix prepared prior to delivery to the site.

1. Install planting mix as shown on the drawings.

3.3 LAWN PLANTING PREPARATION

A. Limit subgrade preparation to areas that will be planted in the immediate future.

B. Loosen subgrade to a minimum depth of 4 inches (100 mm). Remove stones larger than 1-1/2 inches (38 mm) in any dimension and sticks, roots, rubbish, and other extraneous materials.

1. Place approximately 1/2 the thickness of planting soil mixture required. Work into top of loosened subgrade to create a transition layer and then place remainder of planting soil mixture. Total topsoil depth shall be 4" for all 'Seed Mix A' & 'Seed Mix B' areas.

C. Preparation of Unchanged Grades: Where lawns are to be planted in areas unaltered or undisturbed by excavating, grading, or surface soil stripping operations, prepare soil as follows:

1. Remove and dispose of existing grass, vegetation, and turf. Do not turn over into soil being prepared for lawns.

2. Till surface soil to a depth of at least 6 inches (150 mm). Apply required soil amendments and initial fertilizers and mix thoroughly into top 4 inches (100 mm) of soil. Trim high areas and fill in depressions. Till soil to a homogenous mixture of fine texture.

3. Clean surface soil of roots, plants, sods, stones, clay lumps, and other extraneous materials harmful to plant growth.

4. Remove waste material, including grass, vegetation, and turf, and legally dispose of it off the Owner's property.

D. Grade lawn and grass areas to a smooth, even surface with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future. Remove trash, debris, stones larger than 1-1/2 inches (38 mm) in any dimension, and other objects that may interfere with planting or maintenance operations. Seed bed shall be inspected by the Owner’s representative to ensure it has been properly compacted and fine graded prior to seeding, mulching and blanket installation.

E. Moisten prepared lawn areas before planting when soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Restore prepared areas if eroded or otherwise disturbed after fine grading and before planting.

3.4 GROUND COVER, PLANT BED, AND PERENNIAL BED PREPARATION

A. Remove all existing soil to the required depth as shown on the drawings.

B. Install new planting mix to a depth as indicated on drawings.

3.5 EXCAVATION FOR TREES AND SHRUBS

A. Pits and Trenches: Excavate with vertical sides and with bottom of excavation slightly raised at center to assist drainage. Loosen hard subsoil in bottom of excavation.

1. Balled and Burlapped Trees and Shrubs: Excavate a minimum of 1 foot wider than the rootball diameter and equal to ball depth.

2. Container-Grown Trees and Shrubs: Excavate to a minimum of 1 foot wider than the container and equal to the container depth.

B. Obstructions: Notify the Landscape Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

3.6 PLANTING TREES AND SHRUBS

A. Planting Season: Plants shall be planted only within the following dates or as specified on the drawings. If special conditions exist which may warrant a variance in the planting dates, a written request shall be submitted to the Landscape Architect stating the special conditions and the proposed variance. Permission for the variance will be given if, in the opinion of the Landscape Architect, the variance is warranted.

1. Deciduous Trees and Shrubs: March 15 to May 31, and Sept. 15 to Nov. 15.

2. Evergreen Trees and Shrubs, Vines, Perennials: March 1 to May 15, and Sept. 1 to Nov. 1.

3. Ground Covers: March 1 to September 15.

B. Set balled and burlapped stock plumb and in center of pit or trench with top of ball raised above adjacent finish grades as indicated.

1. Place stock on setting layer of compacted planting soil.

2. Remove burlap and wire baskets from tops of balls and partially from sides, but do not remove from under balls. Remove pallets, if any, before setting. Do not use planting stock if ball is cracked or broken before or during planting operation.

3. Place planting mix around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately 1/2 backfilled, water thoroughly before placing remainder

of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill.

C. Set container-grown stock plumb and in center of pit or trench with top of ball raised above adjacent finish grades as indicated.

1. Carefully remove containers so as not to damage root balls.

2. Place stock on setting layer of compacted planting soil.

3. Place planting mix around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately 1/2 backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill.

D. Dish and tamp top of backfill to form a 3-inch- (75-mm-) high mound around the rim of the pit. Do not cover top of root ball with backfill.

3.7 TREE AND SHRUB PRUNING

A. Prune, thin, and shape trees and shrubs as directed by the Landscape Architect.

B. Prune, thin, and shape trees and shrubs according to standard horticultural practice. Prune trees to retain required height and spread. Unless otherwise directed by the Landscape Architect, do not cut tree leaders; remove only injured or dead branches from flowering trees. Prune shrubs to retain natural character. Shrub sizes indicated are size after pruning.

3.8 TREE AND SHRUB GUYING AND STAKING

A. Upright Staking and Tying: Stake trees of 2- through 5-inch (50- through 125-mm) caliper. Stake trees of less than 2-inch (50-mm) caliper only as required to prevent wind tip-out. Use a minimum of 2 stakes of length required to penetrate at least 18 inches (450 mm) below bottom of backfilled excavation and to extend at least 72 inches (1800 mm) above grade. Set vertical stakes and space to avoid penetrating balls or root masses. Support trees with 2 strands of tie wire encased in hose sections at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.

B. Guying and Staking: Guy and stake trees exceeding 14 feet (4.2 m) and more than 3-inch (75-mm) caliper unless otherwise indicated. Securely attach no fewer than 3 guys to stakes 30 inches (760 mm) long, driven to grade. Attach flags to each guy wire, 30 inches (760 mm) above finish grade.

3.9 PLANTING GROUND COVER AND PLANTS

A. Space ground cover and plants as indicated.

B. Dig holes large enough to allow spreading of roots, and backfill with planting soil. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water. Water

thoroughly after planting, taking care not to cover plant crowns with wet soil.

3.10 MULCHING

A. Mulch backfilled surfaces of pits, trenches, planted areas, and other areas indicated.

B. Organic Mulch: Apply the following average thickness of organic mulch and finish level with adjacent finish grades. Do not place mulch against trunks or stems.

1. Thickness: 3 inches (50 mm).

3.11 SEEDING NEW LAWNS

A. Sow seed with a spreader, hydro seeder, or a seeding machine. Use spreader at all confined areas and as directed by Owner's representative. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8 km/h). Evenly distribute seed by sowing equal quantities in 2 directions at right angles to each other.

1. Do not use wet seed or seed that is moldy or otherwise damaged in transit or storage.

B. Sow seed at the following rates: Seeding Rate: 3 to 4 lb per 1000 sq. ft. (1.5 to 2 kg per 100 sq. m).

C. Rake seed lightly into top 1/8 inch (3 mm) of topsoil, roll lightly, and water with fine spray.

D. Install erosion control blankets on all slopes 3:1 or greater. Follow manufacturer's installation instructions rigidly. Install mulch and binders compatible with hydro seeding operations.

3.12 CLEANUP AND PROTECTION

A. During landscaping, keep pavements clean and work area in an orderly condition.

B. Protect landscaping from damage due to landscape operations, operations by other contractors and trades, and trespassers. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged landscape work as directed.

3.13 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of it off the Owner's property.

3.14 SEED MIXTURE SCHEDULE

A. Seed Mix Type 'A': Provide certified grass-seed blends or mixes, proportioned by weight, as follows and meets the product requirements of NYSDOT specifications for "General Roadside Seed Mix":

Proportion	Name
50 to 70 pct.	Festuca Rubra var. Fine Fescue (2 minimum varieties minimum including Creeping Red)
15 to 40 pct.	Lolium Perenne Perennial Ryegrass (2 varieties minimum turf type)
5 to 15 pct.	Lolium Multiflorum Annual Ryegrass
5 to 10 pct.	Trifolium repens White Clover

B. Seed Mix Type 'B': Provide certified grass-seed blends or mixes, proportioned by weight, as follows and meets the product requirements of NYSDOT specifications for "Lawn Seed Mix":

Proportion	Name
15 to 40 pct.	Poa Pratensis (Kentucky Bluegrass, 3 varieties minimum)
15 to 40 pct.	Lolium Perenne Perennial Ryegrass (2 varieties minimum- turf type)
5 to 15 pct.	Lolium Multiflorum Annual Ryegrass
30 to 50 pct.	Festuca rubra var. Fine Fescue (2 varieties minimum must include Creeping Fescue)

END OF SECTION 02900

SECTION 33 05 26.23 BURIED PIPE IDENTIFICATION

PART 1 – GENERAL

1.1 SUMMARY

A. Work Included

1. Under this section the Contractor shall provide all labor, equipment and materials necessary to furnish, install and test identification/location devices for various buried piping and conduit systems complete in place, and as shown on the Drawings, specified herein and as approved by the Engineer.

B. Related Work Described Elsewhere

1. Section 31 20 00 Grading, Excavating and Backfilling

1.2 SUBMITTALS

A. General

1. Submit the following item in accordance with the conditions of the contract and Section 01340, “Submittal Procedures”.

a. Warning Tape

B. Product Data:

1. Manufacturer’s specifications and other data required to demonstrate compliance with specific requirements.

a. Such submittals shall include certified records of physical, chemical and other pertinent tests and/or certified statements from the manufacturer that the materials have been manufactured and tested in conformity with the specifications.

1.3 QUALITY ASSURANCE

A. Codes and Standards

1. All materials and labor furnished under this section shall:

a. Comply with AWWA, ANSI, ASTM, NFPA and all other applicable Federal, State and Municipal codes and regulations including revisions to date of Contract.

b. In all cases where a device or part of the equipment is referred to in this Section in the singular (such as “strap”), it is intended that such references shall apply to as many such devices as are required to complete this installation.

B. Qualifications of Manufacturers

1. Products used in the work of this section shall be produced by manufacturers regularly engaged in the manufacture of similar items and with a history of successful production acceptable to the Engineer.

1.4 PRODUCT HANDLING

A. Protection

1. Use all means necessary to protect materials of this Section before, during and after installation and to protect installed work and materials of all other trades.

B. Replacements

1. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Owner.

PART 2 – PRODUCTS

2.1 GENERAL

A. Design

1. Where used, the names of manufacturers and specific catalog numbers are given only as an indication of the quality of the materials and workmanship to be used.

2.2 WARNING TAPE

A. General Requirements

1. Warning tape shall be provided for all buried piping and conduit excluding storm drainage system piping.

2. The warning tape shall be an acid and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities and shall be resistant to any chemical reagents, solvents or other contaminants likely to be encountered in the soil.

3. A solid foil core shall be incorporated into the warning tape to enable the tape to be located by inductive or conductive pipe locating equipment. Accessories shall be provided as required to maintain the electrical continuity of the tape.

4. Warning tape thickness shall be 5 mils minimum. Warning tape width shall be 4-inches for burial depths of up to 36". The tape width shall be increased an additional 2-inches for each additional 12-inches of bury.

5. Identifying lettering identifying the utility below shall be imprinted continuously over the entire length of the tape. The lettering shall be in permanent black in color, 1-inch high.

B. Color

1. Warning tape color shall be in accordance with the American Public Works Association (APWA) Uniform Color code for Marking of Underground Utilities as summarized below:

a. Red: Electric power lines, cables, conduit, and lightning cables

b. Orange: Telephone, Fiber-optic, and other communications lines, cables and conduits

c. Yellow: Gas, oil, steam, petroleum, or gaseous materials

d. Green: Sewers and drain lines

e. Blue: Water and irrigation lines

C. Manufacturer

1. Warning tapes shall be Terra Tape Sentry Line Detectable Warning Tape as manufactured by Reef Industries or approved equivalent.

PART 3 – EXECUTION

3.1 INSTALLATION

A. General

1. The Contractor shall install the detectable warning tape for all buried piping and conduit excluding storm drainage system piping.

B. Warning Tape

1. Warning tape shall be installed directly above the pipe.

2. The warning tape shall be installed a distance of 24-inches above the pipe or conduit. However, the minimum depth of bury of the warning tape shall be 6-inches.

END OF SECTION 33 05 26.23

SECTION 33 11 13 WATER DISTRIBITION PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included

1. Under this Section the Contractor shall provide all labor, equipment and material necessary to furnish, install and test all piping, fittings, valves and accessories required for the completion of the work as shown on the drawings and summarized in the attached piping schedule, including wall sleeves in all types of walls. The furnishing and installation of all pipe hangers, supports, braces and insulation, including anchor bolts and other concrete inserts and hardware required for the correct installation of all piping are also included in this Section and are covered more specifically in subsequent Sections of these specifications.

B. Standardization

1. Miscellaneous piping, valves and appurtenances supplied with the equipment to be furnished under other items shall conform to the requirements of this Section and subsequent piping Sections.

2. All valves and appurtenances of the same type shall be supplied by a single manufacturer.

3. All pipes and pipe fittings of the same type shall be supplied by a single manufacturer.

C. Related Work Described Elsewhere

1.	Grading , Excavating and Backfilling	Section 31 20 00
2.	Water Distribution Piping	Section 33 11 13
3.	Drainage Structures	Section 33 49 13
4.	Fire Hydrants	Section 33 12 19
5.	Buried Pipe Identification	Section 33 05 26.23

1.2 SUBMITTALS

Submit shop drawings in accordance with 01340 – “Submittals”.

A. Product Data

1. Prior to the commencement of any work the Contractor shall furnish the Engineer with drawings for his review and approval indicating all piping systems and their component parts, including pipe hangers, supports and braces, as well as valves and other accessories along with a listing of recommended spare parts to be supplied with the equipment by the manufacturer. Drawings shall show subdivision of the piping for shop and field fabrication, plus the specifications of the materials being used and the method of proper installation. Detailing and installation of piping shall be coordinated with other piping and conduit to be furnished and installed under this contract.

2. For pipe, pipe fittings, valves, operators and appurtenances, the Contractor shall furnish to the Engineer, at the time of shop drawing submission, certified records of physical, chemical and other pertinent tests and/or certified statements from the manufacturer that the materials have been manufactured and tested in conformity with the specifications. Where such a small quantity of material is required as to make physical testing and chemical analysis impractical, a certificate from the manufacturer stating the results of such tests or analyses of similar materials that were concurrently produced, may at the discretion of the Engineer, be considered as the basis for acceptance of such materials.

3. Manufacturer's specifications and other data required to demonstrate compliance with the specific requirements.

4. A complete bill of materials list showing all items to be furnished and installed under this Section.

5. Complete shop drawings of all work of this Section, showing dimensions and locations of all items including supporting structures and clearance requirements.

1.3 QUALITY ASSURANCE

A. Standards

1. Comply with standards specified in these Specifications.

2. Comply with OSHA, ASTM, AWWA, ANSI and all applicable Federal, State and local codes and regulations regarding the proper manufacture, testing and installation of pipe and pipe fittings, including revisions to date of contract.

3. In all cases where a device or part of the equipment is referred to in this Section in singular (such as "valves"), it is intended that such references shall apply to as many such devices as are required to complete the installation.

B. Qualifications of Manufacturers

1. Products used in the work of this Section shall be produced by manufacturer regularly engaged in the manufacture of similar items and with a history of successful production acceptable to the Engineer.

1.4 PRODUCT HANDLING

A. Protection

1. Use all means necessary to protect the materials of this Section before, during and after installation and to protect installed work and materials of all other trades.

B. Replacements

1. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Owner.

C. Protection of Utilities

1. Protect all existing utilities in the course of excavation, installations, and backfilling procedures.

PART 2 – PRODUCTS

2.1 GENERAL

A. Design

1. Design is based on the use of products outlined on the attached piping schedule and as specified in subsequent Sections of this document. Where used, the names of manufacturers and specific catalog numbers are given as an indication of the quality of materials and workmanship to be used.

B. Pipe Identification

All pipe units shall be identified as to the following:

a. Pipe class
b. Date of manufacture
c. Manufacturer’s name or logo
d. Inside pipe diameter
e. Pipe material

C. PVC Pipe

1. All PVC water pipe and fittings shall be manufactured in accordance with one of the following Standard Specifications:

a. ASTM D2241, “Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR PR Series)”. All PVC SDR Series pipe shall be manufactured from a Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM D2241, consistently meeting and/or exceeding the Quality Assurance test requirements of this standard with regard to pressure rating, material, workmanship, burst pressure, flattening, impact resistance, and extrusion quality.

b. PVC pipe shall be SDR 21 for class 200, as called for on the plans. The pipe shall be plainly marked with the following information: manufacturer's name, size, material (PVC) type and grade or compound, NSF Seal, pressure rating and reference to appropriate product standards.

c. Burst Pressure- 200 psi, SDR-21 minimum quick burst pressure 800 psi.

d. Impact Strength: ASTM D-2444

e. Joints: Pipe joints shall be gasket, push-on type. Gaskets shall be part of a complete pipe section and purchased as such. Lubricant shall be as recommended by the pipe or fitting manufacturer and shall not adversely affect the potable qualities of the water to be transported. The gasketed joint shall meet the laboratory performance requirements specified in ASTM D3139. Solvent cement joining will not be permitted for pipes and fittings larger than two (2) inches.

f. PVC pipe shall be connected to cast or ductile iron fittings with mechanical joints. Use of PVC fittings will not be permitted.

D. Rubber Gasket Joints

1. Rubber gasket joints for ductile iron pressure pipe, fittings, valves, hydrants and other appurtenances for water supply service shall conform to AWWA C111, latest edition. Lubricant, as recommended by the pipe manufacturer and approved by the Owner's Field Representative, shall be used for all pipe joints.

E. Mechanical Joint Fittings

1. Fittings shall be Ductile Iron Compact Fittings (3 inch through 24 inch) rated for 350-psi in accordance with AWWA C153, latest revision. Fittings shall be

furnished with Mechanical Joints in accordance with AWWA Specifications C111, latest revision. All joints shall be furnished complete with accessories consisting of cast iron follower glands, alloy bolts and nuts, and plain tipped rubber gaskets.

2. Mechanical joint restraint shall be incorporated into the design of the follower gland and shall be designed to fit standard mechanical joint bells with standard T-head bolts and shall conform to AWWA C111 and C153, latest editions. Glands shall be manufactured of ductile iron with a minimum factor of safety of 2. Glands shall be listed Underwriters Laboratory and/or Factory Mutual approved.

F. Underground Service Lines And Fittings

1. Underground service lines and fittings shall conform to AWWA C800, latest edition.

2. Service lines two and one half (2 ½) inches or less in diameter shall be Type K seamless copper water tube and fittings conforming to ASTM B88 and AWWA C800, latest revisions.

PART 3 – EXECUTION

3.1 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.

3.2 INSTALLATION

A. Buried Pipe

1. General

a. Trenches shall be dug to the depth required for pipe installation as shown on the drawings, as required to place piping over or under underground structures with a minimum of twelve (12) inches clearance, as may be required by these specifications, or directed by the Engineer.

b. When installing pipes on curves, the intent is to install to the staked alignment. The pipe shall be kept in alignment by placing bends on the curve as required to maintain the required alignment. If pipe deflections

must be constructed, the deflection per joint shall be limited to 50 percent (50%) of the manufacturer's recommended maximum deflection.

c. All piping except storm drainage piping will require warning type and tracing wiring placed at specified height in accordance with standard industry practices.

2. Potable Water Pipe

a. When potable water piping is installed parallel to sanitary sewer or drainage piping, a minimum horizontal separation of ten (10) feet shall be maintained. Where this separation cannot be maintained, a minimum of three (3) feet horizontal and eighteen (18) inches vertical separation shall be maintained with the water line located above the sanitary or drainage line. Separation distance shall be measured from the outside wall from each pipe.

b. Where potable water lines cross sanitary sewer or drainage piping, there shall be a minimum vertical separation distance of eighteen (18) inches between the potable water and sanitary sewer or drainage pipe. This shall be the case whether the potable water pipe is above or below the sanitary sewer or drainage pipe with preference to locating the potable water line above the crossed sanitary or drainage pipe. At all potable water and sanitary sewer or drainage pipe crossings, one full length of pipe shall be located so that both potable water pipe joints will be located as far from the crossed pipe as possible.

c. Where potable water and fire protection lines are above ground the pipe should be painted and labeled in accordance with the internal painting scheme.

d. Where this separation distance cannot be maintained, the sanitary sewer, drainage pipe, or potable water line shall be concrete encased as shown on Contract Drawings following approval by the Engineer.

B. Cleaning Pipe

1. The inside of all pipe and fittings shall be cleaned by brushing and by thoroughly blowing out with air to remove slag, dirt and other sediment, as well as other foreign materials, before being installed. During installation, sufficient care shall be exercised to prevent foreign matter from entering the lines. Use temporary closures during construction to protect open ends of pipe.
2. After installation and testing have been completed, all water lines and drainage systems shall be flushed clean and air, vacuum and gas lines shall be blown clean with dry compressed air.

C. Handling of Pipe

1. Proper and suitable tools and appliances for the safe and convenient handling and laying of all pipes and fittings shall be used. Care shall be taken to prevent the pipe coating from being damaged, particularly on the inside of the pipes and fittings and any damage shall be remedied as directed by the Engineer. No pipe and/or fittings shall be laid which are known to be defective. If any defective pipe is discovered after having been laid, it shall be removed and replaced with sound pipe or fittings in a satisfactory manner by the Contractor at his own expense.

2. All pipe shall be laid to proper line and grade. Open ends of pipe shall be kept plugged with a bulkhead during construction.

D. Cutting of Pipe

1. Whenever pipe requires cutting, it shall be done with an approved pipe cutter in such a manner as to leave a smooth end at right angles to the axis of the pipe; cutting by hammer and cold chisel will not be permitted. When a piece of pipe is cut, no direct compensation will be made for the portion cut off and not used in the line.

E. Manual Valve Operators

1. Wrenches and keys for the operation of buried water valves provided with operating nuts shall be furnished in accordance with the following schedule:

SERVICE	NO. OF UNITS	REMARKS
Buried Valves	Four (4) T-Bars (Various lengths)	For operating nuts furnish inverted combination key type; lengths to be determined based on actual bury

F. Sequence of Work

1. Excavation, cleaning, laying, jointing and backfilling of buried pipe shall be performed as promptly as possible upon completion of the previous operation. In no case shall pipe be left in the trench overnight without completing jointing. Trenches shall be partially backfilled or protected immediately after pipes are laid and joints inspected by the Engineer, unless other protection of the pipeline is directed. This partial backfilling does not imply approval of the buried pipe nor does it relieve the Contractor of the responsibility of locating to repair or replace defective work subsequent to testing. Normally, partial backfilling shall not follow lengths of pipe. The completed pipe line shall never be left exposed in the

trench unnecessarily. Each day at the close of work and at all times when laying is not in progress, the exposed end of the pipe line in the trench shall be closed by the use of an approved pipe plus, bulkhead or barrier of wood or metal. If at any time it becomes necessary to cover the end of an uncompleted pipe line with backfill, the end of the pipe shall be closed using a mechanical joint plug for cast or ductile iron pipe or a suitable closure for other types of pipe.

G. Restraining Joints

1. The joints will be restrained by Mega Lug Joints two connections or 30 feet on any side of a joint or fitting as specified in section 33 11 13 Water Distribution Piping.

3.3 SERVICE LINES

A. General Requirements

1. The Contractor shall make all required connections of the building water service lines into the onsite water system where and as shown on the Drawings. Work shall include making the service line connections into the onsite water system, furnishing and installing all service line pipe from the existing onsite water system to points located five (5) feet outside of the proposed building lines and properly sealing the ends with watertight plugs. Service line extensions from these points into the building will be performed by others.

B. Coordination with Building Contractor

2. The Contractor will be required to coordinate his Work with the work of the Plumbing Contractor to determine the exact location and elevation of the point of entry into the building. If the Plumbing Contractor has installed his portion of the water service line, Work under this Contract shall also include final connection of the water service line five (5) feet outside the building line to the building service line at no additional cost to the Owner.

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3.3 TESTING

A. General

1. The piping system of this specification shall be tested as indicated on the attached piping schedule and in the manner described below. Each test shall be performed in the presence of the Engineer. The Contractor shall provide water, air, and all

labor, equipment and accessories required to perform the tests at no additional cost to the Owner.

B. Water Mains

1. Hydrostatic Testing

a. Pressure testing of new water main installation shall be performed in accordance with ANSI/AWWA C600-82 Section 4 standards. Below are excerpts of said standard. The testing methods described in this Section are specific for water-pressure testing. These procedures should not be applied for air-pressure testing because of the serious safety hazards involved.

2. Pressure Test

a. After the pipe has been laid, all newly laid pipe or any valved section thereof shall be subjected to a hydrostatic pressure of at least 1.5 times the working pressure at the point of testing.

3. Test Pressure Restrictions

a. Test pressure shall:

i. Not be less than 1.5 times the work pressure at the highest point along the test section.

ii. Not exceed pipe or thrust-restraint design pressures.

iii. Be of at least 2-hour duration.

iv. Not vary by more than ±5 psi for the duration of the test.

v. Not exceed twice the rated pressure of the valves or hydrants when the pressure boundary of the test section includes closed gate valves or hydrants. NOTE: Valves shall not be operated in either direction at differential pressure exceeding the rated pressure.

vi. Not exceed the rated pressure of the valves when the pressure boundary of the test section includes closed, resilient-seated gate valves or butterfly valves.

4. Pressurization

a. Each valved section of pipe shall be filled with water slowly and the specified test pressure, based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Engineer. Valves shall not be operated in either the opening or closing direction of differential pressures above the rated pressure. It is good practice to allow the system to stabilize at the test pressure before conducting the leakage test.

5. Air Removal

a. Before applying the specific test pressure, air shall be expelled completely from the pipe, valves, and hydrants. If permanent air vents are not located at all high points, the contractor shall install corporation cock at such points so that the air can be expelled as the line is filled with water. After all the air has been expelled, the corporation cocks shall be closed and the test pressure applied. At the conclusion of the pressure test, the corporation cocks shall be removed and plugged or left in place at the discretion of the Engineer.

6. Examination

a. Any exposed pipe, fittings, valves, hydrants and joints shall be examined carefully during the test. Any damage or defective pipe, fittings, valves or hydrants that are discovered following the pressure test shall be repaired or replaced with sound material, and the test shall be repeated until it is satisfactory to the Engineer.

7. Leakage Test

a. The leakage test shall be conducted concurrently with the pressure test.

8. Leakage Defined

a. Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe, or any valved section thereof, to maintain pressure within 5 psi of the specified test pressure after the air in the pipeline has been expelled and the pipe has been filled with water. Leakage shall not be measured by a drop in pressure in a test section over a period of time. When hydrants are in the test section, the test shall be made against the closed hydrant. Allowable leakage at various pressures is shown in Table 1.

9. Acceptance of Installation

a. Acceptance shall be determined on the basis of allowable leakage. If any tested pipe laid discloses leakage greater than that specified in Table 1, the contractor shall, at his own expense, locate and make repairs as necessary until the leakage is within the specified allowance. All visible leaks are to be repaired regardless of the amount of leakage.

Table 1 - Allowable Leakage per 1000 ft. of Pipeline* - gph

Avg Test Pressure Psi	6	8	10	12	14	16	18	20	24	30
300	0.78	1.04	1.30	1.56	1.82	2.08	2.34	2.60	3.12	3.90
275	0.75	1.00	1.24	1.49	1.74	1.99	2.24	2.49	2.99	3.73
250	0.71	0.95	1.19	1.42	1.66	1.90	2.14	2.37	2.85	3.56
225	0.68	0.90	1.13	1.35	1.58	1.80	2.03	2.25	2.70	3.38
200	0.64	0.85	1.06	1.28	1.48	1.70	1.91	2.12	2.55	3.19
175	0.59	0.80	0.99	1.19	1.39	1.59	1.79	1.98	2.38	2.98
150	0.55	0.74	0.92	1.10	1.29	1.47	1.66	1.84	2.21	2.76
125	0.50	0.67	0.84	1.01	1.18	1.34	1.51	1.68	2.01	2.52
100	0.45	0.60	0.75	0.90	1.05	1.20	1.35	1.50	1.80	2.25

*If the pipeline under test contains sections of various diameters, the allowable leakage will be the sum of the computed leakage for each size.

3.4 DISINFECTION

A. General

1. All potable water piping shall be disinfected with liquid sodium hypochlorite following completion and testing of system piping. The Contractor shall provide all labor, equipment, materials and accessories necessary to disinfect the piping at no additional cost to the Owner including:

   a. Furnishing and installation of chlorination taps.

   b. Cost and services for the drawing of an analysis of samples by a New York State certified laboratory approved by the Engineer.

   c. Submission of ten (10) certified copies of the water analysis report to the Engineer.

   d. Retesting of water samples and resubmission water analysis report as required until a passing water analysis is obtained.

A. Disinfection Procedure

1. The system shall be disinfected in accordance with AWWA C601, latest edition. The Contractor shall open and close all valves in the water lines being disinfected several times during the eight-hour period.

2. Disinfection procedures shall be repeated as required until a passing water analysis is obtained.

C. Flushing

1. All potable water piping shall be flushed prior to disinfection in order to remove any foreign material that may interfere with disinfection or reduce the water quality. This shall be done after completion of the pressure and leakage testing.

2. Flushing shall also be performed after disinfection, in accordance with the required period of ANSI/AWWA C601.

3. After final flushing and before the new main is connected to the distribution system, two (2) consecutive sets of acceptable samples, taken at least 24-hours apart, shall be collected from the new main. A minimum of one (1) sample shall be collected for every 1200 linear feet of water main, plus (1) one set from the end of the line and at least one (1) set from each branch.

4. Samples of water shall be collected and taken to a Certified Testing Laboratory for bacteriological analysis. If the samples fail to meet the Standards for Drinking Water, then the water mains shall be re-flushed and re-sampled. If check samples fail to provide acceptable results then the water mains shall be re-chlorinated and the procedure repeated until satisfactory results are obtained.

5. Flushing shall be done through a convenient hydrant or blow-off at a velocity of 2.4 fps to obtain proper flushing action. Table 2 provides some information on how much water must be used to adequately flush various pipe sizes.

Table 2 - Required Flow and Openings to Flush Pipelines (40-psi Residual pressure in Water Main)

Pipe Diameter (in)	Flow Required to Produce 2.5 fps (approx.) Velocity in gpm	Size of Tap (in)			Number of 2 1/2 in hydrant outlets *
		1	1-1/2	2	
		Number of Taps on Pipe**			
4	100	1	-	-	1
6	200	-	1	-	1

8	400	-	2	1	1
10	600	-	3	2	1
12	900	-	-	3	2
16	1600	-	-	4	2

* With a 40-psi pressure in the main with the hydrant flowing to atmosphere, a 2 –1/2-in hydrant outlet will discharge approximately 1000 gpm and a 4-1/2 inch diameter hydrant nozzle will discharge approximately 2500 gpm.

** Number of taps on pipe based on no significant length of discharge piping. A 10-ft length of galvanized iron (GI) piping will reduce flow by approximately one third.

3.5 THRUST BLOCKING

A. Where water mains change horizontal or vertical directions at hydrants, tees and other fittings, the Contractor shall construct thrust and anchor blocks as detailed on the Drawings. Thrust blocks shall be constructed to transmit forces to undisturbed soil.

B. In leau of thrust blocks the contractor may use restrained type joints. The contractor shall provide shop drawings, layout and specifications for approval.

3.5 INSPECTION

A. During such inspection, the pipelines and structure shall be clean; they shall be dewatered, if required, by the Contractor. In no case will the final acceptance be given until the Contractor has complied with all the requirements set for and the Engineer has made his final inspection of the entire work and is satisfied that the entire work is properly and satisfactorily constructed and will operate in accordance with the requirement of the contract documents.

PIPING SCHEDULE

SYSTEMS	Location Inside	Location Outside	Piping Material	Piping Spec Section	Testing Method	Testing PSIG	Thrust Block Schedule	Remarks
Potable Water and Fire Water Service								
4 inch and larger w/ cover ≥ 4 ft	X (Flange)	X (Push-on & MJ)	PVC	331113	Water	175	See Contract Drawings	Provide thrust block or Megalug 2 joints or 40 ft
4 inch and larger w/ cover < 4 ft	X (Flange)	X (Push-on & MJ)	PVC	331133	Water	175	See Contract Drawings	
Water Service Lines		X	Type K Copper	-	Water	175	See Contract Drawings	

1. Abbreviations

   CISP-Cast Iron Soil Pipe
   PVC-Polyvinyl Chloride Pipe
   SS-Stainless Steel Pipe
   Steel-Galvanized Steel
   BSS-Black Seamless Steel Pipe
   PE-Polyethylene Pipe
   DI-Ductile Iron Pipe
   HJ-Harnessed Joint
   H-High Pressure (Thrust Block)
   I-Intermediate Pressure (Harnessed Joint or Thrust Block)

2. Ductile Iron Pipe for inside service shall be flanged, for outside service, PVC pipe with mechanical joint or push-on with mechanical fittings.

END OF SECTION 33 11 13

SECTION 33 12 16 WATER UTILITY DISTRIBUTION VALVES

PART 1 – GENERAL

1.1 DESCRIPTION

A. Work Included

1. Under this section the Contractor shall provide all labor, equipment and material necessary to furnish, install and test all valves required to complete the piping systems as shown on the drawings and specifications.

B. Related Work Described Elsewhere

1. Includes but is not limited to the following:

a. Section 31 20 00 – Grading, Excavation and Backfilling
b. Section 33 11 13 – Water Distribution Piping

1.2 QUALITY ASSURANCE

A. Standards

1. Comply with standards specified in these Specifications.

2. All materials and work (except water main pipe material) shall comply with the Suez Water New York, Inc "Specifications for the Purchase of Materials and Installation of Water System Appurtenances", dated 5/25/2017.

3. Comply with AWWA, ANSI, ASTM, NFPA, NEC and all other applicable Federal, State and Municipal codes and regulations including revisions to date of Contract.

4. In all cases where a device or part of the equipment is referred to in this Section in the singular (such as "valve"), it is intended that such references shall apply to as many such devices as are required to complete the installation.

5. Comply with NYSDOT regulations including revisions to date of Contract.

6. Comply with all applicable sections of these Specifications.

B. Qualifications of Manufacturers

1. Products used in the work of this section shall be produced by manufacturers regularly engaged in the manufacture of similar items and with a history of successful production acceptable to the Engineer.

1.3 SUBMITTALS

A. General

1. Submit shop drawings in accordance with Section 01340 – "Submittals".

B. Product Data

1. Manufacturer's specification and other data required to demonstrate compliance with specific requirements.

a. Such submittals shall include certified records of physical, chemical and other pertinent tests and/or certified statements from the manufacturer that the materials have been manufactured and tested in conformity with the specifications.

2. Complete Shop Drawings of all work of this Section, showing dimensions and locations of all items.

3. Valves when applicable should comply with Department of Health requirements.

C. Operation and Maintenance Manuals

1. Within thirty (30) days after receiving approved shop drawings, and as a condition of its acceptance, deliver to the Engineer six (6) sets of Manufacturer's Operation and Maintenance Manuals.

1.04 PRODUCT HANDLING

A. Protection

1. Use all means necessary to protect materials of this Section before, during and after installation and to protect installed work and materials of all other trades.

B. Replacements

1. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the owner.

C. Valve Identification

Cast markings shall appear on each valve, identifying the following:

1. Manufacturer's name or mark

2. Size of valve (pipe size)

3. Working pressure

4. Year of valve manufacturer

5. Flow direction arrow (required for swing check valves, rate of flow valves, plug valves, pressure reducing valves and pressure relief valves only).

PART 2 – PRODUCTS

2.01 GENERAL

A. Design

1. Where used, the names of manufacturers and specific catalog numbers are given only as an indication of the quality of the materials and workmanship to be used.

2. For uniformity, all valves of a particular type shall be furnished by one manufacturer.

3. Where valves are to be motor operated, the valve manufacturer shall furnish all necessary information to the operator manufacturer. The Contractor shall coordinate all activities between the two manufacturers and have the ultimate responsibility to provide a matched valve and operator complete and in place.

B. Painting

1. Buried valves are to receive two bituminous seal shop coats before shipping.

C. End Connections

1. Unless specified otherwise, all valve end connections shall match the piping they are to be installed in as described in Section 33 11 13 Water Distribution Piping and in the specific piping sections.

2.02 PRODUCTS

A. Gate Valves, Valve Boxes, Corporation Stops, Curb Stops

1. Materials shall be per the Suez Water New York, Inc "Specifications for the Purchase of Materials and Installation of Water System Appurtenances", dated 5/25/2017.

B. Double Check Detector Valves

1. DCCR Assembly w/Detector Meter Watts Series 709 DCDA Double Check Detector Assembly with UL/FM OS & Y resilient seated gate valves or approved equal from list in the Environmental Health Manual published by New York State Department of Health.

C. Reduced Pressure Zone Valve

1. Reduced Pressure Zone (RPZ) backflow preventer Watts Series 909 Reduced Pressure Zone assembly W/UL/FM OS & Y resilient seated gate valves and 909 AG-M air gap or approved equal from list in the Environmental Health Manual published by New York State Department of Health.

D. Check Valve

1. Check Valves Two Inches (2") and Larger

a. All check valves two inches (2") and larger shall meet the requirements of AWWA C-508 and shall be manufactured by G.A. Industries, Mars, PA, APCO or equal. Check valves installed on ferrous metal pipelines shall be iron body, bronze trimmed swing check valves with outside lever and weight, suitable for 175 PSI working pressure, with flanged or screwed ends. Flange shall be flat-faced, Class 175 pounds ANSI Standard.

b. Furnish the following in accordance with AWWA C508 for approval by the Engineer prior to shipment:

a. Section 1.4, Affidavit of Compliance; and
b. Section 5, certified shop test.

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 all unsatisfactory conditions have been corrected.

B. An inspection by United Water will be conducted and all discrepancies will be Resolved before acceptance of installation.

3.02 INSTALLATION

A. General

1. The installation procedures for valves shall be the same as for joining pipes with the same end connections.

2. All requirements by Suez Water shall be conformed to.

B. Buried and Submerged Valves

1. The excavation, backfilling and compaction of all buried valves shall be in accordance with the requirements of Section 31 20 00 – "Excavation and Backfilling".

2. Valve stems and extension stems shall be of a suitable size to provide for the satisfactory operation of the valve under all conditions. Threads shall be per Suez NY standards. Approved stem guides shall be provided where required. Guides shall be spaced not more than eight (8) feet on centers.

3. Four (4) valve shut off wrenches shall be furnished. Wrenches shall be a minimum of three feet long and of steel construction. If longer wrenches are required to operate the valves the contractor shall provide the appropriate length wrenches regardless of the cause to the owner at no cost. One end of crossbar handle shall be flattened like a chisel and the other end pointed for digging dirt or ice from box covers. The wenches shall be able to operate all valves

C. Cleaning Valves

1. The inside of the valves shall be cleaned by brushing and by thoroughly blowing out with air to remove slag, dirt and other sediment, as well as other foreign materials, before installed. During installation, sufficient care shall be exercised to prevent foreign matter from entering the valves.

D. Handling of Valves

1. Proper and suitable tools and appliances for the safe and convenient handling and laying of all valves shall be used. Care shall be taken to prevent the valve coating from being damaged, particularly on the inside of the pipes and fitting and any damage shall be remedied as directed. No valve shall be laid which are known to be defective. If any defective valve is discovered after having been laid, it shall be removed and replaced with a sound valve in a satisfactory manner by the Contractor at his own expense.

2. All valves shall be laid to proper line and grade. Open ends of valves shall be kept plugged with a bulkhead during construction.

3.03 FIELD TESTING

A. Valves shall be field tested as an integral part of the pipeline. Pipe lines including valves shall be tested as described in Section 33 11 13 – Water Distribution Piping.

3.04 DISINFECTION

A. All valves installed in fresh and domestic water lines shall be disinfected along with the pipeline as described in Section 31 11 13 – Water Distribution Piping and comply with Suez NY, NYSDOT/local and state regulations.

END OF SECTION 33 12 16

SECTION 33 12 19 FIRE HYDRANTS

PART 1 – GENERAL

1.2 DESCRIPTION

A. Work Included

1. Under this section the Contractor shall provide all labor, equipment and materials necessary to furnish, install and test service hydrants in accordance with Section 33 11 13 and as shown on the drawings, specified herein and approved by the Engineer.

2. Drawings and general provisions of the contract including general and supplementary conditions and Divisions 1 & 3 specification sections apply to this Section.

B. Related Work Described Elsewhere

1.	Water Distribution Piping	Section 33 11 13
2.	Water Utility Distribution Valves	Section 33 12 16

1.3 QUALITY ASSURANCE

A. Standards

All materials and labor furnished under this section shall:

1. Comply with standards specified herein as listed in these Specifications.

2. Comply with Suez NY standards.

3. Comply with AWWA, ANSI, ASTM, NFPA and all other applicable Federal, State and Municipal codes and regulations including revisions to date of Contract.

4. In all cases where a device or part of the equipment is referred to in this Section in the singular (such as “strap”), it is intended that such references shall apply to as many such devices as are required to complete this installation.

5. Comply with all applicable sections of these Specifications.

B. Qualifications of Manufacturers

1. Products used in the work of this section shall be produced by manufacturers regularly engaged in the manufacture of similar items and with a history of successful production acceptable to the Engineer.

1.4 SUBMITTALS

A. General

1. Submit shop drawings in accordance with Section 01340 – "Submittals"

B. Product Data

1. Manufacturer's specification and other data required to demonstrate compliance with specific requirements.

2. A complete bill of materials list showing all items to be furnished and installed under this Section.

3. Complete Shop Drawings of all work of this Section, showing dimensions and locations of all items.

C. Operation and Maintenance Manuals

1. Within thirty (30) days after receiving approved shop drawings, and as a condition of its acceptance, deliver to the Engineer six (6) set of Manufacturer's Operation and Maintenance Manuals for the equipment supplied.

1.5 PRODUCT HANDLING

A. Protection

1. Use all means necessary to protect materials of this Section before, during and after installation and to protect installed work and materials of all other trades.

B. Replacements

1. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Railroad.

PART 2 – PRODUCTS

2.1 HYDRANTS

A. Hydrants shall meet or exceed all applicable requirements and tests of ANSI and the latest revisions of AWWA Standard C-502. Hydrants shall be UL Listed and FM approved. Hydrants shall be rated for a working pressure of 250 psi. Hydrants shall be of a true compression type, opening against pressure and closing with the pressure. The hydrant main valve seat shall be 5-1/4 inches in diameter, and be reversible in design.

B. Hydrants shall be a three-way design, having one NST 4-1/2 inch pumper nozzle and two 2-1/2 inch hose nozzles. All nozzles shall thread into the hydrant barrel and shall be field replaceable. The operating nut shall be of one-piece design, 1-1/2 inch pentagon in size and shape. The direction of opening shall be LEFT (counter-clockwise). The bonnet assembly shall be provided with an oil reservoir and lubricating system that automatically circulates lubricant to all stem threads and bearing surfaces each time the hydrant is operated.

C. Hydrants shall be of the traffic-model design, provided with a stainless steel, torque diverting coupling and safety flange on the lower barrel. The hydrant shall be equipped with two drain valves which drain the barrel when the hydrant is closed. The bronze seat ring shall thread into a bronze drain ring.

D. Hydrants shall have a 6-inch MJ shoe and be a 5 foot bury, unless otherwise noted.

D. Hydrants shall be US Pipe Metropolitan / M94 5’0” bury or approved equal.

2.2 FROST-PROOF HYDRANT

Frost-proof hydrants shall be of a non-freezing design, bronze exposed head with cast iron casing guard, galvanized removable key and bronze casing. Minimum depth of bury shall be three feet.

Frost-proof hydrants used in supplying plant water shall be 1-1/2 inch, as manufactured by Jay R. Smith Manufacturing Co., Model 5913, Josam or equal.

PART 3 – EXECUTION

3.1 Hydrants shall be located as shown on the Contract Drawings or as directed by the Engineer. Unless otherwise shown on the Contract Drawings or directed by the Engineer, hydrants shall be set behind the curb line so that the barrel of the hydrant is 14 inches from the curb line or gutter face of the curb. All hydrants shall stand plumb, and shall have their large cutlet (suction hose connection) facing toward the street at right angles to the curb line. They shall conform to the established grade, with the center of the large outlet 15 inches above the established grade of the sidewalk or curb, and with the break-away collar 3 inches above grade.

3.2 Each hydrant shall be connected to the main pipe with a 6-inch branch, controlled either by a tapping valve or by an independent 6-inch gate valve.

3.3 The bowl or elbow shall be well braced against undisturbed surfaces, under the elbow and just above the joint to the hydrant barrel, with substantial blocking. Also, the hydrant barrel shall be blocked one-third down the trench depth. The hydrant elbow, branch and valve shall be tied together by straps and tie rods.

3.4 The hydrant shall be set on one (1') foot of crushed stone or screened gravel. Additional screened gravel or crushed stone shall be placed around the barrel to a height one (1') foot above the drop opening. No hydrant drainage pit or drain shall be connected to a sewer or storm water drain.

3.5 The hydrants will be blocked by providing concrete thrust block whenever necessary and in accordance with manufacturers suggestions.

3.6 Upon completion of the installation and as a condition of its acceptance, provide all necessary equipment and personnel and perform all tests and retests making all adjustments necessary for the equipment to operate as specified.

END OF SECTION 33 12 19

SECTION 33 14 23 HEATED INSULATED ENCLOSURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included

1. Under this section the Contractor shall provide all labor, equipment and material necessary to furnish and install a manufactured heated insulated enclosure. The enclosure will incorporate the following features to provide for freeze protection, positive drainage to prevent submergence of the assembly, security, and accessibility for testing and repair.

2. Provide and install one (1) sectional building manufactured by Hot Box or approved equal that shall meet or exceed the following criteria:

   a. The enclosure must maintain an interior temperature of +40 degrees F with an exterior Temperature of -30 degrees F and a wind Velocity of 15 MPH.

   b. The enclosure must be able to support a snow load of 35 psf

   c. The structure must be able to with stand a wind load of 30 psf and 37 psf in corner zones (defined as extending 3 feet from each corner of the box.

   d. Access to all equipment as shown on the contract plans.

   e. Lighting to provide 10 candelas of light to all components with enclosed switches on both sides of the enclosure. All electrical components rated NEMA 4X.

   f. Grounded power outlets on both sides of the enclosure.(NEMA 4X)

3. A concrete slab that accommodates the piping and related equipment as shown in the plans, but is designed to provide for the drainage of the interior of the building, penetrations and anchoring of the building.

4. All yard piping, electrical connection, piping fittings and appurtenances to provide a complete installation.

B. Related Work Described Elsewhere

1.	Grading, Excavation and Backfill	Section 31 20 00
2.	Erosion and Sediment Control	Section 31 25 00
3.	Valves	Section 33 12 16
4.	Pipe and Pipe Fittings	Section 33 11 13

1.2 SUBMITTALS

A. General

1. Submit shop drawings in accordance with 01340 – “Submittals”.

2. Submit Operation and Maintenance manuals in accordance with section 1390

B. Product Data Required

1. Manufacturer’s specifications and other data required to demonstrate compliance with the specific requirements of this Section.

2. Complete shop drawings of all work of this Section, showing dimensions and locations of all items including supporting structures and clearance requirements. Specific items to be provided include but are not limited to the following:

a. Reinforcing
b. Anchoring
c. Floor sleeves
d. Inserts and other embedded items
e. Wall connections
f. Joint details
g. Load tables
h. Dimensions
i. Materials
j. Manufacturer’s specifications
k. Heating Equipment
l. Lighting Equipment
m. Electrical Appurtenances

C. Design Calculations

1. Where structure design varies from that shown or specified in the Contract Documents, complete design calculations prepared under the supervision of and

stamped by a Professional Engineer registered in the State of New York shall be provided.

D. Certifications

1. The premanfactured structures should be in accordance with A.S.S.E. 1060 and a statement of certification of the manufacturer by the A.S.S.E. shall be provided.

E. Samples

1. Submit for review samples of wall exterior material and colors available and the roof materials and color available.

1.3 QUALITY ASSURANCE

A. Codes and Standards

1. All materials and labor furnished under this Section shall:

a. Comply with ASTM, ANSI, AASHTO and all other applicable Federal, State and Municipal codes and regulations including revisions to date of Contract.

b. In all cases where a device or part of equipment is referred to in this Section in the singular (such as “strap”), it is intended that such references shall apply to as many such items or devices as are required to complete the installation.

2. Referenced Specifications

a. The New York State Department of Transportation Standard Specifications (NYS-DOT Specifications) for Construction and Materials, January 1, 2019 and Latest Revisions, plus addenda when referred to, shall become part of this specification for materials and construction requirements. A referenced New York State (NYS) Pay Item Number shall serve the required work for this project providing materials and construction conforming to all applicable requirements under the NYS-DOT Specifications for that New York State Item, except for measurement and payment. The measurement and payment section of the NYS-DOT Specification shall not apply as all work under this Section shall be included in the Contractor’s lump sum bid for this Contract. Where the New York State DOT Specifications cite requirements differing from those included or specified elsewhere in these

Contract Documents, the more stringent, highest quality requirement shall apply.

b. ASTM C B209, “Mill Finish Aluminum” Where the referenced ASTM Specification cites requirements differing from those included or specified elsewhere in these Contract Documents, the more stringent, highest quality requirement shall apply.

B. Qualifications of Manufacturers

1. Products used in the work of this Section shall be produced by those who are regularly engaged in the production and/or supply of similar items for at least five (5) years and which have a history of successful production, acceptable to the Engineer.

C. Qualification of Installers

1. Use adequate number of skilled workmen who are thoroughly trained in the specific requirements and methods needed for proper performance of work of this Section.

1.4 PRODUCT HANDLING

A. Protection

1. Use all means necessary to protect the materials of this Section before, during and after installation and to protect installed work and materials of other trades.

B. Replacement

1. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Owner.

C. Protection of Utilities

1. Protect all existing utilities in the course of excavation, installation, and backfilling procedures.

PART 2 – PRODUCTS

2.1 GENERAL

A. Design and Scope of Work for Heated Insulated Building

1. Furnish all labor, materials, equipment and appurtenances required to install, test and make completely ready for operation a Heated Insulated Enclosure.

B. Manufacturer

1. Factory or field assembled building shall be manufactured by Hot Box, Jacksonville Florida or approved equal.

2. Options shall include lighting, heating, ventilating and other accessories and be the standard equipment of the manufacturer or as specified by the engineer in the plans and listed under optional equipment or items.

C. The Heated Insulated Enclosure

1. The Enclosure shall be sized as specified on the construction drawings. The building shall be able to withstand a wind load of 30 psf on the walls, 37 psf in the corner zones and a snow load of 35 psf.

2. The building and roof exterior surface shall be a green gel coat with a low luster that is free from fiber pattern, roughness, or other irregularities. Color samples (varieties of green) will be provided to the Owner in the submittal package for selection and use). VII Adhesive applied board stock or material secured by mechanical fasteners shall be cause for rejection.

3. Acceptable materials:

   a. Mill finish aluminum, ASTM B209.

   b. Gel coated fiberglass mat.

4. Insulation shall be polyisocyanurate foam: spray applied, frothed in place or board stock laminated between two (2) layers of fiberglass mat. The insulation shall have the following properties.

   a. Dimensional stability – less than 2% linear change.
   b. Comprehensive strength – 20 PSI.
   c. Water absorption – less than 1% by volume.
   d. Density – nominal 2.0 lbs. per cubic foot.
   e. Flame spread – 25.
   f. Service temperature – 100 degrees F to 250 degrees F.
   g. Insulation thickness shall be 1” for enclosures up to 2” IPS and 1.5” for 2.5 “ IPS and above.

h. Adhesive applied board stock or material secured by mechanical fasteners shall be cause for rejection.

5. Structural member shall be aluminum or fiberglass.

a. No wood or “particle board shall be allowed in assembly.

2.2 COMPONENTS

A. The roof, walls and access panels shall be constructed of the specified materials in the specified thicknesses.

B. Multi-sectional enclosures shall fit together with overlapping “tongue and groove” joints and be secured internally with mechanical fasteners.

C. The enclosure shall be securely attached to a concrete base with anchor brackets installed on the interior of the enclosure itself or through a stainless steel anchor hinge.

D. Access panels shall be provided to allow easy access for operation, maintenance and testing of backflow prevention assembly without removal of assembly.

E. Access panels shall be secured with padlock hasps and staples.

F. Drain openings shall be designed to remain closed except when device is discharging water. Openings shall be designed to accommodate the maximum discharge of the device, and, shall protect against intrusion of wind, debris and animals, through the use of separate aluminum screen and wind flaps.

2.3 HEATING EQUIPMENT

A. Heating equipment shall be furnished and designed by the manufacturer of the enclosure to maintain an interior temperature of +40 degrees F with an exterior outside temperature of –30 degrees F and a wind velocity of 15 MPH.

1. The factory assembled heating equipment shall be UL, ETL, or CSA certified.

2. Field assembled heater parts shall be cause for rejection.

B. Electric power source for heat and accessories shall be G.F.I. protected, with 18” clearance from receptacle base to grade.

2.4 MOUNTING HARDWARE

A. Door latch, two point, padlockable stainless steel exterior.

B. Mounting hardware shall be furnished and shall be stainless steel.

C. All assembly fasteners shall be stainless steel or aluminum.

D. Anchor hardware shall be adjustable up to 1.5” vertically to accommodate uneven concrete slabs.

2.5 OPTIONAL EQUIPMENT

A. Lighting shall be able to provide for 2 candelas of light at any area of the enclosure.

B. Exhaust fan with gravity shutter including canopy with insect screen 10” minimum.

C, Fiberglass intake louver 12” square with gravity shutter and insect screen

2.6 CONCRETE PAD

A. The installation of this pad will be made in Plans and Specifications, accordance with the submittal shop drawings, Specification Section 03300 and good construction practices.

B. The concrete used must be 4000 PSI or greater.

C. The edges of the concrete shall have beveled edges.

PART 3 - INSTALLATION

A. Enclosure shall be assembled and mounted on the concrete pad according to the Manufacturer’s instructions and the contract drawings.

B. Enclosure shall be installed plumb, level and square.

END OF SECTION 33 14 23

SECTION 33 31 13 SANITARY SEWERAGE PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included

1. Under this Section the Contractor shall provide all labor, equipment and material necessary to furnish, install and test all piping, fittings, valves and accessories required for the completion of the work as shown on the drawings and summarized in the attached piping schedule, including wall sleeves in all types of walls. The furnishing and installation of all pipe hangers, supports, braces and insulation, including anchor bolts and other concrete inserts and hardware required for the correct installation of all piping are also included in this Section and are covered more specifically in subsequent Sections of these specifications.

B. Standardization

1. Miscellaneous piping, valves and appurtenances supplied with the equipment to be furnished under other items shall conform to the requirements of this Section and subsequent piping Sections.

2. All valves and appurtenances of the same type shall be supplied by a single manufacturer.

3. All pipes and pipe fittings of the same type shall be supplied by a single manufacturer.

C. Related Work Described Elsewhere

1.	Grading, Excavating and Backfilling	Section 31 20 00
2 .	Drainage Structures	Section 33 49 13
3.	Manholes	Section 33 39 13
4.	Buried Pipe Identification	Section 33 05 26.23

1.2 SUBMITTALS

Submit shop drawings in accordance with 01340 – “Submittals”.

A. Product Data

1. Prior to the commencement of any work the Contractor shall furnish the Engineer with drawings for his review and approval indicating all piping systems and their component parts, including pipe hangers, supports and braces, as well as valves and other accessories along with a listing of recommended spare parts to be supplied with the equipment by the manufacturer. Drawings shall show subdivision of the piping for shop and field fabrication, plus the specifications of the materials being used and the method of proper installation. Detailing and installation of piping shall be coordinated with other piping and conduit to be furnished and installed under this contract.

2. For pipe, pipe fittings, valves, operators and appurtenances, the Contractor shall furnish to the Engineer, at the time of shop drawing submission, certified records of physical, chemical and other pertinent tests and/or certified statements from the manufacturer that the materials have been manufactured and tested in conformity with the specifications. Where such a small quantity of material is required as to make physical testing and chemical analysis impractical, a certificate from the manufacturer stating the results of such tests or analyses of similar materials that were concurrently produced, may at the discretion of the Engineer, be considered as the basis for acceptance of such materials.

3. Manufacturer's specifications and other data required to demonstrate compliance with the specific requirements.

4. A complete bill of materials list showing all items to be furnished and installed under this Section.

5. Complete shop drawings of all work of this Section, showing dimensions and locations of all items including supporting structures and clearance requirements.

1.3 QUALITY ASSURANCE

A. Standards

1. Comply with standards specified in these Specifications.

2. Comply with OSHA, ASTM, AWWA, ANSI and all applicable Federal, State and local codes and regulations regarding the proper manufacture, testing and installation of pipe and pipe fittings, including revisions to date of contract.

3. In all cases where a device or part of the equipment is referred to in this Section in singular (such as "valves"), it is intended that such references shall apply to as many such devices as are required to complete the installation.

B. Qualifications of Manufacturers

1. Products used in the work of this Section shall be produced by manufacturer regularly engaged in the manufacture of similar items and with a history of successful production acceptable to the Engineer.

1.4 PRODUCT HANDLING

A. Protection

1. Use all means necessary to protect the materials of this Section before, during and after installation and to protect installed work and materials of all other trades.

B. Replacements

1. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Owner.

C. Protection of Utilities

1. Protect all existing utilities in the course of excavation, installations, and backfilling procedures.

PART 2 – PRODUCTS

2.1 GENERAL

A. Design

1. Design is based on the use of products outlined on the attached piping schedule and as specified in subsequent Sections of this document. Where used, the names of manufacturers and specific catalog numbers are given as an indication of the quality of materials and workmanship to be used.

B. Pipe Identification

All pipe units shall be identified as to the following:

a. Pipe class
b. Date of manufacture
c. Manufacturer’s name or logo
d. Inside pipe diameter
e. Pipe material

PART 3 – EXECUTION

3.1 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.

3.2 INSTALLATION

A. Buried Pipe

1. General

a. Trenches shall be dug to the depth required for pipe installation as shown on the drawings, as required to place piping over or under underground structures with a minimum of twelve (12) inches clearance, as may be required by these specifications, or directed by the Engineer.

b. Certain buried piping shall be polyethylene encased in accordance with AWWA C105 using Class C (black) material and Installation Method A. The buried pipes which shall be polyethylene encased are defined in the piping schedule. All buried pipe shall also be installed in accordance with Section 31 20 00 – Excavating and Backfilling.

c. When installing pipes on curves, the intent is to install to the staked alignment. The pipe shall be kept in alignment by placing bends on the curve as required to maintain the required alignment. If pipe deflections must be constructed, the deflection per joint shall be limited to 50 percent (50%) of the manufacturer's recommended maximum deflection.

d. All piping except storm drainage piping will require warning type and tracing wiring placed at specified height in accordance with standard industry practices.

2. Potable Water Pipe

a. When potable water piping is installed parallel to sanitary sewer or drainage piping, a minimum horizontal separation of ten (10) feet shall be maintained. Where this separation cannot be maintained, a minimum of three (3) feet horizontal and eighteen (18) inches vertical separation shall be

maintained with the water line located above the sanitary or drainage line. Separation distance shall be measured from the outside wall from each pipe.

b. Where potable water lines cross sanitary sewer or drainage piping, there shall be a minimum vertical separation distance of eighteen (18) inches between the potable water and sanitary sewer or drainage pipe. This shall be the case whether the potable water pipe is above or below the sanitary sewer or drainage pipe with preference to locating the potable water line above the crossed sanitary or drainage pipe. At all potable water and sanitary sewer or drainage pipe crossings, one full length of pipe shall be located so that both potable water pipe joints will be located as far from the crossed pipe as possible.

c. Where potable water and fire protection lines are above ground the pipe should be painted and labeled in accordance with the internal painting scheme.

d. Where this separation distance cannot be maintained, the sanitary sewer, drainage pipe, or potable water line shall be concrete encased as shown on Contract Drawings following approval by the Engineer.

B. Cleaning Pipe

1. The inside of all pipe and fittings shall be cleaned by brushing and by thoroughly blowing out with air to remove slag, dirt and other sediment, as well as other foreign materials, before being installed. During installation, sufficient care shall be exercised to prevent foreign matter from entering the lines. Use temporary closures during construction to protect open ends of pipe.
2. After installation and testing have been completed, all water and sewage lines and drainage systems shall be flushed clean and air, vacuum and gas lines shall be blown clean with dry compressed air.

C. Handling of Pipe

1. Proper and suitable tools and appliances for the safe and convenient handling and laying of all pipes and fittings shall be used. Care shall be taken to prevent the pipe coating from being damaged, particularly on the inside of the pipes and fittings and any damage shall be remedied as directed by the Engineer. No pipe and/or fittings shall be laid which are known to be defective. If any defective pipe is discovered after having been laid, it shall be removed and replaced with sound pipe or fittings in a satisfactory manner by the Contractor at his own expense.

2. All pipe shall be laid to proper line and grade. Open ends of pipe shall be kept plugged with a bulkhead during construction.

D. Cutting of Pipe

1. Whenever pipe requires cutting, it shall be done with an approved pipe cutter in such a manner as to leave a smooth end at right angles to the axis of the pipe; cutting by hammer and cold chisel will not be permitted. When a piece of pipe is cut, no direct compensation will be made for the portion cut off and not used in the line.

E. Sequence of Work

1. Excavation, cleaning, laying, jointing and backfilling of buried pipe shall be performed as promptly as possible upon completion of the previous operation. In no case shall pipe be left in the trench overnight without completing jointing. Trenches shall be partially backfilled or protected immediately after pipes are laid and joints inspected by the Engineer, unless other protection of the pipeline is directed. This partial backfilling does not imply approval of the buried pipe nor does it relieve the Contractor of the responsibility of locating to repair or replace defective work subsequent to testing. Normally, partial backfilling shall not follow lengths of pipe. The completed pipe line shall never be left exposed in the trench unnecessarily. Each day at the close of work and at all times when laying is not in progress, the exposed end of the pipe line in the trench shall be closed by the use of an approved pipe plus, bulkhead or barrier of wood or metal. If at any time it becomes necessary to cover the end of an uncompleted pipe line with backfill, the end of the pipe shall be closed using a mechanical joint plug for cast or ductile iron pipe or a suitable closure for other types of pipe.

3.3 SERVICE LINES

A. General Requirements

1. The Contractor shall make all required connections of the building sanitary sewer service lines into the onsite sanitary sewer system where and as shown on the Drawings. Work shall include making the service line connections into the onsite sanitary sewer system, furnishing and installing all service line pipe from the existing onsite sanitary sewer system to points located five (5) feet outside of the proposed building lines and properly sealing the ends with watertight plugs. Service line extensions from these points into the building will be performed by others.

B. Coordination with Building Contractor

2. The Contractor will be required to coordinate his Work with the work of the Plumbing Contractor to determine the exact location and elevation of the point of entry into the building. If the Plumbing Contractor has installed his portion of the sanitary sewer service line, Work under this Contract shall also include final connection of the sanitary sewer service line five (5) feet outside the building line to the building service line at no additional cost to the Owner.

C. Connection into Offsite Sanitary Sewer System

1. Sanitary sewer service line connections to the pipe of the offsite sanitary sewer system as shown on the Drawings into existing manholes, new manholes, or the offsite mains in a manner satisfactory to the Construction Manager, Engineer and/or Governing Agency.

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3.3 TESTING

A. General

1. The piping system of this specification shall be tested as indicated on the attached piping schedule and in the manner described below. Each test shall be performed in the presence of the Engineer. The Contractor shall provide water, air, and all labor, equipment and accessories required to perform the tests at no additional cost to the Owner.

B. SANITARY SEWERS

1.General Requirements

a. The Contractor shall test the completed sewers, including manholes and laterals, for leakage by infiltration and exfiltration. The contractor shall also test the pipe with a mandrel test. The tests will be conducted as approved by the Construction Manager or Engineer or the Governing Agency. The Contractor shall furnish all necessary equipment, materials and labor for performing the tests as specified.

b. The Contractor shall notify the Construction Manager or Engineer, or the Governing Agency at least 48 hours prior to the start of testing. Testing shall only be performed in the presence of the Construction Manager or Engineer.

c. Sections of pipe tested prior to completion of the Project shall be subject to additional leakage tests, if warranted in the opinion of the Construction Manager, Engineer or the Governing Agency, prior to acceptance of the Project.

2.Low-Pressure Air Exfiltration Testing

a. The sewer mains and/or laterals shall be tested for leakage by the use of low-pressure air as specified hereinafter and as approved by the Construction Manager or Engineer. The test length shall not exceed one (1) interval of pipe between two (2) manholes. Air test procedures may be dangerous and the Contractor shall take all necessary precautions to prevent blowouts.

b. After the pipe has been backfilled and cleaned, pneumatic plugs shall be placed in the line at each manhole and inflated to 25 psi. Low-pressure air shall be introduced into this sealed line until the internal air pressure reaches 4 psi greater than the average back pressure of any ground water that may be over the pipe. At least two (2) minutes shall be allowed for the air pressure to stabilize.

c. After the stabilization period (3.5 psi minimum pressure in the pipe), the portion of line being tested shall be acceptable if the time required in minutes for the pressure to decrease from 3.5 to 3.0 psi (greater than the average back pressure of any ground water that may be over the pipe) is not less than the time indicated in the following table:

Pipe Size (In.)	Time (Min.)
4	2-1/2
6	4
8	5
10	6-1/2
12	7-1/2

3.Infiltration and Exfiltration Testing

a. The test length intervals for either type of leakage test shall be approved by the Construction Manager or Engineer, or the Governing Agency but in no event shall they exceed one thousand (1000) feet. In the case of sewers laid on steep grades, the length of line to be tested by exfiltration at any one time may be limited by the maximum allowable internal pressure on the pipe and joints at the lower end of the line.

b. The test period, wherein the measurements are taken shall not be less than four (4) hours in either type of test.

c. Depending on field conditions, the following tests for leakage shall be employed.

d. Infiltration Test- The test may be used only when ground water levels are at least two (2) feet above the top of the pipe for the entire length of the section to be tested during the entire period of the test. Ground water levels may be measured in an open trench or in standpipes previously placed in backfilled trenches during the backfilling operations. When standpipes are installed in the backfill for ground water measurement, the lower ends of these shall be satisfactorily embedded in a mass of crushed stone or gravel to maintain free percolation and drainage. Infiltration through joints shall be measured by using a watertight weir or any other approved device for volumetric measurement installed at the lower end of the section under test.

e. Exfiltration Test - This test consists of filling the pipe with water to provide a head of at least two (2) feet above the top of the pipe or two (2) feet above ground water, whichever is higher, at the highest point of the pipe line under test, and then measuring the loss of water from the line by the amount which must be added to maintain the original level. In this test the line must remain filled with water for at least twenty four (24) hours prior to the taking of measurements. Exfiltration shall be measured by the drop of water level in a closed-end standpipe or in one of the sewer manholes available for convenient measuring. When a standpipe and plug arrangement is used in the upper manhole of a line under test, there must be some positive method of releasing entrapped air in the sewer prior to taking measurements.

4.Leakage Requirements

a. The total leakage of any section tested shall not exceed the rate of 100 gallons per day per mile per inch of nominal pipe diameter. For purposes of determining the maximum allowable leakage, manholes shall be considered as sections of 48-inch diameter pipe, five (5) feet long, and the equivalent leakage allowance shall be 4.50 gallons per manhole per 24 hours.

3.5 INSPECTION

A. During such inspection, the pipelines and structure shall be clean; they shall be dewatered, if required, by the Contractor. In no case will the final acceptance be given until the Contractor has complied with all the requirements set for and the Engineer has made his final inspection of the entire work and is satisfied that the entire work is properly and satisfactorily constructed and will operate in accordance with the requirement of the contract documents.

PIPING SCHEDULE

SYSTEMS	Location Inside	Location Outside	Piping Material	Testing Method	Testing PSIG
Sanitary Sewers		X	PVC SDR 35	Sanitary	n/a

Notes: 1. Abbreviations

CISP-Cast Iron Soil Pipe
PVC-Polyvinyl Chloride Pipe
SS-Stainless Steel Pipe
Steel-Galvanized Steel
BSS-Black Seamless Steel Pipe
PE-Polyethylene Pipe
DI-Ductile Iron Pipe
HJ-Harnessed Joint
H-High Pressure (Thrust Block)
I-Intermediate Pressure (Harnessed Joint or Thrust Block)

END OF SECTION 33 11 13

SECTION 33 39 13 SANITARY MANHOLES

PART 1 – GENERAL

1.1 DESCRIPTION

A. Work Included

1. Under this Section the Contractor shall provide all labor, equipment and materials necessary to furnish, install and test all manholes complete in place, including frames, covers, steps, etc. and as shown on the drawings, specified herein and approved by the Engineer.

A. Related Work Described Elsewhere

1.	Grading Excavating and Backfilling	Section – 31 20 00
2.	Erosion and Sediment Control	Section – 31 25 00
3.	Site Drainage	Section – 33 40 00
4.	Drainage Structures	Section – 33 49 13

1.2 QUALITY ASSURANCE

A. General

1. Quality Assurance requirements shall be in accordance with the requirements of subsection 1.3 – Quality Assurance of Specification Section 02601 – “Drainage Structures”.

1.3 SUBMITTALS

A. General

1. Submittals shall be in accordance with the requirements of subsection 1.3 – Submittals of Specification Section 33 49 13 – “Drainage Structures”.

2. Shop drawings shall be in accordance with section 1340.

1.4 PRODUCT HANDLING

A. General

1. Product Handling requirements shall be in accordance with the requirements of Subsection 1.4 – Product Handling of Specification Section 33 49 13 – “Drainage Structures.”

PART 2 – PRODUCTS

2.1 GENERAL

A. Design Requirements Cited Elsewhere

1. All manholes shall meet the Town of Ramapo specifications for sanitary manholes.

2. All manholes shall meet or exceed the requirements of subsection 2.1 – "General" of Specification Section 33 49 13 – "Drainage Structures".

B. Pipe Penetrations in Precast Concrete Sections

1. Openings in manholes for sewers or drop connections will not be permitted closer than one foot from the nearest manhole section joint. Special base or riser sections shall be furnished as necessary to meet this requirement.

2.2 SANITARY MANHOLES

A. General

1. Joints between the base section, riser section, and cone section or top slab section of precast concrete of sanitary manholes shall be the tongue and groove or bell type employing a single, continuous rubber o-ring gasket and shall conform to AWWA C302.

2. Drop connections for sanitary manholes shall be constructed where shown or ordered and shall conform to the details shown. Concrete for encasement of external drop pipes shall be Class A concrete. Concrete encasement shall be bonded to the manhole with an epoxy bonding agent. The bonding agent shall be Rockwell "C" as manufactured by Preco Chemical Co. or equivalent.

3. An approved flexible, completely watertight joint shall be provided between each pipe entering or exiting sanitary manholes. This may be accomplished by the use of a flexible rubber boot, a-lock connector, or other means subject to the approval of the Engineer.

4. Manhole steps shall be provided and installed in all drainage structures. Manhole steps shall be designed and installed in accordance with requirements of NYSDOT Specification Section 725-02.

2.3 MANHOLE FRAMES AND COVERS

A. General

1 Provide the sizes and types of frames, covers, grates, and other metal castings shown on the Drawings, complete with all necessary accessories.

2 Castings shall be from best, merchantable gray cast iron, tough, even-grained and free from all flaws and injurious or unsightly defects, and shall be in accordance with ASTM A48-83 Class 30B.

3 Frames and covers, frames and grates shall be match marked.

4 No plugging, burning-in, or filling will be allowed.

5 Frames, covers and grates shall be designed to withstand an AASHTO H205-16 loading.

6 Frames, covers and grates shall be machined to insure proper fit and even bearing in all positions to prevent rocking and rattling under traffic.

7 Covers shall have lettering cast into their surface to indicate “STORM” or “SANITARY” or as indicated in the Contract Drawings.

PART 3 – EXECUTION

3.1 GENERAL

A. Installation Requirements

1. All manholes shall be installed in conformance with the requirements of Part 3 – “Execution” of Specification Section 33 49 13 – “Drainage Structures” except as modified herein.

B. Channels and Benches

1. All manholes shall be provided with an accurately formed channel and bench to convey flow through the manhole.

2. Manhole channel and benches shall be fabricated from Class A concrete.

3. The depth of manhole channels shall be equivalent to the diameter of the connected pipe entering or exiting the manhole plus two inches. Channel depth shall be uniform throughout the channel length.

4. Where two or more pipes enter the manhole, the constructed channels shall provide a smooth transition to the main flow exiting the manhole.

5. Manhole benches shall be provided with a slope of ¼-inch per foot toward the channel to promote drainage.

6. Manhole benches shall be provided with a non-slip, broom finish.

7. Manhole channels shall be provided with a steel trowel finish.

8. Manhole steps shall be oriented over the largest manhole bench. Manholes with steps located over channels will not be accepted.

9. The main flow-thru channel of rectangular manholes shall be located parallel to the long axis of the manhole.

3.2 SANITARY MANHOLES

A. Precast Concrete Sections

1. All manhole joints shall be sealed with cement mortar inside and out and troweled smooth to the contour of the wall.

B. Plastering

1. All grade rings, block and brick work shall be neatly plastered inside and out with ½-inch of cement mortar as the work progresses.

C. Watertightness

1. All manholes shall be free of visible leakage.

2. Each manhole shall be hydrostatically tested for leaks and inspected, all leaks shall be repaired in a manner subject to the approval of the Engineer.

3. Unless otherwise noted, conduct all manhole testing in the presence of the Engineer.

4. Notify the Engineer a minimum of two business days in advance of the testing.

E. Coatings and Linings

1. All exterior surfaces of sanitary manholes shall receive two 8 mil coats of high build shop applied asphalt base foundation coatings as approved by the Engineer.

2. Coatings shall be applied in accordance with the manufacturer's requirements.

3. Coatings shall be field touched up after installation.

3.3 GRADING AT MANHOLES

A. General

1. The Contractor shall be responsible for the proper height of all manholes necessary to reach final grade at all locations.

2. The Contractor is cautioned that the Engineer's review of shop drawings for manhole components will be general in nature. The contractor shall provide an adequate supply of random length precast manhole riser sections to adjust any manhole to meet field conditions for final grading.

B. Manholes in Unpaved Area

1. All manholes in unpaved areas shall be built as shown or as directed by the engineer to a rim elevation higher than the finished grade.

2. The ground surface shall be graded to drain away from the manhole.

3. Unless otherwise indicated, shown, or directed by the Engineer, fill shall be placed around the manhole to a the level of the upper rim of the manhole frame, and the surface evenly graded on a 1V:5H slope away from the manhole rim to the surrounding grade.

C. Manholes in Paved Areas

1. All manholes in paved areas shall be constructed so that the rim elevation of the manhole is no less than 1/16 inch and no greater than 1/8 inch below the paving top course.

2. Manhole with rims set at or above the pavement surface shall not be accepted. The frame and cover of manholes with rims set at or above the pavement surface shall have their frame and cover reset and pavement repaired to the satisfaction of the Engineer at no cost to the Owner.

END OF SECTION 33 39 13

SECTION 33 40 00 SITE DRAINAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included

1. Under this Section the Contractor shall provide all labor, equipment and materials necessary to furnish and install a stormwater drainage system complete in place, as shown on the drawings, specified herein and approved by the Engineer.

2. In general, work to be included under this section shall include, but not be limited to the following permanent drainage features.

   a. Storm sewer including catch basins, manholes and other structures.

B. Related Work Described Elsewhere

1.	Grading, Excavation and Backfilling	Section 31 20 00
2.	Erosion and Sediment Control	Section 31 25 00
3.	Drainage Structures	Section 33 49 13

1.2 QUALITY ASSURANCE

A. Standards

1. All equipment and labor furnished under this Section shall:

   a. Comply with OSHA, ASTM, ANSI and all other applicable Federal, State and Municipal codes and regulations including revisions to date of contract.

   b. Comply with the Town of Ramapo standards for site drainage structures.

   c. In all cases where a device or part of the equipment is referred to in this Section in the singular (such as “motor”), it is intended that such references shall apply to as many such devices as are required to complete the installation.

   d. Referenced specifications: The New York State Department of Transportation Standard Specifications (NYS-DOT Specifications) for Construction and Materials, January 1, 2019, plus addenda when referred to, shall become part of this specification for materials and construction

conforming to all applicable requirements under the NYS-DOT Specifications for that New York State Item, except for measurement and payment. The measurement and payment section of the NYS-DOT Specification shall not apply, as all work under this section shall be included in the Contractor's price bid for this Contract. Where the New York State DOT Specifications site requirements differing from those included in these specifications, the more stringent, highest quality requirement shall apply.

B. Qualifications of Suppliers

1. Products used in the work of this Section shall be produced by those who are regularly engaged in the production and/or supply of similar items for at least five (5) years and which have a history of successful production, acceptable to the Engineer.

C. Qualifications of Installers

1. Use adequate number of skilled workmen who are thoroughly trained and experience in the specified requirements and the methods needed for proper performance of the work of this Section.

1.3 SUBMITTALS

A. General

1. Submit shop drawings in accordance with Section 01340 – "Submittals".

B. Product Data

1. Manufacturer's specifications and other data required to demonstrate compliance with specific requirements.

a. Such submittals shall include certified records of physical, chemical and other pertinent tests and/or certified statements from the manufacturer that the materials have been manufactured and tested in conformity with the specifications.

2. Complete shop drawings of all work showing dimensions and locations of all items including supporting structures and clearance requirements.

1.4 PRODUCT HANDLING

A. Protection

1. Use all means necessary to protect the materials of this Section before, during and after installation and to protect installed work and materials of all other trades.

B. Replacements

1. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Owner.

C. Protection of Utilities

1. Protect all existing utilities in the course of excavation, installations, and backfilling procedures.

PART 2 – PRODUCTS

2.1 MATERIALS

A. High Density Polyethylene Pipe and Appurtenances

1. High Density Polyethylene Pipe shall conform to ASTM F714 AND AWNA C 906-99 for sizes shown.

2. The product shall be Performance Pipe Disscoplex 4000 PE 3408 high-density polyethylene piping for potable water distribution or equal.

3. Polyvinyl Chloride-LPVC Pipe (SDR35) shall conform to NYSDOT Standard Specifications Section 706.

4. Service Weight Cast Iron Soil Pipe and Fittings shall conform to ASTM A888 A-74. Joints shall be hub and spigot with compression gaskets conforming With ASTM C-564.

5. Reinforced concrete inlet (catch basins) shall conform to requirements of Section 33 49 13 DRAINAGE STRUCTURES.

6. Manholes shall conform to Section 33 49 13 DRAINAGE STRUCTURES.

B. Fittings

1. All fittings shall be made by the same manufacturer as the pipe.

C. Pipe and Filter Material - Underdrains

1. High Density Polyethylene Pipe shall conform to NYSDOT Specification Section 706 for sizes shown.

D. Underdrain Filter Material

1. Filter Material shall be approved crushed aggregate with no less than 85% by weight passing the 3/8" screen and 100% by weight retained on the #35 screen.

E. Filter Fabric

1. Filter Fabric shall be long-chain polymeric filament, woven or non-woven cloth with a melting point of not less than 200 degrees F. Grab tensile strength shall be not less than 125 pounds when tested in accordance with ASTM D-1682. After exposure to 300 degrees F for 1 hour (under no stress), It shall retain 80 percent of its original grab strength. Drainage Fabric shall be a nonwoven polypropylene geotextile with an Apparent Opening Size (AOS) of U.S. Standard Sieve No. 70. Drainage Fabric shall be Mirafi 140N or approved equal.

2. The fabric shall be capable of supporting, without tearing, construction equipment needed for placement of materials on top of the fabric. The fabric must be capable of retaining the subgrade and subbase soils while permitting the free passage of water from those soils through the fabric and into the trench backfill. Storage and handling of filter fabric shall be in accordance with the manufacturer's recommendations.

3. Prior to its use, the fabric shall be stored in a protective wrapping that will shield it from sunlight, heat, ultraviolet rays, mud, dirt, dust and debris to the extent that its strength or toughness is not diminished. Torn or punctured filter fabric shall not be used.

PART 3 – EXECUTION

3.1 INSPECTION

A. Examine the areas and conditions 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.

3.2 EXCAVATING, TRENCHING, BEDDING AND BACKFILLING

A. General

1. Provide excavating, trenching, bedding and backfilling for storm drain system in accordance with the provisions of Section 31 20 00 Grading, Excavation and Backfilling as shown on the drawings and specifications.

B. Movement of Construction Machinery

1. Use all means necessary to avoid displacement of, and injury to the pipe and structures while compacting by rolling or operating equipment over a culvert, storm drain, or any below grade structure at any stage of construction is solely at the risk of the Contractor.

2. If pipe becomes damaged as determined by the engineer, it will be

3. Replaced at no cost to the owner.

C. Leader Drains

1. The Contractor shall make all required connections of the building leader drains into the onsite drainage system where and as shown on the Drawings. Work shall furnishing and installing all leader drain pipe from the onsite drainage system to points located five (5) feet outside of the proposed building lines and properly sealing the ends with watertight plugs. Leader drain extensions from these points into the building will be performed by others.

2. The Contractor will be required to coordinate his work with the work of the Plumbing Contractor to determine the exact location and elevation of the point of entry into the building.

3. If the Plumbing Contractor has installed his portion of the leader drain, work under this Contract shall also include final connections of the leader drain five (5) feet outside the building line to the building leader drains.

4. Leader drain connections to the pipe of the onsite drainage system shall be made at structures or with proper fittings supplied by the pipe manufacturer.

5. Where manufacturer's fittings are not available, the Contractor shall cut a neat circular hole in the drainage pipe to facilitate connection of the leader drain pipe. Pipe opening shall be sealed with 5 inches minimum of concrete grout.

3.3 PIPE INSTALLATION

A. General

1. Pipe shall be installed as specified below:

a. Installation shall be in accordance with Section 603 of the NYSDOT Specification and as indicated herein.

b. 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.

c. Place all pipe to the grades and alignment shown, with a tolerance of 0.10 ft. (total) vertical deviation between structures.

d. Provide all required equipment for lowering pipe safety into the trenches.

e. Polyvinyl Chloride Pipe: lay pipe as indicated above and in strict accordance with the manufacturer's recommendations as approved by the Engineer.

f. Pipe will be cut flush with interior of drainage structure.

g. Where specified, install gaskets in all pipes in accordance with manufacturer's recommendations and as approved by the Engineer.

h. Joining pipe of different materials: Provide fittings or couplings made for the pipe materials joining.

i. Joining pipe of different sizes: Provide reducer fittings of the required sizes and configurations. Use saddle connection when branch lines join a main or collector main. Use eccentric collar joint when the slope of the pipe is less than 1%.

j. Surveying will be done before backfilling is performed.

D. Underdrains

1. The Contractor shall install all underdrains where and as shown on the Drawings.

2. A minimum four (4) inch layer of approved underdrain filter material shall be placed and compacted in the bottom of the trench as bedding for the pipe. Underdrain pipe of the type and sizes specified shall be embedded firmly in this bedding material to the line and grade shown on the Drawings.

3. All underdrain material shall be wrapped with filter fabric to separate underdrain material from adjacent soil material.

4. Unless otherwise specified, perforated pipe shall be laid with the perforations down and the pipe sections shall be joined securely with the appropriate fittings or bands. Upgrade ends of pipe underdrains shall be closed with suitable plug.

5. After the pipe installation has been inspected and approved, underdrain filter material shall be hand-shoveled around and over the pipe to such a depth that,

after compaction, it extends a minimum of four (4) inches above the underdrain pipe.

6. The surface of the underdrain filter material shall then be compacted with a vibrating pad compactor, and the remainder of the filter material placed in six (6) inch lifts, each thoroughly compacted with a vibrating pad compactor. The height of filter material over all pipes shall be as indicated on the Drawings.

7. Pipe to pipe connections and changes in pipe alignment shall be made only with prefabricated fittings to be supplied by the manufacturer of the pipe (e.g. tees, wyes, etc.).

END OF SECTION 33 40 00

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SECTION 33 49 13 DRAINAGE STRUCTURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included

1. Under this section the Contractor shall provide all labor, equipment and material necessary to furnish, install all cast-in-place and precast concrete drainage structures including catch basins complete in place including frames, grates, covers, steps, etc. and as shown on the drawings, specified herein and approved by the Engineer.

B. Related Work Described Elsewhere

1.	Grading, Excavation and Backfilling	Section – 31 20 00
2.	Erosion and Sediment Control	Section – 31 25 00
3.	Site Drainage	Section – 33 40 00

1.2 SUBMITTALS

A. General

1. Submit shop drawings in accordance with 01340 – “Submittals”.

B. Product Data Required

1. Manufacturer’s specifications and other data required to demonstrate compliance with the specific requirements of this Section.

2. Complete shop drawings of all work of this Section, showing dimensions and locations of all items including supporting structures and clearance requirements. Specific items to be provided include but are not limited to the following:

a. Reinforcing
b. Steps
c. Wall sleeves
d. Inserts and other embedded items
e. Pipe connections
f. Joint details
g. Casting weights
h. Dimensions

i. Materials
j. Manufacturer's specifications
k. Load tables

C. Design Calculations

1. Where structure design varies from that shown or specified in the Contract Documents, complete design calculations prepared under the supervision of and stamped by a Professional Engineer registered in the State of New York shall be provided.

D. Certifications

1. When precast concrete drainage structures are proposed, a statement of certification of the manufacturer by the Precast Concrete Institute shall be provided.

1.3 QUALITY ASSURANCE

A. Codes and Standards

1. All materials and labor furnished under this Section shall:

a. Comply with ASTM, ANSI, AASHTO and all other applicable Federal, State and Municipal codes and regulations including revisions to date of Contract.

b. Comply with the Town of Ramapo standards for drainage structures.

c. In all cases where a device or part of equipment is referred to in this Section in the singular (such as "step"), it is intended that such references shall apply to as many such items or devices as are required to complete the installation.

2. Referenced Specifications

a. The New York State Department of Transportation Standard Specifications (NYS-DOT Specifications) for Construction and Materials, Latest Revisions, plus addenda when referred to, shall become part of this specification for materials and construction requirements. A referenced New York State (NYS) Pay Item Number shall serve the required work for this project providing materials and construction conforming to all applicable requirements under the NYS-DOT Specifications for that New York State Item, except for measurement and payment. The measurement and payment section of the NYS-DOT Specification shall not apply as all work under this

Section shall be included in the Contractor's lump sum bid for this Contract. Where the New York State DOT Specifications cite requirements differing from those included or specified elsewhere in these Contract Documents, the more stringent, highest quality requirement shall apply.

b. ASTM C 478, "Specification for Precast Concrete Manhole Sections". Where the referenced ASTM Specification cites requirements differing from those included or specified elsewhere in these Contract Documents, the more stringent, highest quality requirement shall apply.

B. Qualifications of Manufacturers

1. Products used in the work of this Section shall be produced by those who are regularly engaged in the production and/or supply of similar items for at least five (5) years and which have a history of successful production, acceptable to the Engineer.

2. Precast concrete manufacturers shall be certified by the Precast Concrete Institute.

C. Qualification of Installers

1. Use adequate number of skilled workmen who are thoroughly trained in the specific requirements and methods needed for proper performance of work of this Section.

1.4 PRODUCT HANDLING

A. Protection

1. Use all means necessary to protect the materials of this Section before, during and after installation and to protect installed work and materials of other trades.

B. Replacement

1. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Owner.

C. Protection of Utilities

1. Protect all existing utilities in the course of excavation, installation, and backfilling procedures.

PART 2 – PRODUCTS

2.1 GENERAL

A. Design

1. Structures shall conform in shape, size, dimensions, materials, and other respects to the details shown, specified, or as ordered by the Engineer.

2. Drainage structures shall be cast-in-place or precast concrete. Circular drainage structures shall be precast concrete only. Knock out structures will not be allowed.

3. All cast-in-place concrete shall be NYSDOT Specification Section Class A concrete.

4. In conformance with the requirements of NYSDOT Specification Section 706-04, "Precast Concrete Drainage Units", the minimum compressive strength of concrete in precast concrete drainage structures shall be 3625 psi for rectangular structures and 4300 psi for circular structures.

5. Drainage structure reinforcement shall be in conformance with the requirements of:

   a. The NYSDOT including Group 604 "Drainage Structures" Standard Sheets.

   b. ASTM C 478.

6. As a minimum, structures shall be designed to withstand all loads imposed including earth pressure, H20 – 44 loading plus 30 percent for impact applied as a result of continuous high density traffic, and construction loading.

7. Manhole steps shall be provided and installed in all drainage structures. Manhole steps shall be designed and installed in accordance with the requirements of NYSDOT Specification Section 725-02 "Steps for Manholes".

8. Inverts shall be as shown and shall conform accurately to the size, shape and slope indicated on the Contract Drawings.

9. Wall Openings

   a. Corner pipe entries into rectangular drainage structures shall not be permitted.

b. All wall openings shall be formed completely through the structure wall section.

c. Circular wall openings shall be formed for each circular pipe entering perpendicular to the wall.

d. When non-circular pipes are specified or round pipe entries are skewed, rectangular openings may be used.

e. Wall openings in circular structures shall be perpendicular to the structure wall. Skewed pipe entries into circular structures shall not be permitted.

f. When non-circular pipes are specified, or round pipe entries are skewed, only rectangular drainage structures shall be used.

g. When non-circular pipes are specified, or round pipe entries are skewed rectangular openings may be used. The clearance between the outside of the pipe and the rectangular openings through which the pipe passes shall be no less than 2-inches and no more than 3-inches.

10. Where precast structures are made up of various precast components such as base sections, riser sections and top sections, the joint between sections shall be the tongue and groove or bell type.

11. Drainage structures shall be designed to provide a clearance of 17-inches between the top of concrete and finished grade to allow for the installation of concrete grade rings or brick between, the bottom of the at grade castings and the concrete portion of the drainage structure. Where drainage structure configuration and/or finished grade elevations prevent the maintenance of 17 inch clearance, a minimum clearance of ½ inch shall be provided between the bottom of the at grade casting and the top of the drainage structure concrete.

12. When prefabricated grade rings are provided to bring castings to grade they shall meet the requirements of NYSDOT Specification Section 715-13 “Prefabricated Adjustment Ring and Frames for Drainage Units and Manholes”.

13. Lifting holes, if used in precast concrete components shall be tapered. No more than two holes shall be cast in each section. Tapered solid rubber plugs shall be furnished to seal the lifting holes. The holes shall be designed to be sealed by the plugs being driven from the outside face of the section.

14. All precast concrete components shall be marked with the name or trademark of the manufacturer, the casting date, and the weight of the component.

PART 3 – EXECUTION

3.1 LAYING MASONARY

A. Brick

1. Brick shall be satisfactory wet when being laid.

2. Each brick shall be laid in mortar so as to form full bed, end and side joints in one operation.

3. Joints shall not be wider than 3/8 inch except when bricks are laid radically in which case the narrowest part of the joint shall not exceed ¼ inch.

B. Concrete Block

1. The vertical keyways in concrete block shall be completely filled with mortar.

C. Grade Rings

1. Grade rings shall be laid in a full bed of mortar and shall be thoroughly bonded.

3.2 MASONARY ADJUSTMENT COURSES

A. Use

1. Grade rings or brick stacks shall be used for all precast and masonry structures to bring castings to finished grade.

B. Installation

1. Masonry adjustment courses shall be constructed on the top slab or concrete wall on which the frame will be installed.

2. The height of the masonry adjustment course shall be as necessary to bring the frame to grade but shall not exceed 12-inches.

3. Masonry work shall be kept moist for a period of three days after completion. Precautions shall be taken to prevent the masonry work from freezing during cold weather.

3.3 PRECAST ITEMS

A. Bases

1. Precast concrete bases shall be set on a crushed stone, crushed gravel or other foundation material as shown.

2. Base units shall be set at the proper grade, carefully leveled and aligned.

B. Precast Sections

1. Precast sections shall be set vertical with steps and sections in true alignment.

2. Lifting holes shall be sealed tight with a solid rubber plug driven into the hole from the outside of the structure and the remaining void filled with a 1 to 2 cement-sand mortar.

3.4 BACKFILLING

A. Placement

1. No structure shall be backfilled until all mortar impacted by the backfill has set.

2. Backfill shall be carried up evenly on all sides of the structures to prevent the development of overturning forces.

3.5 PIPE PENETRATIONS

A. Pipe Joints

1. An approved joint shall be provided for each pipe entering and existing the structure.

2. Joints may be accomplished by installing a flexible boot or grouting the space between the outside wall of the pipe and the drainage structure with a non-shrink grout. Grout shall be Sika-Set Mortar as manufactured by Sika Co. or equivalent.

3. Where joints are grated in-place or epoxy bonding agent shall be applied to the concrete prior to grating. The bonding agent shall be Rockwell “C” as manufactured by Preco Chemical Co. or equivalent.

B. Protrusion into Structure

1. Pipes shall not protrude inside the structure unless otherwise indicated on the Contract Drawings or directed by the Engineer.

2. Pipes shall be cut in an approved manner to be flush with the inside wall of the structure.

C. Watertightness

1. All drainage structures shall be free of visible leakage.

2. All visible leaks shall be repaired in a manner subject to the approval of the Engineer.

END OF SECTION 33 49 13

SECTION 412213 - HOISTS AND CRANES

PART 1 - GENERAL

1.1 SUMMARY

A. The work specified in this section includes furnishing monorail system complete with electrification, monorail track, hoist, trolley, and pendant control up at the location shown on the Drawings. Include all wiring, conduit, piping and controls required to connect the equipment to the building utilities, and to interconnect the various system components as part of the work of this section.

A. Related Sections:
   1. Section 011000 – Summary of Work.
   2. Section 013300 – Submittal Procedures.
   3. Section 017823 – Operation and Maintenance Data.
   4. Section 055000 – Metal Fabrications.
   5. Section 110500 – Common Work Results for Shop Equipment.
   6. Division 26 – Electrical.

1.2 REFERENCES

A. American National Standards Institute (ANSI).
   1. ANS1 MH 27.1 Specifications for Underhung Cranes and Monorail Systems.
   2. ANSI B30.10, Hooks
   3. ANSI B30.11, Monorail Systems and Underhung Cranes.
   4. ANSI B30.16, Overhead Hoists.

B. American Welding Society (AWS).
   1. AWS D14.1, Specifications for Welding Industrial and Mill Cranes.

C. Hoist Manufacturer's Institute (HMI).
   1. HMI 100, Standard Specifications for Electric Wire Rope Hoists.

D. Occupational Safety and Health Administration (OSHA):
   1. 29 CFR 1910 Subpart 179 Overhead and Gantry Cranes

1.3 SUBMITTALS

A. Pursuant to Section 013300, Submittal Procedures, and Section 110500, Basic Equipment Materials and Methods, the contractor shall submit:
   1. Material and Equipment List.
   2. Product Data including catalog cuts.
   3. Shop Drawings.
   4. Training Program and Operations and Maintenance Manuals.
   5. Spares / Maintenance Materials.
   6. Certificates specified in Article 1.6.
   7. Results of tests specified in Article 3.3.

1.4 QUALITY ASSURANCE

A. Qualifications:
   1. Submit load test certificate for each electric wire rope hoist, which indicates actual breaking strength of the wire rope on the manufacturer's minimum wire rope breaking strength.

1.5 VERIFICATION OF DIMENSIONS

A. Contractor is responsible for coordination and proper relation of all work to the building structure and to the work of all trades. The Contractor shall verify all dimensions of the building that relate to fabrication of the monorail and notify the Engineer of any discrepancy.

1.6 CERTIFICATIONS

A. Submit load test certificate for each electric wire rope hoist, which indicates actual breaking strength of the wire rope or the manufacturer's minimum wire rope breaking strength.

B. Crane Hook Certification: Provide a certification in writing of satisfactory nondestructive test hook (including hook, hook shank, and retaining nut), and certifications that hook has satisfactorily completed proof test in accordance with ANSI B30.10.

PART 2 - PRODUCTS

2.1 ½ TON MONORAIL AND HOIST

A. Equipment Item No. TS-9.

B. Acceptable Manufacturers:
   1. Products of the following manufacturers are specified herein as the standard of quality for the 1/2 ton monorail and hoist:
      a. Acco Chain and Lifting Products Division
         76 Acco Drive
         York, PA 17402
         Telephone: (800) 967-7333
   2. Products of equal quality and utility of the following manufacturers will be accepted:
      a. Crane America Services, Inc. (DEMAG Crane and Components)
         3440 Office Park Drive
         Dayton, Ohio 45439
         (937) 293-6526
      b. Mannesmann Dematic Corp.
         2727 Paces Ferry Road SE
         Ste 2-1500
         Atlanta, GA 30339
         Telephone: (877) 725-7500

C. Monorail System Design Criteria:
   1. Design and provide all material in accordance with ANSI MH 27.1.

2. Design all material with a minimum safety factor of 5 based on the ultimate strength of the material.
3. Include an impact factor of at least 15 percent of the full live load rated capacity of hoist in design calculations for track, trolleys and loading imposed on structure.
4. Design system for service classification, Class C (moderate service) in accordance with ANSI MH 27.1.

D. Monorail Track:
1. Construct monorail track of hard alloy steel designated and produced specifically for underhung crane and monorail application. Provide standard end stops.
2. Design track to accommodate a 1/2 ton hoist and a maximum unsupported span of 12 feet.
3. Operating flange shall be 3.25 inch.

E. Hoist Design Criteria:
1. Wire rope electric hoist shall be equipped with motorized trolley.
2. HMI – H4 Service Classification.
3. Wire Rope Drum: Large diameter with deep machined grooves. Two full turns of rope shall remain on the drum at lowest hook position.
4. Wire Rope: Lubricated with swaged fittings at both ends.
5. Load Blocks: Shrouded type to protect wire rope and sheaves. Sheaves shall be supported on prelubricated, sealed, anti-friction ball bearings.
6. Hook: Drop forged, heat treated, ductile alloy steel with spring latch.
7. Gravity type limit switch shall interrupt the raising circuit to stop the hoist and set both mechanical load brake and motor brake when the hook reaches the upper limit at reversing circuit to prevent overtravel in up direction.
8. Gear Train: Combination of helical and spur gears, in accordance with American Gear Manufacturer's Association (AGMA) standards. Gears shall operate in a sealed oil bath.
9. Mechanical Load Brake: Weston type multiple disc.
10. Motor Brake: Rectified DC Magnet-actuated disc type with a minimum torque rating of 150% of the full load motor torque.
11. Overload Cutoff Device: Load sensing unit completely independent of the hoist gearing. The overload unit interrupts the raising circuit, stops hoist motor, sets the motor and mechanical brake, and resets when overload is lowered and removed.
12. Motor: Two speed 0.7457 kW (1 hp) Standard NEMA C face Class F insulation, TEFC. Automatic reset thermostats for overcurrent protection. Rated at 30 minute duty with ± 10% voltage variation.
13. Controls: Three pole magnetic reversing type, mechanically interlocked with 115 volt control circuit and rated of 600 volts, includes control transformer. Enclosure NEMA type 4X with lightweight impact resistant LEXAN resin cover deep molded.
14. Trolley: Integral hoist type trolley designed to accommodate the hoist specified herein. Four wheel trolley with steel wheel drive. Solid state trolley controls shall be combined with hoist controls into a single enclosure.
15. The control of the crane shall be by Push Button Station: Pendant type. Provide a 6 button station to control hoist, trolley, and mainline disconnect. Clearly mark the function of each pushbutton. Hoist suspended momentary contact type pushbuttons in NEMA 4X enclosure. The bottom of pendant control shall be located approximately 4 feet above finished floor.
    a. The following controls shall be provided:
        1) Hoist: raise/lower.

2) Trolley: forward/reverse.
3) Mainline disconnect.

F.Capacities:

1. Hoist:
   a. Lift: 32 feet.
   b. Lifting Speed: 20 FPM
   c. Lift Capacity: 1/2 ton.
   d. Bottom of beam to saddle of hook: 24 inches (approximate).
   e. Load: 1 horsepower
2. Trolley:
   a. Single Speed: 50 FPM.
   b. Load: ½ horsepower.
3. Trolley Brake.

G. Hoist Power Supply: 460 volts, 3 phase, 60 hertz.

H. Electrification: Track supported festooning system with multiple wires.

I. Paint: Monorail and hoist shall be painted safety yellow with the rated load painted clearly in black paint.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install monorail system in strict accordance with the approved shop drawings and manufacturer's installation instructions.

B. Monorail Track to be installed straight and level. The method of fastening monorail track and switches to the support structure shall be provided as work of Section 055000 Metal Fabrications. Operating flanges of monorail track and track switches shall be installed at the same elevation above finished floor. Coordinate monorail installation with work of Division 26 - Electrical.

C. Coordinate safety interlocks with work of Division 26 - Electrical.

D. Proceed with start-up, testing and instructions in accordance with Section 110500.

3.2 FIELD QUALITY CONTROL

A. Provide the services of a qualified, certified manufacturer's representative to perform the following:
   1. Supervise preparatory work performed by other trades.
   2. Supervise installation.
   3. Supervise testing, by the Contractor in the presence of the Engineer, to ensure proper operation of the equipment.

3.3 FIELD TESTING

A. Perform testing of the equipment and system in accordance with the requirements specified in the General and Supplemental Conditions. Perform and document all testing procedures recommended by the manufacturer and OSHA standards, ANSI B30.10 and ANSI B30.11. Testing to be performed by a qualified Independent Inspection and Testing Agency.
   1. Test each monorail for operation and load test not less than 100 percent and not more than 125 percent of the rated load.

3.4 TRAINING PROGRAM AND OPERATION AND MAINTENANCE MANUALS

A. Provide a training program and operation and maintenance manual in accordance with the requirements specified in the General and Supplemental Conditions and Section 017823.

END OF SECTION 412213

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SECTION 413423 - COATING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. All wiring, conduit, piping, ductwork and controls required to connect the Small Parts Paint Booth to building utilities and to exhaust fumes are also a part of the Work of this Section.

B. Related Sections:
   1. Section 011000 – Summary of Work.
   2. Section 013300 – Submittal Procedures.
   3. Section 017823 – Operation and Maintenance Data.
   4. Section 017900 - Demonstration and Training.
   5. Section 110500 – Common Work Results For Shop Equipment.
   6. Division 23 – Mechanical.
   7. Division 26 – Electrical.

1.2 REFERENCES

A. National Fire Protection Association (NFPA):
   1. NFPA 33 Standard for Spray Application Using Flammable or Combustible Liquids.
   2. NFPA 70 National Electrical Code (NEC)
   3. NFPA 91 Standard for Exhaust Systems, for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.

B. Occupational Safety and Health Administration (OSHA):
   1. 29 CFR 1910 Occupational Safety and Health Standards.

C. Local Codes and Standards:
   1. New York Building Code.
   2. New York Fire Code.

1.3 QUALITY ASSURANCE

A. Use adequate numbers of skilled workers who are completely familiar with the specified requirements and the materials and methods necessary for proper performance of the Work of this Section.

1.4 SUBMITTALS

A. Pursuant to General and Supplemental Conditions, Section 013300, Submittal Procedures and Section 110500, Common Work For Shop Equipment, the Contractor shall submit:
   1. Material and equipment list itemizing products furnished to satisfy the requirements of this section.
   2. Product data including catalog cuts, manufacturer’s assembly and installation data, manufacturer’s certificates of compliance, and samples.
   3. Shop drawings.
   4. Schedule of Work.

5. Training Program and Operations and Maintenance Manual.
6. List of recommended spare parts and maintenance materials.
7. Evidence of manufacturers and installers experience including names, addresses and phone numbers of reference clients.
8. Working drawings showing booth placement, ductwork runs, and required clearances.
9. Embedded anchor and mounting device requirements.
10. Testing methods and procedures.
11. Seismic design certification, seismic design calculations (if requested), and guy wire support details.
12. Authorities having Jurisdiction Permits required for operation of Small Parts Paint Booth.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, and handle products without damaging them.
   1. Receive, unload, check, protect, and store equipment in facilities suitable to keep it clean, dry, and free from damage, vandalism, and pilferage.
   2. Pay demurrage charges and claims for damage resulting from unloading operations.
   3. Examine equipment for visible and concealed damage. Report any damage to carrier, supplier, and Engineer as soon as possible.

B. Protect equipment from loss, deterioration, and damage until work is complete.
   1. Protect equipment during storage and prior to start-up.
   2. Protect exposed finished surfaces with removable coating or film, cover openings to exclude dirt and fouling materials, and protect unfinished surfaces against rust, corrosion, and other damage.
   3. Protect equipment from paint or coating spills and spots.

1.6 WARRANTY

A. Provide the Owner with a one-year warranty of equipment, parts, and replacement labor.

1.7 MAINTENANCE

A. Spare Parts: Provide spare parts as recommended by the manufacturer for annual maintenance.

PART 2 – PRODUCTS

2.1 SMALL PARTS PAINT BOOTH

A. Equipment Item No. MS-8.

B. Acceptable Manufacturers

   1. The products of the following manufacturer are specified as the standard of quality for the Small Parts Paint Booth.

a. Paasche Airbrush Co.
9511 58th Place
Kenosha, WI 53144
Telephone: (773) 867-9191.
Model No.: FABSF-4-T1 Top Exhaust

2. Products of equal quality and utility of the following manufacturers will be accepted.
   a. Global Finishing Solutions
   12731 Norway Road
   Osseo, WI 54758
   Telephone: (800) 848-8738.
   b. Or approved equal.

C. Design Requirements:

1. Type: Small parts paint booth with shelf and dry type filter bank at rear of booth.

2. Construction: In accordance with NFPA 33 and the following:
   a. Wall and Ceiling Panels: Single-skin galvanized steel, 18 gauge minimum.
   b. Exhaust Filters: Fiber glass filters.

3. 18 inch fan with sparkless aluminum blade.

4. Belt Guard

5. Draft Guard

6. Two Sets of Paint Filters

7. Work Area: 4 feet wide x 4 feet 6 inches high x 3 feet deep.

8. Overall Size: 4 feet 4 inches wide x 5 feet 2 inches deep x 8 feet 2 inches high.

9. Lighting: LED Light Fixture (Class I Div II) with bulbs

10. Air Delivery: 2,420 CFM.

11. Provide top exhaust.

D. Utility Requirements: 115V/230V/1PH/1/3HP, Totally Enclosed Explosion Proof Motor.

E. Accessories:

1. Provide 1 case of 50 filters.

2. 24 inch flat roof flange.

3. Duct with cleanout to extend thru the roof.

4. On/Off switch

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install equipment in strict accordance with the approved shop drawings and manufacturer's installation instructions. Use installation procedures conforming to local and state building codes.

B. Install and support ductwork in accordance with Division 23.

C. Proceed with start-up in accordance with Section 110500.

3.2 FIELD QUALITY CONTROL

A. Provide the services of a qualified manufacturer's representative to perform the following:

1. Supervise preparatory work performed by other trades.

2. Supervise installation.

3. Supervise testing, by the Contractor in the presence of the Engineer to ensure proper operation of the equipment.

3.3 FIELD TESTING

A. Perform testing of the equipment and system in accordance with the requirements specified in the General and Supplemental Conditions. Perform and document all testing procedures recommended by the manufacturer.

3.4 TRAINING PROGRAM AND OPERATION AND MAINTENANCE MANUALS

A. Provide a training program and operation and maintenance manual in accordance with Section 110500 Common Work Results For Shop Equipment, Section 017823 Operation and Maintenance

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SECTION 415219 - MATERIAL STORAGE TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes the following:

1. Furnishing, installing and testing material storage tanks for lubricants and coolant.

B. Related Sections:
1. Section 013300 – Submittal Procedures.
2. Section 017823 – Operations and Maintenance Data.
3. Section 110500 – Common Work Results for Equipment.
4. Section 135000 – Special Instrumentation.
5. Division 22 – Plumbing.

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM B 117, Test Method of Salt Spray Testing.

B. International Codes Council (ICC):

1. International Fire Code (IFC).

C. Underwriters Laboratories, Inc. (UL):

1. UL142 – Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids.

D. Steel Structures Painting Council (SSPC) Surface Preparation Specifications:

1. SSPC-SP 6, Commercial Blast Cleaning.

E. 40 CFR 264.193 – Containment and Detection of Releases

F. Occupational Safety and Health Administration (OSHA):

1. 29 CFR 1910.106 Occupational Safety and Health Administration, Flammable and Combustible Liquids.

1.3 SUBMITTALS

A. Submit shop drawings, catalog cuts and all manufacturers' data covering all equipment covered in this section. If submitting catalog cuts, assure that the models specified or submitted are highlighted or underlined. No generic information will be accepted. Submit the following for review and approval:

1. Shop drawings.
2. Product data.
3. Installation Instructions.
4. Operations and maintenance manuals.

B. Shop Drawings: Shop drawings shall consist of the following as applicable:

1. Layout drawings showing equipment layout, elevations, and all required dimensions.
2. Detail drawings.

3. Foundation and structural support drawings including fittings, grounding and anchoring locations, connections to the Work of other sections, and all dimensions required to properly install the equipment.

C. Product Data: Manufacturer's literature including catalog cuts, pamphlets, descriptive literature, equipment specifications, performance and test data, and brochures which adequately describe the piece of equipment or product. Provide sufficient product and preventive maintenance information to properly address each equipment item and all major components installed to the maximum extent possible during the equipment submittal and approval phase of the project.

D. Installation Instructions: Manufacturer's recommended installation instructions and manufacturer's installation drawings.

1.4 QUALITY ASSURANCE

A. Reference Standards:

1. Underwriters' Laboratories:
   a. UL-142 – Steel Aboveground Tanks for Flammable and Combustible Liquids.
2. Prior to performance of work, obtain applicable permits, from state and local authorities having jurisdiction.

1.5 DELIVERABLES:

A. Operations and Maintenance Manuals:

1. Provide Operations and Maintenance Manuals in accordance with the requirements of Section 017823 Operation and Maintenance Data and Section 110500 Common Work Results for Shop Equipment.

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle products in compliance with the requirements specified in Section 110050 and the requirements of the Owner.

1.7 WARRANTY

A. Provide warranty per Division 01 and 110500 Common Work Results for Shop Equipment.

B. Manufacturer shall warrant all equipment including parts and labor for a period of one (1) year from date of acceptance.

C. Contractor shall provide written documentation from the manufacturer that warranty service will be available at the delivery location(s). Service shall be provided within 24 hours after notification from the Owner.

PART 2 - PRODUCTS

2.1 ABOVEGROUND STORAGE TANK, 550 GALLONS.

A. Equipment Item No. LR-1

B. Acceptable Manufacturers:

1. The products of the following manufacturer are specified as the standard of quality for the Aboveground Storage Tank, 550 Gallons:
   a. Containment Solutions
      14489 Croghan Pike
      Mount Union, PA 17066
      Telephone: 814-542-8621
      Model: 550 Gallon AST, Double Wall Tank
2. Products of equal quality and utility of the following manufacturers will be accepted.
   a. Highland Tank.
      One Highland Road
      Stoystown, PA 15563
      Telephone: 814-893-5701
   b. Modern Welding
      303 Steel Drive
      Elizabethtown, KY 42702
      Telephone: 800-473-5276
   c. Or approved equal

C. Construction Features:

1. Tank have total capacity of 550 gallons, with double wall for motor oil and hydraulic oil.

2. Tank shall conform to and be labeled in accordance with Underwriters Laboratories Standard UL-142 for double-wall tanks.

3. Tank shall be Double-Wall all welded construction.

4. Shall be fabricated of 10 gauge thick mild carbon steel for the inner tank and outer tank.

5. Tank shall include the following as a minimum. Additional fittings shall be provided if required by agencies having jurisdiction.
   a. Five (5) 2inch forged steel fittings per compartment.
   b. One (1) 4inch forged steel fill fitting.
   c. One (1) 6inch primary emergency vent per compartment.
   d. One (1) Sight Glass fitting for leak detection.
   e. One (1) 6inch flange in interstice extension box, marked with warning label for secondary emergency vent use only.
6. Fabrication shall include 2inch high supports welded to the tank underside, providing ground clearance for visual inspection.

D. Dimensions:

1. Overall Size: 5 feet-2 inch long x 3 feet-10 inch wide x 5 feet-1 inch height.

E. Accessories:

1. Gauge with local overfill alarm: Provide a tank mounted direct reading fluid gauge with local overfill alarm.
   a. The movement of the float and arm assembly shall provide direct reading of tank. Graduations: Full, ¾, ½, ¼, Empty.
   b. The movement of the float and arm assembly shall be transmitted through a gasket which isolates the indicating mechanism from liquid within the tank.
   c. Tank gauge shall be factory calibrated for tank being furnished.
   d. Overfill alarm:
      1) Non-contact magnetic reed switch system
      2) Audible alarm: 110 dB.
      3) Reset/test switch.
      4) Power: 9 VDC lithium battery. Design life in application: 3 years minimum
   e. Acceptable Manufacturers:
      1) At-a-Glance, Type D Direct Reading Gauge, with At-a-Glance Alarm, as manufactured by Krueger Sentry Gauge, Green Bay, WI, or approved equal,
2. Spill Containment Box with Cover: Two (2) required, one to be installed on each product compartment.

F. Exterior Finish:

1. SP6 Sandblast
2. Primer: color as recommended by the Manufacturer
3. Top coat: Manufacturers Standard White Epoxy Paint System

G. Labeling:

1. In addition to U.L. labeling specified elsewhere, label tank in accordance with the requirements of agencies having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions with Installer present for compliance with requirements for installation and other conditions affecting performance of equipment. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install storage tanks and accessories for lubricants and coolant in accordance with manufacturer's installation instructions, and approved submittals.

B. Installation Instructions: Install those Products, as specified previously under PART 2 and not specifically covered for installation herein under PART 3, in strict accordance with manufacturer's installation instructions and at locations indicated on the Drawings.

C. Tank Gauge Installation: In accordance with manufacturer's printed installation instructions, and approved submittals.

3.3 FIELD QUALITY CONTROL

A. General: Inform the Owner of the times when acceptance tests are to be conducted. Conduct acceptance tests in the presence of and to the satisfaction of the Owner.

B. Tests: Test tank and accessories, tank gauge, and leak monitoring system in accordance with tank manufacturer’s recommendations.

C. Correct defects discovered during testing and repeat the particular test involved. Repairs and re-testing at no increase in contract price.

END OF SECTION 415219

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SECTION 46 25 00 OIL WATER SEPARATORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included

1. Under this Section the Contractor shall provide all labor, equipment and material necessary to furnish, install and test two oil water separators (one 1000 gallon and one 3000 gallon) all piping, fittings, valves and accessories required for the completion of the work as shown on the drawings and summarized in this specification and as required in local, state or national codes. The furnishing and installation of all concrete, pipe piping and structures required for the correct installation of all piping are also included in this Section and are covered more specifically in subsequent Sections of these specifications.

B. Related Work Described Elsewhere

1.	Excavation, Excavation and Backfill	Section 31 20 00
2.	Sanitary Sewerage Piping	Section 33 31 13
3.	Drainage Structures	Section 33 49 13
4.	Concrete	Section 03 30 00

1.2 QUALITY ASSURANCE

A. Standards

1. Comply with standards specified in these Specifications.
2. Comply with OSHA, ASTM, AWWA, ANSI and all applicable Federal, State and local codes and regulations regarding the proper manufacture, testing and installation of pipe and pipe fittings, including revisions to date of contract.

3. In all cases where a device or part of the equipment is referred to in this Section in singular (such as “tank”), it is intended that such references shall apply to as many such devices as are required to complete the installation.

B. Qualifications of Manufacturers

1. Products used in the work of this Section shall be produced by manufacturer regularly engaged in the manufacture of similar items and with a history of successful production acceptable to the Engineer.

1.3 SUBMITTALS

A. General

1. Submit Shop Drawings in accordance with the requirements Section 01340 – Shop Drawings.

2. Submit Operation and Maintenance Manuals in compliance with the requirements of specification Section 01390 – Manufacturer's Operation and Maintenance Manuals

A. Product Data

1. Prior to the commencement of any work the Contractor shall furnish the Engineer with drawings for his review and approval indicating vessels make and model and their component parts, including tie down straps, manhole covers, vent piping, as well as valves and other accessories along with a listing of recommended spare parts to be supplied with the equipment by the manufacturer. Drawings shall show subdivision of the equipment and piping for shop and field fabrication, plus the specifications of the materials being used and the method of proper installation. Detailing and installation of tank placement and piping shall be coordinated with other piping and conduit to be furnished and installed under this contract.

2. For equipment, pipe, pipe fittings, valves, operators and appurtenances, the Contractor shall furnish to the Engineer, at the time of shop drawing submission, certified records of physical, chemical and other pertinent tests and/or certified statements from the manufacturer that the materials have been manufactured and tested in conformity with the specifications. Where such a small quantity of material is required as to make physical testing and chemical analysis impractical, a certificate from the manufacturer stating the results of such tests or analyses of similar materials that were concurrently produced, may at the discretion of the Engineer, be considered as the basis for acceptance of such materials.

3. Manufacturer's specifications and other data required to demonstrate compliance with the specific requirements.

4. Complete shop drawings of all work of this Section, showing dimensions and locations of all items including supporting structures and clearance requirements.

1.4 PRODUCT HANDLING

A. Protection

1. Use all means necessary to protect the materials of this Section before, during and after installation and to protect installed work and materials of all other trades.

B. Replacements

1. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Owner.

C. Protection of Utilities

1. Protect all existing utilities in the course of excavation, installations, and backfilling procedures.

PART 2 – PRODUCTS

2.1 GENERAL

A. Design

1. Design is based on the use of products shown in the drawings and NYS Plumbing Codes and as specified in subsequent Sections of this document. Where used, the names of manufacturers and specific catalog numbers are given as an indication of the quality of materials and workmanship to be used.

2. The separator needs to be listed in Underwriters Laboratory UL-SU-2215 and a document of certification will be required.

3. The separator shall be tested and evaluated in accordance with DIN 1999, a certification of testing will be required

B. Oil Water Separators

1. Provide and install HTC- ACT 100-G single wall interior coated Oil water separators manufactured by Highland Tank & MFG Company or approved equal. Size and location as shown on the plans and details.

2. The tanks shall be designed for gravity separation of sand, grit, settleable solids, or semisolids and free oils from waste water. The source of the must be equipped with a three compartment design with a sludge compartment and two treatment tanks in the oil water separator.

3. The separator shall contain an inclined plate coalescer with removable corrugated, protected plates, sloped towards the sedimentation chamber.

4. The tanks shall have internal protective coating of Polyurethane of not less than 13mils.

5. The tank shall have an exterior coating of Polyurethane of not less than 70 mils, where indicated.

6. All manway entrance covers shall be H-20 Load rated.

7. Manufacturer tie down straps will be provided on tanks that have tie down pads.

8. Warranty: the manufacturer shall have a minimum of a 30 year rust through warranty on their product

PART 3 – EXECUTION

3.1 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.

3.2 INSTALLATION

A. Excavation And Bedding

1. General

a. The bottom of the excavation shall be covered with a minimum of 12 inches of bedding, suitably graded and leveled. Bedding and backfill material surrounding the tank to a width and depth of 12 inches all around the tank.

b. Where anchoring by means of a concrete pad, the tank shall not be place directly on the pad. Bedding material at least 6 inches deep must be spread evenly over the dimensions of the pad to separate the tank from the pad.

c. Bedding and backfill shall consist of homogenous pea gravel, or clean sand. Clean sand is 100% passing a 0.5 inch sieve and no more than 12% passing through a 200 sieve. Pea gravel shall be common as 3/8 inch but 100 % smaller than ¾ inch. No angular material will be approved.

d. The depth of backfilling will be in accordance with manufacturers recommendations. This will be a minimum of 60% to 100% of the tank height in 12 inch lifts.

e. The 1000 Gallon Separator in located in a high ground water area and will require a concrete ballast. Insure that proper strapping is provided. If metal straps are used a dielectric material must be used.

B. Testing Air pressure testing (soap bubble testing) will be required to ensure complete sealing of the tank. Plugs shall be used to temporary seal the tanks for the above ground air test and then later removed.

C. The manufacturer will be required to provide certification that testing on the coating was done and passed (spark testing).

D. Installation of the tanks will adhere to the more stringent of the manufacturers recommendations or as described in the contract plans and specifications.

END OF SECTION 46 25 00

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APPENDIX 1

Geotechnical Report

Tectonic

PRACTICAL SOLUTIONS. EXCEPTIONAL SERVICE.

GEOTECHNICAL INVESTIGATION
PROPOSED ROCKLAND CO. HIGHWAY DEPARTMENT FACILITY
TOWNSHIPS OF RAMAPO AND CLARKSTOWN, NEW YORK

Submitted To:

County of Rockland
Rockland County Highway Department

23 New Hempstead Road
New City, New York 10956

October 11, 2019

W.O. 10037.01

Submitted By:

Tectonic Engineering & Surveying Consultants P.C.

1279 Route 300, 2nd Floor
Newburgh, NY 12550

(P) 845.567.6656
(F) 845.567.6248

Tectonic
PRACTICAL SOLUTIONS. EXCEPTIONAL SERVICE.

County of Rockland
Rockland County Highway Department
23 New Hempstead Road
New City, New York 10956

Attention: Mr. Andrew M. Connors PE, Deputy Superintendent of Highways
(Via Email: ConnorsA@co.rockland.ny.us)

October 11, 2019

RE: W.O. 10037.01
GEOTECHNICAL INVESTIGATION
PROPOSED ROCKLAND CO. HIGHWAY DEPARTMENT FACILITY
TOWNSHIPS OF RAMAPO AND CLARKSTOWN, NEW YORK

Dear Mr. Connors;

Tectonic Engineering & Surveying Consultants P.C. is pleased to submit this geotechnical investigation and engineering evaluation for the proposed Rockland County Highway Department facility that will span the boarders between Chestnut Ridge and Nanuet, New York. The purpose of the investigation was to characterize the subsurface conditions within specific areas of the proposed site development and to perform infiltration tests in the area of proposed stormwater retention basins. The borings supplement historic borings and test pits performed by others elsewhere on the project site. The purpose of the engineering evaluation was to develop geotechnical design and construction criteria for the proposed site development based on the results of the investigation and the historic subsurface data.

We appreciate this opportunity to assist you with this project. If you have any questions, please do not hesitate to contact the undersigned.

Sincerely,

TECTONIC ENGINEERING & SURVEYING CONSULTANTS P.C.

Mark A. Stier, P.E., PG
Executive Vice President

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GEOTECHNICAL INVESTIGATION
PROPOSED ROCKLAND CO. HIGHWAY DEPARTMENT FACILITY
TOWNSHIPS OF RAMAPO AND CLARKSTOWN, NEW YORK

TABLE OF CONTENTS

1.0 INTRODUCTION

Pursuant to your request and authorization, we have completed a geotechnical investigation and engineering evaluation for the proposed Rockland County Highway Department facility that will span the boarders between Chestnut Ridge and Nanuet, New York. The purpose of the investigation was to characterize the subsurface conditions within specific areas of the proposed site development and to perform infiltration tests in the area of proposed stormwater retention basins. The borings supplement historic borings and test pits performed by others elsewhere on the project site. The purpose of the engineering evaluation was to develop geotechnical design and construction criteria for the proposed site development based on the results of the investigation and the historic subsurface data.

The following sections summarize the performed scope of services; provides general descriptions of the existing site conditions and proposed construction; and describe the performed investigations. These are followed by a discussion of the findings and our geotechnical recommendations for the proposed site development.

2.0 SCOPE OF SERVICES

The following services were performed for the Rockland County Highway Department, herein referred to as Client:

- Drilling, sampling, and logging of four (4) test borings to depths ranging up to 102 feet.
- Performance of three (3) infiltration tests within test pits excavated by the Client's forces in the area of proposed stormwater retention basins, plus the logging of a supplemental test pit near the infiltration test locations. The original scope of performing four infiltration tests within drilled holes was modified for the reasons described in Section 5.
- Field inspection services by geotechnical engineers and engineering geologists to confirm conformance of the investigation to appropriate standards, collect samples for laboratory testing, and prepare logs of the encountered subsurface conditions.
- Laboratory testing of representative soil samples to assist in the evaluation of the engineering properties of the encountered soils, to check field classifications of soils, and to comply with New York State Department of Environmental Conservation guidelines for infiltration testing.
- Compilation of the subsurface data and the performance of a geotechnical engineering evaluation of the data as it relates to the proposed site development.
- Preparation of this geotechnical report presenting the results of the subsurface investigations, laboratory testing, analyses, and our recommendations for the proposed site development.

3.0 SITE DESCRIPTION

The proposed new highway facility is to be located on lands located north of the intersection of the New York State Thruway and the Garden State Parkway (GSP), immediately north of the westbound Thruway exit and entrance ramps. The area of proposed development spans an area measuring in excess of 2,500 feet in the east-west direction, extending from Scotland Hill Road on the west to South Passaic Road on the east, transitioning from Chestnut Ridge, Township of Ramapo on the west to Nanuet, Township of Clarkstown, on the east. The site is comparatively narrow in the north-south direction, ranging up to several hundred feet. The site is bound on the north by residential developments located along Levitsky Court, Old Nyack Turnpike, and Maplewood Gardens within the central and western areas of the site. On the eastern end of the site, the site is bound on the north by commercial developments located south of Pipetown Hill Road. Commercial properties also bound the south side of the project site on the east, businesses located along the north side of Old Nyack Turnpike near the initiation point of the GSP clover leaf exit ramp from the Thruway. It is also noted that a high voltage transmission line traverses the site in approximately the north-south direction near the eastern end of the site.

At the time of the investigation, the eastern end of the site consisted of undeveloped, mostly wooded lands, and the central and western portion of the site consisted largely of cleared ground, with the region in the middle having been cut. An exception is at the north, near the residential properties, which was largely undisturbed. Catch basins were noted along within the cleared region, indicating a road once traversed this region, likely the Old Nyack Turnpike. Fill stockpiles were also noted in several areas of the cleared region of the site.

The topography across the site is variable. Based on topographic contours on the drawing entitled “Boring Plan”, dated July 15, 2019, by McLaren Engineering Group, surface grades generally rise from east to west across the site. Ground surface elevations are identified to be on the order of +350 feet near South Passaic Road on the east, and to rise to a high elevation of approximately +494 feet at a point approximately 400 feet east of Scotland Hill Road. Surface grades then gradually drop to an elevation of about +470 feet along Scotland Hill Road. A ridge has been left between the GSP entrance ramp and the disturbed ground, apparently created from soil removal in the area of the relic roadway and the GSP entrance ramp. Also, in general, grades slope down from the southern portion of the site to the GSP entrance ramp. The referenced drawing also identifies wetlands to exist near the eastern end of the site. The largest wetland measure roughly 2 acres in size and it is located about 350 feet west of South Passaic Road.

4.0 PROJECT DESCRIPTION

Based on review of the previously referenced boring plan, the new highway department facility is to consist of the construction of seven buildings, numbered 1 through 6, and 8, the construction of fuel island with associated underground tanks, the construction of an access road and parking areas, and the construction of stormwater retention basins. The buildings are numbered from west to east, they occupy roughly the western two-thirds of the site, and they are to be constructed at three different levels to accommodate the sloping topography. The proposed stormwater retention basins will be located on the east end of the site between South Passaic Road and the previously identified wetland area. Site grading calls for both cut and fill slopes at gradients of 2 horizontal to 1 vertical.

Building 1 and its associated parking lot will front Scotland Hill Road, and the building will have a footprint of approximately 12,500 square feet and a finish floor elevation of +478 feet. Existing grades within the footprint of Building 1 range from roughly +483 to +486, so cuts in excess of 8 feet will be required for Building 1 construction. Buildings 2, 3 and 4, which have footprints measuring roughly 18,000, 11,000, and 45,000 square feet, respectively, abut each other, and will connect to the higher Building 1 via what appears to be an enclosed passage way. The finish floor of Building 4 is identified to be +462, and based on perimeter grades, Buildings 2 and 3 are anticipated to have a similar floor elevation. Existing grades across the footprints of these three buildings range from a high of about +494 on the west to a low elevation on the order of +440 feet on the southeast. Therefore, cuts ranging up to approximately 20 to 30 feet will be required for Buildings 2 and 3 and the western portion of Building 4, and fills ranging in excess of 22 feet will be required in the southeastern portion of Building 4. Buildings 5, 6 and 8 and the fuel island are grouped in the east central region of the site, and the buildings and fuel island will have floor/slab elevations ranging from about +443 to +444.5 feet. Existing grades within this region from roughly +408 to +446 feet, and therefore, fills ranging from several feet to in excess of 36 feet will be required within this region of the site.

We understand that none of the buildings will have basements and that the tanks will bear approximately 16 feet below proposed grade.

5.0 SUBSURFACE INVESTIGATION

The subsurface investigation consisted of the performance of four test borings, three infiltration tests, and a test pit. The borings were performed within the footprints of Buildings 1 and 8. The infiltration tests and test pit were performed in the area of the proposed stormwater retention basins. The borings were designated

TEC-1 through TEC-4, and the infiltration tests were designated as PT-1 through PT-3. The test pit was designated TP-101. The boring and test pits are supplemented by six test borings and nine test pits performed by others. These historic borings were designated as B-1 through B-6, and the test pits are designated as TP-1 and TP-3 through TP-10 (no TP-2). The locations of the recently performed and historic borings and test pits and the infiltration tests are shown on the attached Boring Location Plan, Figure 1.

The recent test borings were performed between the dates of September 13 and 18, 2019 by Craig Test Boring Company Inc. using a CME 750 ATV mounted drill rig equipped with an automatic hammer. The borings were advanced to depths ranging from 77 to 102 feet using a tricone drill bit and mud-rotary drilling techniques. Four-inch nominal driven steel casing was installed to depths ranging from 10 to 15 feet to stabilize the near surface soils. Standard Penetration Testing was typically conducted continuously to a depth of 12 feet and at 5-foot maximum intervals thereafter.

The test borings were performed under the full-time observation of a geotechnical engineer or engineering geologist. The engineer observed that the investigation was performed in accordance with the appropriate standards and prepared logs of the encountered subsurface conditions. Logs of the test borings are attached in Appendix I.

The infiltration tests were first attempted by installing casing to the intended 10-foot test depth using the drill rig, in accordance with our proposal. However, shallow refusals were encountered on what was believed to be bedrock, and on communication with the Client, the infiltrations tests were cancelled. The Client subsequently performed test pits at three of the attempted test locations and identified that the shallow refusals were the result of relic foundations, and infiltration tests were subsequently conducted on September 24 and 25, 2019 within the excavations. The testing was performed in Appendix D of the New York State Stormwater Management Design Manual (Appendix D). Specifically, testing was performed within 4-inch nominal PVC pipe placed within hand excavated holes at the base of the test pits. The holes were presoaked on the September 24, and testing was performed on September 25. Infiltration test PT-1 was performed at a depth of 11 feet below ground surface. PT-2 and PT-3 were performed at a depth of 10 feet below ground surface. On completion of testing, representative samples of the tested soils were obtained for laboratory grainsize analysis. The test pit was performed to verify that both bedrock and groundwater were below a depth of 14 feet from existing grade as required by Appendix D. The results of the infiltration testing and the test pit are provided in Section 7.

The historic boring and test pits were performed in the summer and fall of 2005 to depths ranging from about 26.5 feet to 56 feet. The borings were performed by CMI Subsurface Investigations, Inc. using a 3-7/8 diameter tricone bit and mud rotary drilling techniques. Near surface soils were stabilized with driven 4-inch nominal steel casing. Split-spoon sampling was performed continuously to a depth of 10 to 12 feet. The boring logs prepared by CMI's driller are attached in Appendix II and summarized in Section 7.

The test pits were performed in September of 2005 to depths ranging from 6 to 15 feet under the observations of McLaren Engineering Group. The test pits findings were summarized in Appendix D of the report entitled "Geotechnical Report, County of Rockland Highway Department/Emergency Operations Facility, Capital Project No. 1307, Clarkstown, New York", dated January 29, 2007, by McLaren Engineering Group. The test pit lots are reproduced in Appendix II of this report and summarized in Section 7.

6.0 LABORATORY TESTING

Laboratory testing was conducted on selected samples to evaluate field identification of soil samples and assist in identifying the soil's engineering properties. The laboratory testing consisted of the performance of six gradation analyses performed in accordance with ASTM D6913. Testing also included two Atterberg Limits determinations, performed in accordance with ASTM Standard D4318. These tests supplement ten gradation analyses performed by McLaren Engineering Group in 2005. The results of the recently performed and historic laboratory testing are provided in Appendix III and discussed in Section 7.

7.0 SUBSURFACE CONDITIONS

The encountered subsurface conditions generally consist, in turn, of a layer of topsoil ranging up to roughly 1 foot in thickness; glacial till soils, which are poorly sorted soils deposited directly by ice during past glaciation; and bedrock. Based on review of the state geologic map, the bedrock at the site consists of sandstone and conglomerate of the Brunswick Formation, which is of upper Triassic age. Occasionally, soils to a depth of 1 to 3 feet are loose, and may represent a thin layer of fill or disturbed native glacial till soils. Also, fill was identified to extend to a depth of 6 feet at historic test pit TP-9, performed at the northeastern corner of the site. The nature of the fill was not identified. As previously noted, fill stockpiles were also observed within the disturbed areas of the site.

The following subsections provide generalized descriptions of the encountered native soil and groundwater conditions.

7.1 Glacial Till

Glacial till underlies the topsoil and comprises the materials encountered at the boring and test pit locations except within the eastern portion of the site. At historic test pits TP-8, TP-9 and TP-10, located within the previously noted wetland as well as north of the proposed retention basins, bedrock was identified to exist at depths of 9, 7 and 4 feet, respectively. Another exception is that fill of uncharacterized nature was identified to extend to a depth of 6 feet at test pit TP-9.

The glacial till has variable composition, but is most commonly characterized as sandy gravelly silt, which has the Unified Classification of ML, or gravelly, silty sand, which has the Unified Classification of SM. The fines contents of the tested samples ranges from approximately 20 to 80 percent, but is most commonly in the range from 30 to 60 percent. Occasionally the till is characterized and being clayey, and Atterberg limits testing on soil samples indicate plasticity indices ranging up to 5 percent. This indicates that the till is at least locally derived from shale bedrock. The glacial till can be expected to contain cobbles and boulders, also.

SPT N-values within the till vary, but most commonly indicate that the till is in a dense to very dense state. Exceptions occasionally exist within the upper couple of feet, which likely represent soils loosened by frost, or disturbed soils due to past site use. There are also exceptions where the soils are predominately fine grained and slightly plastic, where SPT N-values as low as 9 blows per foot (bpf) were encountered. These lower N-values indicate stiff to very stiff soil consistencies.

7.2 Bedrock

As noted, bedrock at the site consists of sandstone and conglomerate of the Brunswick formation. It was only encountered within the east end of the site, north of the proposed retention basins at test pits TP-9 and TP-10, and within the referenced wetland at TP-8. The other test pits and the borings, which extended in depth up to 102 feet, were terminated in soil.

Although not sampled at the boring locations nor characterized at the test pit locations, sandstones and conglomerates of this unit are typically shallow dipping and often interbedded with finer grained strata, giving outcrops a bedded appearance.

7.3 Groundwater

Due to the introduction of water during mud-rotary drilling and the relatively low permeability of the site soils, groundwater could not be measured reliably at the recently performed test boring locations, and ground water conditions were not documented on logs of the historic borings, likely for the same reason. The test pit explorations provide the best characterization of groundwater conditions. The table that follows identifies the ground surface elevation at each test pit, the test pit depth, and the depth and corresponding elevation groundwater was encountered, if it was encountered.

TABLE 7.1 - SUMMARY OF SUBSURFACE CONDITIONS

Boring I.D.	Ground Surface Elevation[1] (feet)	Test Pit Depth	Groundwater Depth at Test Pit	Elevation of Groundwater[3] (feet)
TP-101	362	14	N.E.	<348
TP-1	482	12.5	N.E.	<469.5
TP-3	442	10	10.5	431.5
TP-4	426	10.5	10	416
TP-5	412	15	N.E.	<397
TP-6	366	6	5.5	360.5
TP-7	359	6	5.5	353.5
TP-8	354	9	N.E.	<345
TP-9	354	7	Not Identified	Unknown
TP-10	348	4	3.5	344.5

Notes:

1. Ground surface elevations estimated from elevation contours on previously referenced Boring Location Plan by McLaren Engineering Group.

2. Identified groundwater elevation based on identified ground surface elevation at test pit. If groundwater was not encountered, the elevation of the test pit bottom is identified with the less-than sign to indicate that groundwater was below the base elevation at the time of the test pit excavation. The depth and elevation of groundwater will vary with changing seasons, weather conditions and other factors. Groundwater should be anticipated to be encountered at other depths and elevations at other times.

   N.E. = Not Encountered

It should be noted that groundwater levels will vary with season, weather and other factors, including modifications proposed as part of the proposed development. Consequently, groundwater should be anticipated to be encountered at other depths at other times. Also, there are wetlands within the eastern portion of the site, therefore water is known to be locally shallow.

7.4 Infiltration Test Results

Infiltration test results are provided in the table below. Test pit TP-101 showed that both bedrock and groundwater was below a depth of 14 feet in the vicinity of the performed infiltration testing.

Test ID	Stable Infiltration Rate (inches per hour)
PT-1	2.5
PT-2	12
PT-3	20.25

8.0 SEISMIC SITE COEFFICIENTS AND LIQUEFACTION POTENTIAL

Based on the results of the test borings, the site falls under Seismic Site Class D. The corresponding maximum spectral response accelerations at short periods (S_{MS}) is equal to 0.426g and at a 1-second period (S_{M1}) is equal to 0.173g.

Due to highly over-consolidated nature of the glacial till soils, the site soils are not subject to liquefaction during the design earthquake event.

9.0 DISCUSSION & CONCLUSIONS

The following bulleted items discuss the geotechnical considerations related to development of the proposed site. The discussion relies heavily on our understanding of the proposed site development as detailed in Section 4.

- It is anticipated that the economic viability of the site necessitates the reuse of site soils as fill and that site grading will be performed to make the site as balanced as possible in terms of cut and fill volumes. Because the glacial till typically has a high fines content, the glacial till is highly moisture sensitive. Protocols need to be established in cut and fill operations to promote drying and to minimize the infiltration of surface or subsurface water into material proposed for fill use. Otherwise, significant construction delays will result, as disking, lime treatment, or other measures might be required to allow the soil to be placed to the minimum required density, which should be 95 percent of the maximum Modified Proctor density, unless otherwise specified.

- The glacial till should be assumed to contain significant quantities of cobbles and boulders. Ideally, the cobbles and boulders would be screened and processed for use as select granular fill on the site. If this is undesirable, the cobbles and boulders can be placed within the soil fill in deeper fill areas, provided they are adequately dispersed (not nested) and care is exercised to compact soil around the perimeters of the boulders. Alternatively, the boulders can be broken into smaller cobbles that can be more readily incorporated into the fill. It is preferred that oversized materials be placed in fills beneath parking lots, driveways and landscaped areas.

- The investigation indicates that bedrock is unlikely to be encountered in areas of mass excavation. Subsequently, we anticipate that substantial rock excavation will not be required for the proposed site development. Rock may be encountered during installation of drainage piping on the eastern end of the site, and there is a slight chance that bedrock may be encountered near the periphery of the stormwater retention basins. If rock excavation is found to be required for utilities or other structures, it is anticipated that only a comparatively thin weathered zone will be rippable with a large bulldozer or heavy excavator. Deeper excavations within bedrock are anticipated to require excavator mounted hydraulic hammers for cost effective rock fracturing and removal.

- The undisturbed glacial till soils, as well as glacial till soils placed and compacted atop undisturbed glacial till will provide good shallow bearing foundation support for the proposed building and ancillary structures. Generally, undisturbed glacial till soils suitable for supporting foundations will typically be encountered within approximately 1 to 2 feet of existing grade.

- Groundwater observations at test pits indicate that groundwater will not have a significant impact on building design. Groundwater was below an elevation of +469 feet at the test pit performed in the general area of Building 1, and the finish floor of this structure is to be +478. Test pit 3, performed in the eastern extends of Building 4 identified water at approximately +431.5 feet, which is substantially below the proposed finish floor elevation of +462 feet. Due to site grades dropping to the east between Buildings 1 and 4, it is anticipated that subsurface water can be adequately controlled through the use of perimeter footing drains within the deeper cut areas of Buildings 2, 3 and 4. Due to site grades being raised in the area of Buildings 5, 6 and 8 and the fuel island, perimeter foundation drains are anticipated to be adequate for these structures also. Below grade tanks associated with the fuel island are anticipated to bear approximately 16 feet below grade, or at approximately elevation +428 feet. This is above existing grade in the area of the proposed tanks, and therefore, the tank is not expected to be subject to significant uplift forces due to groundwater. Some subsurface seepage could emerge from proposed cut slopes north of Buildings 3 and 4 from higher ground to the north, as well as from other cut slopes.

- Because of their high fines contents, the glacial till soils should be considered moderately to highly frost susceptible. Design measures to minimize the frost heave of pavements and slabs should be implemented, especially in locations near potential water sources. This would include areas near the base of cut slopes.

- The planned 2 Horizontal to 1 Vertical (2:1) cut slopes will be grossly stable. The proposed 2:1 fill slopes will also be stable provided the soils are adequately compacted. It is noted that adequate compaction is commonly not done, and surface slope instabilities are not uncommon on 2:1 fill slopes comprised of these soils. As will be discussed in Section 11, the proper

compact of the faces of fill slopes usually requires constructing the slope beyond the intended slope limit and trimming the slope to the required lines and grades.

- The site geology is not prone to the development of sinkholes. However, existing structures such as catch basins and piping should be removed to prevent sinkholes development.
- The on-site soils are not subject to liquefaction.

10.0 RECOMMENDATIONS

The following sections provide recommendations for the design of the proposed building foundations. The recommendations are based on the results of the subsurface investigations presented in this report and our experience working with similar site conditions.

10.1 Foundations

The proposed buildings and associated structures can be supported on continuous wall footings and spread footings bearing on undisturbed native soils, or on-site fill soils placed over these materials. In areas where fill placement is required, the soil subgrades should be prepared and the fill should be placed and compacted in lifts, as recommended in Section 11 of this report. Foundations bearing on fill or within the top two (2) feet of the native soil should be designed using a net allowable bearing pressure of 4,000 pounds per square foot (psf), or less. Foundation bearing on undisturbed native soils, at depths greater than two (2) feet below existing grade, may be designed using a net allowable bearing pressure of 6,000 psf. The foundations for buildings that straddle the cut/fill line should be designed utilizing the lower bearing pressure. Subgrade preparation recommendations are provided in Section 11, below.

The stepping of spread footing foundations should be done to prevent overlapping of the foundation's zones of influence. We recommend that the zone of influence of a foundation be taken as imaginary planes sloping downward and outward from the bottom edges of the foundations at a slope of 1H:1V. Higher foundations should be lowered, as required, to meet this requirement.

We recommend that continuous wall footings be designed with a minimum width of 2 feet and spread footings should have a minimal width of 3 feet. Exterior footings should bear at least 3.5 feet below the adjacent outside grade for frost protection. Interior foundations should bear at least 1.5 feet below the finished floor slab elevation within heated sections of the building. Using the above

design criteria, total settlement is estimated to be less than 1.0 inch and differential settlements are estimated to be less than 0.5 inches. The differential settlement is estimated over a distance of about 30 feet along continuous footings, or between adjacent column footings.

10.2 Foundation and Retaining Walls

Below grade building and retaining walls should be backfilled with non-expansive, free draining soil. For this reason, we do not recommend the use of the on-site soils as backfill within the zone immediately adjacent to the wall. The outside boundary of this zone is defined by an imaginary line sloping upward from the base of the wall at a 1 horizontal to 1 vertical slope. Import structural fill, as defined in Section 11, should be used within these zones. Walls retaining select fill can be designed in accordance with the following criteria:

Soil Parameter	Select Fill Backfill
Angle of internal Friction	35º
Active earth pressure Coefficient (K_a) (1)	0.27
At rest earth pressure Coefficient (K_o) (2) (restrained wall)	0.43
Passive earth pressure Coefficient (K_p) (3)	3.69
Total unit weight of soil (pounds per cubic foot)	130

1) Use for free standing walls where movement of up to 0.0025 X height of wall is both possible and tolerable. Otherwise, use at-rest coefficient.

2) Use for walls restrained against outward lateral movement.

3) Passive resistance should be reduced by one half ($^1/_2$) within the zone of frost penetration (3.5 feet).

Concrete foundations cast directly against the native on-site soils or fill can be assumed to have a coefficient of sliding resistance of 0.34.

Additional loading due to temporary and permanent surcharges, such as earthquake, automobiles and construction traffic, should be added to the lateral loading exerted by the backfill. Loads due to supported structures should be applied in appropriate combinations with the lateral loads.

We recommend that a moisture barrier be applied to below grade walls and that drainage provision be provided. Drainage provisions can consist of a minimum 12-inch wide drainage layer of crushed stone or clean gravel placed against the full-height with a collector pipe at the footing bottom. Alternatively, a geocomposite drainage board could be used in lieu of the crushed stone drainage layer. The collector pipe at the bottom of the footing should drain by gravity away from the building to daylight or be connected to the site's stormwater management system. The gradation specification for the drainage material is provided in Section 11.4 of this report. The stone or gravel should be completely separated from the soil backfill by a permeable geotextile having an apparent opening size (AOS) equal to the #70 U.S. Sieve, such as Tencate's Mirafi 140N. Grading of the surface of the backfill and the surrounding topography and pavements should provide positive drainage away from the walls. Roof drains should be positively drained to areas away from the building.

10.3 Slabs-on-Grade

Slab-on-grade floors should be supported on a minimum 6-inch thick layer of free draining ½- to ¾-inch crushed stone placed over undisturbed native soil or native site (general) fill soils. Subgrade preparation recommendations are provided in Section 11 of this report. A vapor barrier consisting of a polyethylene membrane at least 15 mils thick, such as Stego® Wrap Vapor Barrier, should be placed beneath all moisture sensitive floor slabs. A coefficient of friction of 0.3 should be used between the slab and the vapor barrier.

For design of slabs-on-grade with a 6-inch crushed stone base, a modulus of subgrade reaction of 150 pounds per cubic inch (pci) is recommended. The modulus of subgrade reaction is suitable for estimating distributions of bearing pressure beneath the slab and for estimating bending moments and shears within the slab. It is not intended for the purpose of calculating total or differential settlements.

11.0 CONSTRUCTION RECOMMENDATIONS

The following sections provide our general site and building construction recommendations.

11.1 General Site Preparation

Topsoil, stumps, roots greater than 1-inch in diameter, existing building foundations, existing catch basins and drain pipes and other deleterious materials should be stripped and removed from the site. Topsoil removed from the stripping operation may be stockpiled and processed (if necessary) to meet the site civil engineer's and/or landscape architect's specifications for topsoil to be placed around the site. All debris and unsuitable materials removed from the site should be disposed of at a legal disposal facility. Existing utilities within the project limits, if any, should be re-routed or protected from damage by construction equipment.

It is anticipated that the majority of the fill soil used for this project will be cut from across the site. The on-site soils are sensitive to disturbance and will be difficult to compact when wet. Delays associated with stabilization of the soils should be expected when the soil is placed in wet conditions, such as during wet periods or when excavated from below the groundwater table. If the Client wishes to minimize delays, it would be prudent to limit performing earthwork to the summer months. Overly wet fill should be dried to meet the recommendations given below. This may be achieved by air drying, with or without mechanical manipulation through harrowing. Lime stabilization may also be used to reduce the moisture content of fill soils. Imported structural fill should be used for backfilling retaining walls and foundation walls. See Section 11.4 for further details and recommendations for fill materials.

Given the relative stiffness of the glacial till (both undisturbed and compacted) and the potential for seepage through cut slopes, it is recommended that all slopes steeper than 2.5 Horizontal to 1 Vertical be stabilized with a cellular slope stabilization grid. A geocell slope-stabilization material, like Typar's Geocell GS, or Presto Geosystems' Geoweb® is recommended. The geocells should be installed on the slope face in accordance with the manufacturer's recommendations and topsoil should be subsequently placed.

11.2 Subgrade Preparations

All fill, pavement, foundation and slab subgrades should be inspected by the geotechnical engineer prior to the placement of asphalt, concrete or fill. The subgrades should consist of firm, stable and unyielding glacial till or compacted fill placed over suitable glacial till soil. All existing uncontrolled fill should also be removed.

Foundation subgrades should be prepared by removing all soil loosened by machine excavation. Fill, floor and pavement subgrades may be prepared by recompacting loosened materials. The foundation subgrades, slab-on-grade subgrades, pavement subgrades, and any areas to receive fill should be proofrolled under the observation of the geotechnical engineer. Proofrolling in confined areas should be performed with a double-drum vibratory roller having a minimum static weight of 1.5 tons. Proofrolling in open areas should be performed with a static roller having a minimum weight of 10 tons, or by a fully-loaded 10-wheeled dump truck. Soils not meeting the recommended requirements for suitable bearing materials, all existing fill, or areas found to be soft and yielding during proofrolling, should be removed. The area of removal should be within the zone of influence of the foundations, which is defined as zone contained within imaginary planes sloping downward and outward from the bottom edges of the foundation at a slope of 1 horizontal to 1 vertical. When unsuitable material is encountered beneath slabs or pavement, the area of removal should span the entire soft, yielding area beneath the slab or pavement. Over-excavated areas should be re-established with compacted fill.

11.3 Protection of Subgrades and Temporary Dewatering

Subgrades should be protected from the effects of frost, construction traffic, groundwater, and surface water. The necessary temporary protection should be provided immediately subsequent to excavation and be maintained until placing fill or concrete. Temporary surface drainage measures are recommended to divert runoff away from the proposed construction limits. Permanent drainage measures – typically underdrains and curtain drains – are recommended within cut areas that extend more than 2 feet below existing grade.

If subsurface seepage is encountered, dewatering should be performed to maintain groundwater approximately 2 feet below the deepest excavation. Temporary dewatering can be best achieved through the use of use of sump pits and pumps. Sump pits should be placed outside of the zone of influence of foundations, with the surrounding subgrade sloped to direct groundwater to the pits. Four (4) to six (6) inches of clean crushed stone, as recommended below, may be placed above the excavated subgrades for protection during foundation construction.

11.4 General Excavation

All excavations should conform to the latest OSHA requirement regarding worker safety. The soils will vary from having OSHA designation Class B and C soils.

The results of our subsurface investigation indicate that the required on-site excavations should be feasible with normal heavy-duty earthmoving equipment in good working order. However, larger boulders may be encountered that require excavator mounted hydraulic hammer to fracture. Also, and as noted, bedrock requiring excavator mounted hydraulic hammers to fracture may also be encountered in deeper excavations on the eastern end of the site.

11.5 Fill and Backfill Materials

Structural fill shall consist of sand, gravel, crushed stone, crushed gravel, or a mixture of these, it shall contain no organic matter, and it shall conform to the following gradation:

Sieve Size	Percent Finer by Weight
3 inch	100
¼ inch	30-70
No. 40	5-40
No. 200	0-10

Based on the results of our subsurface investigation and laboratory testing, the majority of the on-site soils are not suitable for use as structural fill as all but isolated layers have excessive fines (soil passing the No. 200 sieve).

General fill for raising grade beneath buildings, roads and other structures can consist of the on-site native glacial tills free of organic matter and having a maximum particle sizes of 8 inches ($^{2}/_{3}$ of a 12-inch loose lift thickness). It is anticipated that drying and some screening of oversize material will be required. Oversized material should be crushed or placed as discussed in Section 9 of this report.

All fill and backfill should be compacted to at least 95 percent of the maximum dry density, within 2 percent of the optimum moisture content, as determined by ASTM D1557. The lift thickness for the fill soils will vary depending on the type of compaction equipment used. Fills should generally be placed in uniform horizontal lifts not exceeding 12 inches in loose thickness. In confined areas, the loose lift thickness should be 6 inches or less and each lift should be compacted with sufficient

passes of hand operated vibratory or impact compaction equipment. A geotechnical engineer with appropriate field and laboratory support should inspect all footing subgrades, approve materials for use as fill, and test backfill materials for compliance with the recommended compaction.

Free draining crushed stone placed below slabs and as drainage materials behind foundation and retaining walls, and within curtain drains and underdrains should meet the specification for Underdrain Filter Type I materials, as specified in the NYSDOT Standard Specifications (Item 733.2001), as follows:

Sieve Size	Percent Finer by Weight
1 inch	100
½ inch	30-100
¼ inch	0 – 30
No. 10	0 – 10
No. 20	0 – 5

In some cases, it may be preferable to place flowable fill as backfill within utility trenches or as a substitute for compacted fill to restore the grade when undercutting unsuitable materials from beneath buildings or other structures. In that case, the flowable fill should have a minimum 28-day unconfined compressive strength of 150 psi and should meet the requirements for Controlled Low Strength Material (CLSM), as specified in Section 733-01 – "Flowable Fill" of the NYSDOT Standard Specifications.

It allows proper compaction of proposed fill slopes; the slope face should be constructed a minimum distance of 4 feet beyond the proposed slope face and then trimmed to the proper location. This provides some confinement of soils that will comprise the slope face during compaction. Otherwise, compaction results largely in the lateral spread of soils at the slope face and compromises fill compaction.

12.0 CONSTRUCTION MONITORING

A geotechnical engineer familiar with the existing subsurface conditions and having the appropriate laboratory and field-testing support should be engaged by the owner to observe that all earthwork is performed in accordance with the specifications, the Code, and the design criteria provided in this report.

The following work should be performed under the observation of the geotechnical engineer:

- Placement and compaction of fill
- Foundation subgrade preparation
- Proofrolling of floor, pavement and foundation subgrades
- Temporary dewatering activities

All materials proposed for use as soil fill should be tested and approved prior to delivery or use on-site. All fill materials should be tested as they are being placed to verify that the required compaction is being achieved.

13.0 LIMITATIONS

Our professional services have been performed using the degree of care and skill ordinarily exercised under similar circumstances by reputable geotechnical engineers and geologists practicing in this or similar situations. The interpretation of the field data is based on good judgment and experience. However, no matter how qualified the geotechnical engineer or detailed the investigation, subsurface conditions cannot always be predicted between the points of actual sampling and testing. No other warranty, expressed or implied, is made as to professional advice included in this report.

The recommendations and data contained in this report are intended for preliminary design purposes only. The use of this report as a construction document is neither intended nor authorized by Tectonic Engineering Consultants P.C. (Tectonic). Contractors and others involved in the construction of this project are advised to make an independent assessment of the subsurface conditions for establishing quantities, schedules and construction techniques.

This report has been prepared for the exclusive use of the Rockland County Highway Department and their designees for the specific application to the proposed construction described in this report. In the event that any changes in nature, design or location of proposed structures are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions modified or verified in writing by Tectonic. It is recommended that Tectonic be retained to review the plans and specifications prior to bidding and to provide construction monitoring and inspection services to ensure proper implementation of the recommendations contained herein, which would otherwise limit our professional liability.

FIGURE I

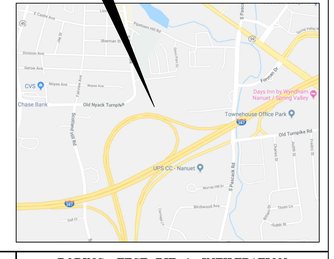
LEGEND

B-1	APPROXIMATE HISTORICAL BORING LOCATION
TP-1	APPROXIMATE HISTORICAL TEST PIT LOCATION
PT-1	APPROXIMATE PERCOLATION TEST LOCATION
TEC-1	APPROXIMATE TECTONIC BORING LOCATION
TTP-101	APPROXIMATE TECTONIC TEST PIT LOCATION

NOTES

1. PLAN BASED ON A DRAWING BY McLAREN ENGINEERING GROUP, DATED 7/16/2019.
2. BORINGS TEC-1 THRU TEC-4 WERE FIELD LOCATED BY TECTONIC AND SHOULD BE CONSIDERED APPROXIMATE.
3. INFILTRATION TEST LOCATIONS WERE FIELD LOCATED BY TECTONIC AND SHOULD BE CONSIDERED APPROXIMATE.
4. HISTORICAL BORINGS B-1 THRU B-6 WERE LOCATED BY OTHERS AND SHOULD BE CONSIDERED APPROXIMATE.
5. HISTORICAL TEST PIT LOCATIONS TP-1 THRU TP-10 WERE LOCATED BY OTHERS AND SHOULD BE CONSIDERED APPROXIMATE.

SITE



0 1 2 3

ORIGINAL SIZE IN INCHES

Tectonic
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70 Pleasant Hill Road
P.O. Box 37
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Phone: (845) 534-5959
(800) 829-6531
www.tectonicengineering.com
Project Contact Info
1279 Route 300
Newburgh, NY 12550
Phone: (845) 567-6656

BORING, TEST PIT & INFILTRATION TEST LOCATION PLAN

NEW ROCKLAND HIGHWAY FACILITY
ROCKLAND COUNTY
CHESTNUT RIDGE AND NANUET, NEW YORK

Date	Work Order	Drawing No.	Rev
10/10/19	10037.01	FIGURE 1	0
Scale 1" = 1200'			

APPENDIX I

Tectonic

PROJECT No. **10037.01**
PROJECT: **Rockland County New Highway Facility**
LOCATION: **Nanuet, NY**

BORING No. TEC-1

SHEET No. 1 of 4

CLIENT: **Rockland County Highway Department**
CONTRACTOR: **Craig Test Borings Co., Inc.**
METHOD OF ADVANCING BORING | DIA. | DEPTH
POWER AUGER: | | TO
ROT. DRILL: | **3 7/8"** | **0** TO **100'**
CASING: | **4"** | **0** TO **15'**
DIAMOND CORE: | | TO
CME 750 Rubber Tire Rig with Automatic Hammer

GROUND WATER | DATE | TIME | DEPTH
MON. WELL ☐ YES ☒ NO
SCREEN DEPTH: **---** TO **---**
WEATHER: **Clear** TEMP: **61° F**
DEPTH TO ROCK: **Not Encountered'**
*CHANGES IN STRATA ARE INFERRED

INSPECTOR: **Scott Cohen**
DRILLER: **Paul Mullins**
SURFACE ELEVATION: **435.0**
DATUM: **See Remarks**
DATE START: **9/13/19**
DATE FINISH: **9/13/19**

UNCONFINED COMPRESS. STRENGTH (TONS/FT) ● 1 2 3 4 5
PLASTIC LIMIT % | WATER CONTENT % | LIQUID LIMIT % 10 20 30 40 50
STANDARD PENETRATION (BLOWS/FT.) ● 10 20 30 40 50

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLE NUMBER	RECOV. LENGTH (IN.)	RQD (%)	MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL
1–2	39	19, 21, 18, 16	S-1	6		M	SM	2" Topsoil like material Bwn-tn m-f SAND, and Silt, little c-f Gravel (FILL)
3–4	25	10, 10, 15, 19	S-2	10		M	ML	Bwn SILT, and m-f Sand, little c-f Gravel, trace brick fragments (FILL)
5–6	30	13, 15, 15, 15	S-3	8		M	ML	Bwn SILT, some c-f Sand, some c-f Gravel
7–8	40	15, 25, 15, 10	S-4	4		M	ML	Same
9–10	9	2, 4, 5, 5	S-5	8		M	ML	Bwn-tn SILT & CLAY, little m-f Sand, little c-f Gravel
11–12	22	11, 11, 11, 13	S-6	24		M	ML	Tn CLAYEY SILT, little f Sand, little c-f Gravel PP=2.5tsf
13–14								
15–16	42	15, 19, 23, 25	S-7	6		M	ML	Bwn-tn CLAYEY SILT, some c-f Gravel
17–18								
19–20								
21–22	39	22, 22, 17, 20	S-8	15		M	ML	Bwn-tn CLAYEY SILT, little c-f Gravel, little f Sand
23–24								
25								

ELEVATION (FT.): 430.0, 425.0, 420.0, 415.0, 410.0

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

BORING LOG 10037.01.GPJ TECTONIC ENG.GDT 10/11/19

Tectonic

PROJECT No. **10037.01**

PROJECT: **Rockland County New Highway Facility**

LOCATION: **Nanuet, NY**

BORING No. TEC-1

CLIENT: **Rockland County Highway Department**

CONTRACTOR: **Craig Test Borings Co., Inc.**

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLES: SAMPLE NUMBER	SAMPLES: RECOV. LENGTH (IN.)	SAMPLES: RECOV. RQD (%)	MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL
26	26	10 13 13 13	S-9	6		M	ML	Gy SILT & CLAY, little f Sand, little f Gravel
31	30	20 16 14 16	S-10	0				No recovery in spoon
36	38	10 14 24 24	S-11	12		M	ML	Gy SILT, little f Sand
41	29	17 12 17 23	S-12	12		M	ML	Gy SILT, little f Sand, trace f Gravel
46	86	30 43 43 55	S-13	15		M	ML	Gy SILT, some c-f Gravel, little f Sand
51	50+	23 50/4	S-14	5		M	ML	Gy SILT, little c-f Gravel, little f Sand

LITHOLOGY*

UNCONFINED COMPRESS. STRENGTH (TONS/FT)

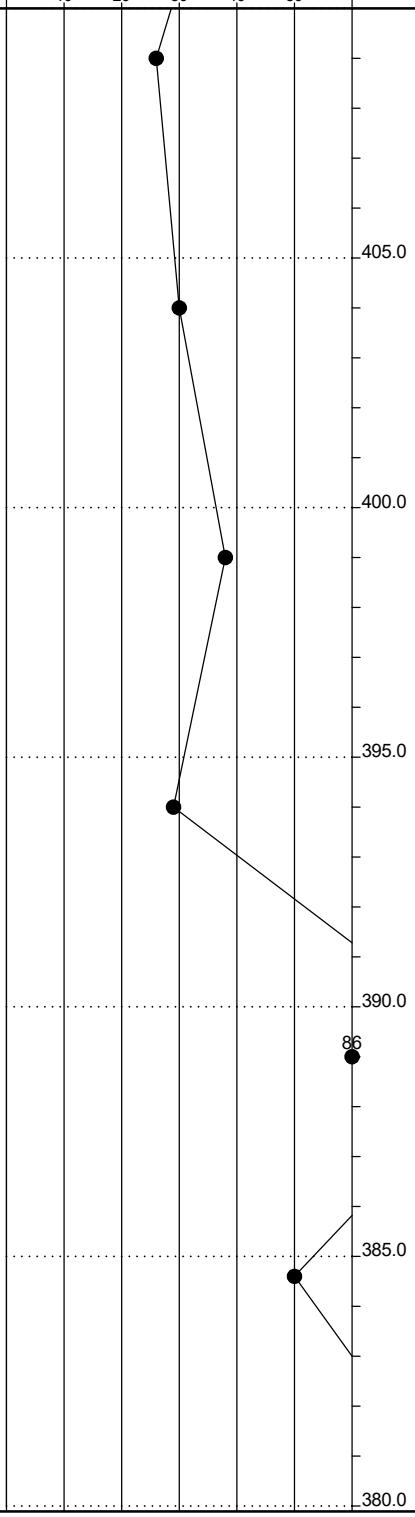
1 2 3 4 5

PLASTIC LIMIT % WATER CONTENT % LIQUID LIMIT %

10 20 30 40 50

STANDARD PENETRATION (BLOWS/FT.)

10 20 30 40 50



ELEVATION (FT.)

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

Tectonic

PROJECT No.	**10037.01**
PROJECT:	**Rockland County New Highway Facility**
LOCATION:	**Nanuet, NY**

BORING No. TEC-1

CLIENT: **Rockland County Highway Department**

CONTRACTOR: **Craig Test Borings Co., Inc.**

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLES: SAMPLE NUMBER	SAMPLES: RECOV. LENGTH (IN.)	SAMPLES: RECOV. RQD (%)	MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL	LITHOLOGY*	ELEVATION (FT.)
56	85	23 29 56 68	S-15	18		M	ML	Same		85
57										
58										
59										
60										375.0
61	60+	50 60/3	S-16	2		M	ML	Gy SILT, some c-f Gravel, little f Sand		
62										
63										
64										
65										370.0
66	50+	64 50/2	S-17	2		M	ML	Bwn-gy SILT, some c-f Gravel, little f Sand		
67										
68										
69										
70										365.0
71	124	40 57 67 62	S-18	24		M	ML	Same		124
72										
73										
74										
75										360.0
76	50+	74 50/3	S-19	6		M	ML	Same		
77										
78										
79										
80										355.0
81	78	39 25 53 56	S-20	20		M	ML	Bwn-rd SILT & CLAY, little f Sand, trace f Gravel		78
82										
83										
84										
85										350.0

UNCONFINED COMPRESS. STRENGTH (TONS/FT)
1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %
10 20 30 40 50

STANDARD PENETRATION (BLOWS/FT.)
10 20 30 40 50

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

Tectonic

PROJECT No. **10037.01**

PROJECT: **Rockland County New Highway Facility**

LOCATION: **Nanuet, NY**

BORING No. TEC-1

SHEET No. 4 of 4

CLIENT: **Rockland County Highway Department**

CONTRACTOR: **Craig Test Borings Co., Inc.**

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLES: SAMPLE NUMBER	SAMPLES: RECOV. LENGTH (IN.)	SAMPLES: RECOV. RQD (%)	SAMPLES: MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL	LITHOLOGY*	ELEVATION (FT.)
86	38	32 19 19 51	S-21	20		M	ML	Bwn-rd CLAYEY SILT, little f Sand		
87										
88										
89										
90										345.0
91	42	17 18 24 34	S-22	24		M	ML	Bwn-rd CLAYEY SILT, little f Sand, trace c-f Gravel		
92										
93										
94										
95	50+	70	S-23	4		M	SM	Rd m-f SAND, some Silt & Clay		340.0
96		50/2								
97										
98										
99										
100	68+	68/3	S-24	3		M	SP	Rd m-f SAND, trace c-f Gravel, trace Silt		335.0
101								End of Boring at 100.3'		
102										
103										
104										
105										330.0
106										
107										
108										
109										
110										325.0
111										
112										
113										
114										
115										320.0

UNCONFINED COMPRESS. STRENGTH (TONS/FT)
1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %
10 20 30 40 50

STANDARD PENETRATION (BLOWS/FT.)
10 20 30 40 50

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

BORING LOG 10037.01.GPJ TECTONIC ENG.GDT 10/11/19

Tectonic

PROJECT No. **10037.01**
PROJECT: **Rockland County New Highway Facility**
LOCATION: **Nanuet, NY**

BORING No. TEC-2

SHEET No. 1 of 4

CLIENT: **Rockland County Highway Department**
CONTRACTOR: **Craig Test Borings Co., Inc.**
METHOD OF ADVANCING BORING | DIA. | DEPTH
POWER AUGER: | | TO
ROT. DRILL: | **3 7/8"** | **0** TO **100'**
CASING: | **4"** | **0** TO **15'**
DIAMOND CORE: | | TO
CME 750 Rubber Tire Rig with Automatic Hammer

GROUND WATER | DATE | TIME | DEPTH

INSPECTOR: **Scott Cohen**
DRILLER: **Paul Mullins**
SURFACE ELEVATION: **430.0**
DATUM: **See Remarks**
DATE START: **9/16/19**
DATE FINISH: **9/16/19**
MON. WELL ☐ YES ☒ NO
SCREEN DEPTH: **---** TO **---**
WEATHER: **Overcast** TEMP: **64° F**
DEPTH TO ROCK: **Not Encountered'**
*CHANGES IN STRATA ARE INFERRED

UNCONFINED COMPRESS. STRENGTH (TONS/FT) ● 1 2 3 4 5
PLASTIC LIMIT % | WATER CONTENT % | LIQUID LIMIT % ✕ ⊗ △ 10 20 30 40 50
STANDARD PENETRATION (BLOWS/FT.) ● 10 20 30 40 50

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLE NUMBER	RECOV. LENGTH (IN.)	RECOV. RQD (%)	MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL	LITHOLOGY*	ELEVATION (FT.)
1	46	20 19 27 22	S-1	12		M	ML	Gy-bwn SILT, some c-f Gravel, little m-f Sand		
3	57	21 28 29 33	S-2	24		M	ML	Gy SILT, some c-f Gravel, trace f Sand		
5	97	30 32 65 50	S-3	24		M	ML	Gy CLAYEY SILT, some c-f Gravel, trace f Sand		425.0
7	69	40 37 32 27	S-4	24		M	ML	Gy CLAYEY SILT, some c-f Gravel, trace m-f Sand		
9	38	11 18 20 22	S-5	24		M	ML	Gy CLAYEY SILT, little c-f Gravel, trace m-f Sand		420.0
11	65	28 26 39 33	S-6	20		M	ML	Gy SILT, little c-f Sand, trace f Gravel		
13										
15										415.0
16	85	32 37 48 38	S-7	20		M	ML	Same		
18										
20										410.0
21	62	19 30 32 33	S-8	22		M	ML	Gy SILT, little c-f Sand, trace f Gravel, trace Clay		
23										
25										405.0

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

BORING LOG 10037.01.GPJ TECTONIC ENG.GDT 10/11/19

Tectonic

PROJECT No. **10037.01**
PROJECT: **Rockland County New Highway Facility**
LOCATION: **Nanuet, NY**

BORING No. TEC-2

SHEET No. 2 of 4

CLIENT: **Rockland County Highway Department**
CONTRACTOR: **Craig Test Borings Co., Inc.**

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLES: SAMPLE NUMBER	SAMPLES: RECOV. LENGTH (IN.)	SAMPLES: RECOV. RQD (%)	SAMPLES: MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL	LITHOLOGY*	ELEVATION (FT.)
26	55	17 28 27 37	S-9	24		M		Gy SILT, little c-f Sand, little f Gravel, trace Clay		
27										
28										
29										
30										400.0
31	56	16 24 32 32	S-10	20		M	ML	Gy SILT, some m-f Sand, little c-f Gravel		
32										
33										
34										
35										395.0
36	128	21 48 80 100/5	S-11	22		M	ML	Gy SILT, some m-f Sand, little c-f Gravel		128
37										
38										
39										
40										390.0
41	115+	37 65 50/3	S-12	9		M	ML	Gy SILT, some m-f Sand, little c-f Gravel		115
42										
43										
44										
45										385.0
46	91+	37 41 50/3	S-13	6		M	ML	Gy SILT, some f Gravel, little m-f Sand		91
47										
48										
49										
50										380.0
51	104	30 53 51 60	S-14	18		M	ML	Same		104
52										
53										
54										
55										375.0

UNCONFINED COMPRESS. STRENGTH (TONS/FT)
1 2 3 4 5
PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %
10 20 30 40 50
STANDARD PENETRATION (BLOWS/FT.)
10 20 30 40 50

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

Tectonic

PROJECT No. **10037.01**
PROJECT: **Rockland County New Highway Facility**
LOCATION: **Nanuet, NY**

BORING No. TEC-2

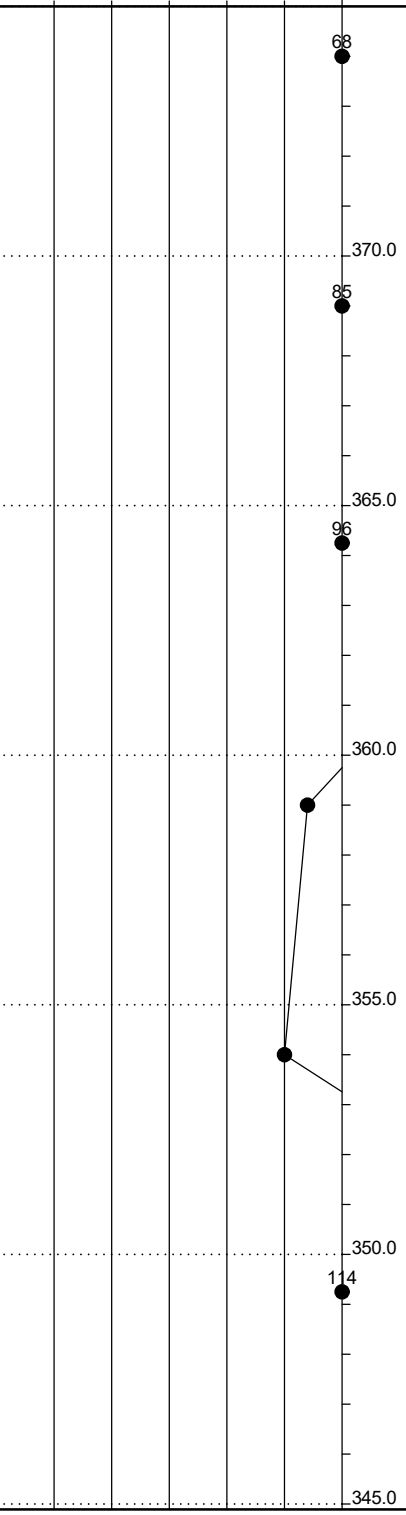
SHEET No. 3 of 4

CLIENT: **Rockland County Highway Department**
CONTRACTOR: **Craig Test Borings Co., Inc.**

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLES: SAMPLE NUMBER	SAMPLES: RECOV. LENGTH (IN.)	SAMPLES: RECOV. RQD (%)	SAMPLES: MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL
56	68	35 35 33 49	S-15			M	ML	Gy-bwn SILT, little f Gravel, little m-f Sand
57								
58								
59								
60								
61	85+	26 35 50/4	S-16	12		M	ML	Bwn-gy, little c-f Gravel, little m-f Sand
62								
63								
64								
65								
66	96+	27 46 50/4	S-17	10		M	ML	Same
67								
68								
69								
70								
71	54	26 24 30 32	S-18	18		M	ML	Bwn-gy SILT, some c-f Gravel, little c-f Sand, trace Clay
72								
73								
74								
75								
76	50	17 24 26 45	S-19	24		M	ML	Bwn CLAYEY SILT, little c-f Gravel, trace Sand
77								
78								
79								
80								
81	114+	38 64 50/4	S-20	10		M	ML	Rd-bwn SILT, little c-f Sand, little f Gravel
82								
83								
84								
85								

LITHOLOGY*

UNCONFINED COMPRESS. STRENGTH (TONS/FT)
1 2 3 4 5
PLASTIC LIMIT % WATER CONTENT % LIQUID LIMIT %
10 20 30 40 50
STANDARD PENETRATION (BLOWS/FT.)
10 20 30 40 50



ELEVATION (FT.)

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

Tectonic

PROJECT No.	**10037.01**
PROJECT:	**Rockland County New Highway Facility**
LOCATION:	**Nanuet, NY**

BORING No. TEC-2

SHEET No. 4 of 4

CLIENT: **Rockland County Highway Department**

CONTRACTOR: **Craig Test Borings Co., Inc.**

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLES: SAMPLE NUMBER	SAMPLES: RECOV. LENGTH (IN.)	SAMPLES: RECOV. RQD (%)	SAMPLES: MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL	LITHOLOGY*	ELEVATION (FT.)
86	126+	39 76 50/2	S-21	10		M	ML	Rd-bwn SILT, little c-f Sand, little c-f Gravel		126
87										
88										
89										
90										340.0
91	52+	42 52/4	S-22	9		M	ML	Rd-bwn SILT, little c-f Sand, trace f Gravel		
92										
93										
94										
95	50+	50/2	S-23	2		M	ML	Rd-bwn SILT, little c-f Sand, trace f Gravel		335.0
96										
97										
98										
99										
100	50+	50/2	S-24	2		M	ML	Rd-bwn SILT, trace f Gravel, trace m-f Sand		330.0
101								End of Boring at 100'		
102										
103										
104										
105										325.0
106										
107										
108										
109										
110										320.0
111										
112										
113										
114										
115										315.0

UNCONFINED COMPRESS. STRENGTH (TONS/FT)
1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %
10 20 30 40 50

STANDARD PENETRATION (BLOWS/FT.)
10 20 30 40 50

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

BORING LOG 10037.01.GPJ TECTONIC ENG.GDT 10/11/19

Tectonic

PROJECT No. **10037.01**
PROJECT: **Rockland County New Highway Facility**
LOCATION: **Nanuet, NY**

BORING No. TEC-3

SHEET No. 1 of 4

CLIENT: **Rockland County Highway Department**
CONTRACTOR: **Craig Test Borings Co., Inc.**
METHOD OF ADVANCING BORING | DIA. | DEPTH
POWER AUGER: | | TO
ROT. DRILL: | **3 7/8"** | **0** TO **100'**
CASING: | **4"** | **0** TO **15'**
DIAMOND CORE: | | TO
CME 750 Rubber Tire Rig with Automatic Hammer

GROUND WATER | DATE | TIME | DEPTH
MON. WELL ☐ YES ☒ NO
SCREEN DEPTH: **---** TO **---**
WEATHER: **Clear** TEMP: **65° F**
DEPTH TO ROCK: **Not Encountered'**
*CHANGES IN STRATA ARE INFERRED

INSPECTOR: **Scott Cohen**
DRILLER: **Paul Mullins**
SURFACE ELEVATION: **486.0**
DATUM: **See Remarks**
DATE START: **9/17/19**
DATE FINISH: **9/17/19**

UNCONFINED COMPRESS. STRENGTH (TONS/FT) ● 1 2 3 4 5
PLASTIC LIMIT % | WATER CONTENT % | LIQUID LIMIT % ✕ ⊗ △ 10 20 30 40 50
STANDARD PENETRATION (BLOWS/FT.) ● 10 20 30 40 50

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLE NUMBER	RECOV. LENGTH (IN.)	RQD (%)	MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL	LITHOLOGY*	ELEVATION (FT.)
1–2	4	1 2 2 2	S-1	4		M	ML	4" Topsoil like material Bwn-rd SILT, and m-f Sand, little c-f Gravel		
3–4	14	4 7 7 8	S-2	6		M	ML	Same		
5–6	11	5 5 6 4	S-3	7		M	ML	Bwn-rd SILT, little m-f Sand, trace f Gravel		481.0
7–8	15	4 6 9 6	S-4	4		M	SM	Bwn-tn c-f SAND, little Silt		
9–10	13	3 6 7 11	S-5	18		M	ML	Bwn-rd CLAYEY SILT, little m-f Sand, trace c-f Gravel		476.0
11–12	55	20 25 30 32	S-6	15		M	ML	Bwn-gy CLAYEY SILT, little m-f Sand, little c-f Gravel		
13–15										471.0
16–17	74	24 33 41 49	S-7	24		M	ML	Bwn CLAYEY SILT, some c-f Gravel, little m-f Sand		74
18–20										466.0
21–22	49	25 25 24 48	S-8	16		M	ML	Bwn-tn CLAYEY SILT, some c-f Gravel, some c-f Sand		
23–25										461.0

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

BORING LOG 10037.01.GPJ TECTONIC ENG.GDT 10/11/19

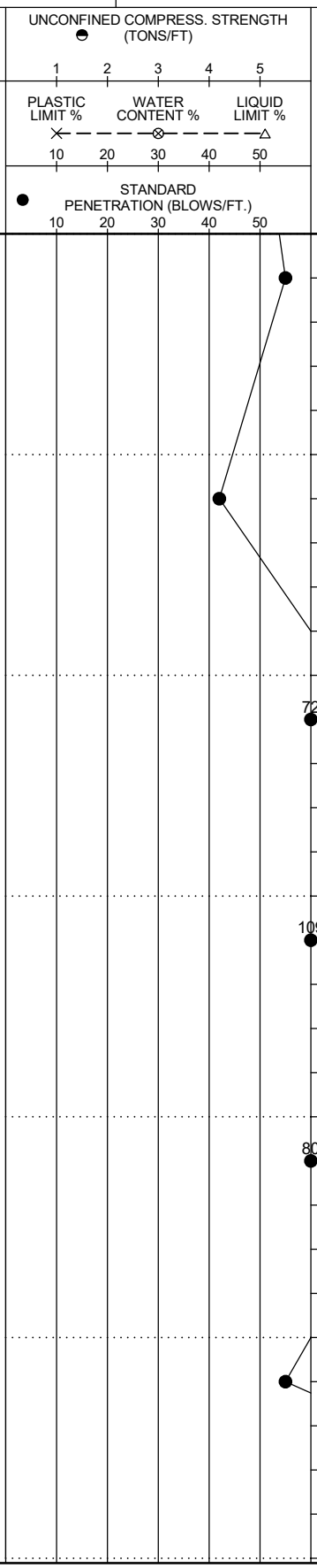
Tectonic

PROJECT No. **10037.01**
PROJECT: **Rockland County New Highway Facility**
LOCATION: **Nanuet, NY**

BORING No. TEC-3

CLIENT: **Rockland County Highway Department**
CONTRACTOR: **Craig Test Borings Co., Inc.**

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLES: SAMPLE NUMBER	SAMPLES: RECOV. LENGTH (IN.)	SAMPLES: RECOV. RQD (%)	MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL	LITHOLOGY*	ELEVATION (FT.)
26	55	21 25 30 35	S-9	21		M	ML	Gy CLAYEY SILT, little f Sand		
27										
28										
29										
30										456.0
31	42	23 19 23 22	S-10	10		M	ML	Gy CLAYEY SILT, little c-f Gravel, little m-f Sand		
32										
33										
34										
35										451.0
36	72	24 23 49 70	S-11	16		M	ML	Rd-gy CLAYEY SILT, little c-f Gravel, little m-f Sand		
37										
38										
39										
40										446.0
41	109	32 42 67 50/3	S-12	16		M	ML	Same		
42										
43										
44										
45										441.0
46	80	34 31 49 51	S-13	24		M	ML	Same		
47										
48										
49										
50										436.0
51	55	26 26 29 34	S-14	20		M	ML	Rd-gy SILT little c-f Gravel, little f Sand		
52										
53										
54										
55										431.0



REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

Tectonic

PROJECT No.	**10037.01**
PROJECT:	**Rockland County New Highway Facility**
LOCATION:	**Nanuet, NY**

BORING No. TEC-3

CLIENT: **Rockland County Highway Department**

CONTRACTOR: **Craig Test Borings Co., Inc.**

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLES: SAMPLE NUMBER	SAMPLES: RECOV. LENGTH (IN.)	SAMPLES: RECOV. RQD (%)	MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL	LITHOLOGY*	ELEVATION (FT.)
56	152	39 84 68 50/4	S-15	10		M	ML	Same		152
57										
58										
59										
60	100+	100/0	S-16					No Recovery in spoon Attempted core @ 61' boulder cored from 61 - 63'		100 426.0
61										
62										
63										
64										
65										421.0
66	135	42 66 69 50/3	S-17	6		M	ML	Rd-gy CLAYEY SILT, and c-f Gravel, trace c-f Sand		135
67										
68										
69										
70										416.0
71	57	17 20 37 34	S-18	20		M	ML	Rd-gy SILT, little m-f Sand, trace f Gravel		
72										
73										
74										
75										411.0
76	77	25 45 32 27	S-19	12		M	ML	Rd-gy SILT, little c-f Gravel, little m-f Sand		77
77										
78										
79										
80										406.0
81	65	34 37 28 32	S-20	18		M	ML	Bwn-gy SILT, little c-f Gravel, little m-f Sand		65
82										
83										
84										
85										401.0

UNCONFINED COMPRESS. STRENGTH (TONS/FT)
1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %
10 20 30 40 50

STANDARD PENETRATION (BLOWS/FT.)
10 20 30 40 50

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

Tectonic

PROJECT No. **10037.01**
PROJECT: **Rockland County New Highway Facility**
LOCATION: **Nanuet, NY**

BORING No. TEC-3

SHEET No. 4 of 4

CLIENT: **Rockland County Highway Department**
CONTRACTOR: **Craig Test Borings Co., Inc.**

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLES: SAMPLE NUMBER	SAMPLES: RECOV. LENGTH (IN.)	SAMPLES: RECOV. RQD (%)	SAMPLES: MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL	LITHOLOGY*	ELEVATION (FT.)
86	74	21 40 34 24	S-21	10		M	ML	Same		74
87										
88										
89										
90										396.0
91	37	27 21 16 22	S-22	16		M	ML	Bwn-gy SILT, some c-f Gravel, little m-f Sand		
92										
93										
94										
95										391.0
96	108+	19 58 50/2	S-23	2		M	SM	Bwn-tn c-f SAND, little Silt		108
97										
98										
99										
100										386.0
101	67	37 31 36 48	S-24	15		M	ML	Bwn-rd SILT, some c-f Gravel, little m-f Sand		67
102										
103								End of Boring at 102'		
104										
105										381.0
106										
107										
108										
109										
110										376.0
111										
112										
113										
114										
115										371.0

UNCONFINED COMPRESS. STRENGTH (TONS/FT)
1 2 3 4 5
PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %
10 20 30 40 50
STANDARD PENETRATION (BLOWS/FT.)
10 20 30 40 50

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

BORING LOG 10037.01.GPJ TECTONIC ENG.GDT 10/11/19

Tectonic

BORING No. TEC-4

PROJECT No. **10037.01**
PROJECT: **Rockland County New Highway Facility**
LOCATION: **Nanuet, NY**
SHEET No. 1 of 3

CLIENT: **Rockland County Highway Department**
CONTRACTOR: **Craig Test Borings Co., Inc.**
METHOD OF ADVANCING BORING | DIA. | DEPTH
POWER AUGER: | | TO
ROT. DRILL: | **3 7/8"** | **0** TO **75'**
CASING: | **4"** | **0** TO **10'**
DIAMOND CORE: | | TO
CME 750 Rubber Tire Rig with Automatic Hammer

GROUND WATER | DATE | TIME | DEPTH
MON. WELL ☐ YES ☒ NO
SCREEN DEPTH: **---** TO **---**
WEATHER: **Clear** TEMP: **55° F**
DEPTH TO ROCK: **Not Encountered'**
*CHANGES IN STRATA ARE INFERRED

INSPECTOR: **Scott Cohen**
DRILLER: **Paul Mullins**
SURFACE ELEVATION: **483.0**
DATUM: **See Remarks**
DATE START: **9/18/19**
DATE FINISH: **9/18/19**

UNCONFINED COMPRESS. STRENGTH (TONS/FT) ● 1 2 3 4 5
PLASTIC LIMIT % | WATER CONTENT % | LIQUID LIMIT % ✕ ⊗ △ 10 20 30 40 50
STANDARD PENETRATION (BLOWS/FT.) ● 10 20 30 40 50

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLES: SAMPLE NUMBER	RECOV.: LENGTH (IN.)	RECOV.: RQD (%)	MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL	LITHOLOGY*	ELEVATION (FT.)
1–2	2	5 1 1 1	S-1	4		M	ML	2" Topsoil like material Rd-bwn SILT, some m-f Sand, little c-f Gravel		
3–4	18	3 6 12 10	S-2	8		M	ML	Bwn SILT, some c-f Sand, little c-f Gravel		
5–6	22	11 11 11 11	S-3	12		M	ML	Rd-bwn SILT, little c-f Gravel, little m-f Sand		478.0
7–8	33	22 17 16 9	S-4	12		M	ML	Same		
9–10	16	14 8 8 9	S-5	9		M	ML	Rd-bwn SILT, some c-f Sand, little f Gravel		473.0
11–12	19	15 10 9 9	S-6	15		M	ML	Bwn-tn CLAYEY SILT, some m-f Sand, trace c-f Grave;l		
13–15										468.0
16–17	85+	17 35 50/3	S-7	7		M	ML	Bwn-tn SILT, some c-f Gravel, little m-f Sand		85
18–20										463.0
21–22	107+	46 57 50/4	S-8	6		M	ML	Bwn-tn CLAYEY SILT, little c-f Gravel, little m-f Sand		107
23–25										458.0

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

BORING LOG 10037.01.GPJ TECTONIC ENG.GDT 10/11/19

Tectonic

PROJECT No. **10037.01**
PROJECT: **Rockland County New Highway Facility**
LOCATION: **Nanuet, NY**

BORING No. TEC-4

CLIENT: **Rockland County Highway Department**
CONTRACTOR: **Craig Test Borings Co., Inc.**

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLES: SAMPLE NUMBER	SAMPLES: RECOV. LENGTH (IN.)	SAMPLES: RECOV. RQD (%)	MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL	LITHOLOGY*	UNCONFINED COMPRESS. STRENGTH (TONS/FT) / PLASTIC LIMIT % / WATER CONTENT % / LIQUID LIMIT % / STANDARD PENETRATION (BLOWS/FT.)	ELEVATION (FT.)
26	97	30 54 43 43	S-9	16		M	ML	Bwn-gy CLAYEY SILT, little c-f Gravel, trace m-f Sand		97	
27											
28											
29											
30											453.0
31	72	20 34 38 40	S-10	14		M	ML	Gy-bwn SILT, some c-f Gravel, some m-f Sand		72	
32											
33											
34											
35											448.0
36	121	30 65 56 72	S-11	12		M	ML	Rd-bwn SILT, little c-f Gravel, little m-f Sand		121	
37											
38											
39											
40											443.0
41	70+	40 70/4	S-12	6		M	ML	Rd-gy SILT, little m-f Sand, trace c-f Gravel		70	
42											
43											
44											
45											438.0
46	110+	39 60 50/4	S-13	9		M	ML	Bwn-gy SILT, little c-f Gravel, little m-f Sand		110	
47											
48											
49											
50											433.0
51	88	36 48 40	S-14	18		M	ML	Rd-bwn SILT, little c-f Gravel, little m-f Sand		88	
52											
53											
54											
55											428.0

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

Tectonic

PROJECT No.	**10037.01**
PROJECT:	**Rockland County New Highway Facility**
LOCATION:	**Nanuet, NY**

BORING No. TEC-4

CLIENT: **Rockland County Highway Department**

CONTRACTOR: **Craig Test Borings Co., Inc.**

DEPTH (FT.)	N OR MIN./FT.	PENETRATION RESISTANCE (BL/6 IN.)	SAMPLES: SAMPLE NUMBER	SAMPLES: RECOV. LENGTH (IN.)	SAMPLES: RECOV. RQD (%)	MOISTURE	UNIFIED SOIL CLASS.	DESCRIPTION OF MATERIAL	LITHOLOGY*	ELEVATION (FT.)
56	80	26 24 56 78	S-15	16		M	ML	Same		80
57										
58										
59										
60										423.0
61	72	28 28 44 76	S-16	14		M	ML	Same		72
62										
63										
64										
65										418.0
66	109+	54 59 50/3	S-17	6		M	ML	Rd-bwn SILT, little m-f Sand, trace c-f Gravel		109
67										
68										
69										
70										413.0
71	68+	65 68/4	S-18	6		M	SM	Bwn-gy c-f SAND, some Silt, some c-f Gravel		68
72										
73										
74										
75										408.0
76	109	58 53 56 61	S-19	12		M	SM	Bwn-gy c-f SAND, and Silt, trace f Gravel		109
77										
78								End of Boring at 77'		
79										
80										403.0
81										
82										
83										
84										
85										398.0

UNCONFINED COMPRESS. STRENGTH (TONS/FT) ● 1 2 3 4 5

PLASTIC LIMIT % × — WATER CONTENT % ⊗ — LIQUID LIMIT % △ 10 20 30 40 50

STANDARD PENETRATION (BLOWS/FT.) ● 10 20 30 40 50

REMARKS: Surface elevation estimated from elevation contours on topographic drawing provided by Client.

Tectonic
PRACTICAL SOLUTIONS. EXCEPTIONAL SERVICE.

LEGEND FOR SOIL DESCRIPTION

COARSE GRAINED SOIL (Coarser then No. 200 Sieve)

DESCRIPTIVE TERM & GRAIN SIZE

TERM	SAND					GRAVEL
coarse - c	No.	4	Sieve to No.	10	Sieve	3" to 3/4"
medium - m	No.	10	Sieve to No.	40	Sieve	3/4" to 3/16"
fine - f	No,	40	Sieve to No.	200	Sieve	

COBBLES 3" to 10"

BOULDERS 10" +

GRADATION DESIGNATIONS	PROPORTIONS OF COMPONENT
fine, f	Less than 10% coarse to medium
medium to fine, m-f	Less than 10% coarse
medium, m	Less than 10% coarse and fine
coarse to medium, c-m	Less than 10% fine
coarse, c	Less than 10% medium and fine
coarse to fine, c-f	All greater than 10%

FINE GRAINED SOIL (Finer than No. 200 Sieve)

DESCRIPTION	PLASTICITY INDEX	PLASTICITY
Silt	0 - 1	none
Clayey Silt	2 - 5	slight
Silt & Clay	6 - 10	low
Clay & Silt	11 - 20	medium
Silty Clay	21 - 40	high
Clay	greater than 40	very high

PROPORTION

DESCRIPTIVE TERM	PERCENT OF SAMPLE WEIGHT
trace	1 - 10
little	10 - 20
some	20 - 35
and	35 - 50

The primary component is fully capitalized

COLOR

Blue - blue	Gy - gray	Wh - white
Blk - black	Or - orange	Yl - yellow
Bwn - brown	Rd - red	Lgt - light
Gn - green	Tn - tan	Dk - dark

SAMPLE NOTATION

S - Split Spoon Soil Sample
U - Undisturbed Tube Sample
C - Core Sample
B - Bulk Soil Sample
NR - No Recovery of Sample

WOC - Weight of Casing
WOR - Weight of Rods
WOH - Weight of Hammer
PPR - Compressive Strength based on Pocket Penetrometer
TV - Shear Strength (tsf) based on Torvane

ADDITIONAL CLASSIFICATIONS

New York City Building Code soil classifications are given in parentheses at the end of each description of material, if applicable. See sections 1804.2 of the 2008 Building Code for further details.

Tectonic	W.O. No. 10037.01	Date: 9/24/2019	TEST PIT
	Project: Rockland County New Highway Facility		TP-101
(800) 829-6531	Location: Nanuet, NY		

Client: Rockland County Department of Health	Depth to Seepage: NE	Inspector: Liam McGrath
Contractor: Rockland County	Depth to Groundwater: NE	Surface Elevation: +362'
Equipment: Deere Backhoe	Depth to Bedrock: NE	Datum: See Remarks

SAMPLES		Unified Soil Classification	Soil Profile	Strata Change (ft.)	Foundation Profile	REMARKS
Sample No.	Moisture					
			Ground Surface	0		The purpose of the test pit was to verify no bedrock or groundwater was located within 4' of the proposed detention basin bottom elevation. The test pit was located between Percolation Test 2 & 3 Datum was based on plan set created by McLaren Engineering Group, dated 7/16/2019
	M	SP	Topsoil	0.5		
	M	SP/SM	Lgt Bwn c-f SAND, many Cobbles, little c-f Gravel, little Silt, sparse organics (roots)	6		
	M	SM	Rd-Bwn c-f SAND, some c-f Gravel, some Clayey Silt, few Cobbles	12		
	M	SM	Bwn c-f SAND, little Silt, little c-f Gravel, few Cobbles	14		
			End of excavation			

PARTICLE SIZE		PROPORTION (exclusive of boulders & cobbles)	PROPORTION (boulders & cobbles)		MOISTURE
Boulder: 10"(+)	Sand: No.200 Sieve-3/16"	trace: 0-10%	sparse:	0-10%	D: dry
Cobble: 3-10"	Silt/Clay: No.200 Sieve (-)	little: 10-20%	few:	10-35%	M: moist
Gravel: 3/16"-3"		some: 20-35%	many:	35-65%	W: wet
		and: 35-50%			

APPENDIX II

102266-20

Bus.: (845) 365-9710 Fax.: (845) 365-9713
CMI Subsurface Investigations, Inc.
375 Western Highway Tappan, New York 10983

BORING NO. B-1 CMH DTW WRM CSZ

SHEET 1 of 2

BORING LOG

PROJECT ROCKLAND CO. HIGHWAY DEPT. FACILITY
LOCATION OLD NYACK TURNPIKE, SPRING VALLEY, NY
CLIENT MCLAREN ENGINEERING GROUP
INSPECTOR _____ DRILLER VINCE GANDOLFO HELPER GUS TSERBIS

PROJECT NO. _____
START DATE 9/7/05
FINISH DATE 9/7/05
RIG MOBIL B-61 HDX

DEPTH (FEET)	SAMPLE NO.	DEPTH (FROM/TO)	SOIL BLOWS / 6" 0"-6"	6"-12"	12"-18"	18"-24"	RECOVERY (INCHES)	ROCK CORE RUN (IN.)	ROCK CORE REC. (IN.)	DEPTH (FROM/TO)	SOIL/ROCK DESCRIPTION & REMARKS	CASING BLOWS
	S1	0/2	6	7	7	15	24				TAN SILT, LITTLE FC GRAVEL, TRACE F SAND, DRY, MEDIUM DENSE.	
	S2	2/4	100/6"	SPT	REFUSAL		5				GRADING TO VERY DENSE.	
5	S3	5/7	100/6"	SPT	REFUSAL		4				BROWN FM SAND, LITTLE SILT, TRACE F GRAVEL, DRY, VERY DENSE.	
	S4	7/9	8	7	100/3"	SPT REFUSAL	4				-SAME AS ABOVE SAMPLE-	
10	S5	9/11	21	100/4"	SPT REFUSAL		7				GRADING TO RED BROWN FMC SAND, SOME FC GRAVEL, LITTLE SILT, VERY DENSE.	
15	S6	15/17	23	22	17	17	12				RED BROWN FM SAND, LITTLE SILT, TRACE F GRAVEL, DENSE.	
20	S7	20/22	16	24	37	49					GRADING TO FC GRAVEL, VERY DENSE.	
25	S8	25/27	58	100/5"	SPT REFUSAL		8				OLIVE GREY SANDY SILT, SOME F GRAVEL, VERY DENSE.	
30	S9	30/32	100/5"	SPT	REFUSAL		5				-SAME AS ABOVE SAMPLE-	
35	S10	35/37	100/4"	SPT	REFUSAL		4				GREY SILTY F SAND, LITTLE SILT, F GRAVEL, MOIST, VERY DENSE.	

TOOLS & EQUIPMENT USED

CASING SIZE	4"	SPOON SIZE	2"
CASING HAMMER	300 LB	SPOON HAMMER	140 LB
HAMMER FALL - CASING	30"	HAMMER FALL - SPOON	30"
CORE BARREL USED		DRILLING MUD USED	REVERT
CORE BIT USED		UNDISTURBED SAMPLER	
AUGER SIZE		STANDBY TIME	

MISCELLANEOUS ITEMS

GROUND WATER DATA

DATE	TIME	DEPTH (FT.)

OBSERVATION WELL

DEPTH (FT.)	DIAMETER (IN.)	SCREEN LENGTH (FT.)

- DRILLERS LOG -

Bus.: (845) 365-9710 Fax.: (845) 365-9713

CMI Subsurface Investigations, Inc.

375 Western Highway Tappan, New York 10983

BORING NO. B-1

SHEET 2 of 2

BORING LOG

PROJECT ROCKLAND CO. HIGHWAY DEPT. FACILITY
LOCATION OLD NYACK TURNPIKE, SPRING VALLEY, NY
CLIENT MCLAREN ENGINEERING GROUP
INSPECTOR _____ DRILLER VINCE GANDOLFO HELPER GUS TSERBIS

PROJECT NO. _____
START DATE 9/7/05
FINISH DATE 9/7/05
RIG MOBIL B-61 HDX

DEPTH (FEET)	SAMPLE NO.	DEPTH (FROM/TO)	SOIL BLOWS / 6" 0"-6"	6"-12"	12"-18"	18"-24"	RECOVERY (INCHES)	ROCK CORE RUN (IN.)	ROCK CORE REC. (IN.)	DEPTH (FROM/TO)	SOIL/ROCK DESCRIPTION & REMARKS	CASING BLOWS
40	S11	40/42	34	79	100/3"	SPT REFUSAL					GREY SILTY F SAND, LITTLE F GRAVEL, MOIST, VERY DENSE.	
45	S12	45/47	100/5"	SPT	REFUSAL						- SAME AS ABOVE SAMPLE.	
50	S13	50/52	88	100/4"	SPT REFUSAL						- SAME -	
55	S14	55/57	76	100/5"	SPT REFUSAL						GRADING TO TRACE OF CLAY.	
											BORING TERMINATED @ 55.89'(FT) BELOW GRADE.	
60												
65												
70												
75												

TOOLS & EQUIPMENT USED

CASING SIZE	4"	SPOON SIZE	2"
CASING HAMMER	300 LB	SPOON HAMMER	140 LB
HAMMER FALL - CASING	30"	HAMMER FALL - SPOON	30"
CORE BARREL USED		DRILLING MUD USED	REVERT
CORE BIT USED		UNDISTURBED SAMPLER	
AUGER SIZE		STANDBY TIME	

MISCELLANEOUS ITEMS _____

GROUND WATER DATA

DATE	TIME	DEPTH (FT.)

OBSERVATION WELL

DEPTH (FT.)	DIAMETER (IN.)	SCREEN LENGTH (FT)

- DRILLERS LOG -

BORING NO. B-1 SHEET 2 OF 2

Bus.: (845) 365-9710 Fax.: (845) 365-9713

CMI Subsurface Investigations, Inc.

375 Western Highway Tappan, New York 10983

BORING NO. B-2

SHEET 1 of 2

BORING LOG

PROJECT ROCKLAND CO. HIGHWAY DEPT FACILITY
LOCATION OLD NYACK TURNPIKE, SPRING VALLEY, NY
CLIENT McLAREN ENGINEERING GROUP
INSPECTOR _____ DRILLER VINCE GANDOLFO HELPER MIKE MARTHALER

PROJECT NO. _____
START DATE 9/6/05
FINISH DATE 9/6/05
RIG MOBIL B-61 HDX

DEPTH (FEET)	SAMPLE NO.	DEPTH (FROM/TO)	SOIL BLOWS / 6" 0"-6"	6"-12"	12"-18"	18"-24"	RECOVERY (INCHES)	ROCK CORE RUN (IN.)	ROCK CORE REC. (IN.)	DEPTH (FROM/TO)	SOIL/ROCK DESCRIPTION & REMARKS	CASING BLOWS
—	S1	0/2	6	16	27	29	19				TAN F SAND, LITTLE F GRAVEL, TRACE SILT, DRY, DENSE.	
—	S2	2/4	57	37	42	34	18				GRADING TO LITTLE FC GRAVEL, VERY DENSE	
— 5	S3	4/6	10	15	17	21	14				OLIVE TAN FM SAND, LITTLE CLAY, TRACE SILT, DENSE.	
—	S4	6/8	18	43	13	7	14				GRADING TO NO CLAY, VERY DENSE.	
— 10	S5	8/10	7	29	24	45	15				GRADING TO LITTLE F GRAVEL.	
—	S6	10/12	33	46	71	100/5"	22				OLIVE TAN FMC SAND LITTLE SILT, TRACE OF F GRAVEL, VERY DENSE.	
—												
— 15	S7	15/17	44	85	100/4"	SPT REFUSAL	16				OLIVE TAN SILTY F SAND, TRACE F GRAVEL, DRY, VERY DENSE.	
—												
—												
— 20												
—	S8	20/22	59	80	100/4"	SPT REFUSAL	14				GREY SILTY F SAND, LITTLE FC GRAVEL, MOIST, VERY DENSE.	
—												
— 25	S9	25/27	37	48	100/3"	SPT REFUSAL	15				OLIVE TAN SANDY SILT, SOME CLAY, MOIST, VERY DENSE.	
—												
—												
— 30												
—	S10	30/32	54	100/6"	SPT REFUSAL		11				GRADING TO LITTLE F GRAVEL.	
—												
— 35	S11	35/37	100/3"	SPT	REFUSAL		1				TAN FMC SAND AND C GRAVEL, MOIST, VERY DENSE.	
—												

TOOLS & EQUIPMENT USED

CASING SIZE	4"	SPOON SIZE	2"
CASING HAMMER	300 LB	SPOON HAMMER	140 LB
HAMMER FALL - CASING	30"	HAMMER FALL - SPOON	30"
CORE BARREL USED	____	DRILLING MUD USED	REVERT
CORE BIT USED	____	UNDISTURBED SAMPLER	____
AUGER SIZE	____	STANDBY TIME	____

MISCELLANEOUS ITEMS _____

GROUND WATER DATA

DATE	TIME	DEPTH (FT.)

OBSERVATION WELL

DEPTH (FT.)	DIAMETER (IN.)	SCREEN LENGTH
20' (FT)	1¼ INCH	10 (FT) SCREEN 10 (FT) RISER

- DRILLER'S LOG -

Bus.: (845) 365-9710 Fax.: (845) 365-9713

CMI Subsurface Investigations, Inc.

375 Western Highway Tappan, New York 10983

BORING NO. B-2

SHEET 2 of 2

BORING LOG

PROJECT ROCKLAND CO. HIGHWAY DEPT. FACILITY
LOCATION OLD NYACK TURNPIKE, SPRING VALLEY, NY
CLIENT MCLAREN ENGINEERING GROUP
INSPECTOR _____ DRILLER VINCE GIANDOLFO HELPER MIKE MARCHALLEK RIG MOBIL B-61 HDX

PROJECT NO. _____
START DATE 9/6/05
FINISH DATE 9/6/05

DEPTH (FEET)	SAMPLE NO.	DEPTH (FROM/TO)	SOIL BLOWS / 6" 0"-6"	6"-12"	12"-18"	18"-24"	RECOVERY (INCHES)	ROCK CORE RUN (IN.)	ROCK CORE REC. (IN.)	DEPTH (FROM/TO)	SOIL/ROCK DESCRIPTION & REMARKS	CASING BLOWS
40	S12	40/42	100/4"	SPT	REFUSAL		3				RED BROWN SILTY F SAND, LITTLE F GRAVEL, MOIST, VERY DENSE.	
45	S13	45/47	100/3"	SPT	REFUSAL		1				GRADING TO FC GRAVEL, TRACE OF CLAY.	
50	S14	50/52	42	100/5"	SPT REFUSAL		9				TAN SILT, TRACE OF F SAND, F GRAVEL, MOIST, VERY DENSE.	
55	S15	55/57	58	100/6"	SPT REFUSAL		10				RED BROWN SILTY F SAND, LITTLE F GRAVEL, MOIST, VERY DENSE.	
											BORING TERMINATED @ 56 FT BELOW GRADE.	
60												
65												
70												
75												

TOOLS & EQUIPMENT USED

CASING SIZE	4"	SPOON SIZE	2"
CASING HAMMER	300 LB	SPOON HAMMER	140 LB
HAMMER FALL - CASING	30"	HAMMER FALL - SPOON	30"
CORE BARREL USED	____	DRILLING MUD USED	REVERT
CORE BIT USED	____	UNDISTURBED SAMPLER	____
AUGER SIZE	____	STANDBY TIME	____

MISCELLANEOUS ITEMS _____

GROUND WATER DATA

DATE	TIME	DEPTH (FT.)

OBSERVATION WELL

DEPTH (FT.)	DIAMETER (IN.)	SCREEN LENGTH
20 (FT)	1¼ INCH	10 (FT) SCREEN
	10 SLOT	10 (FT) RISER

- DRILLER'S LOG -

BORING NO. B-2 SHEET 2 OF 2

Bus.: (845) 365-9710 Fax.: (845) 365-9713

CMI Subsurface Investigations, Inc.

375 Western Highway Tappan, New York 10983

BORING NO. B-3

SHEET 1 of 1

BORING LOG

PROJECT ROCKLAND CO. HIGHWAY DEPT. FACILITY

LOCATION OLD NYACK TURNPIKE, SPRING VALLEY, NY

CLIENT McLAREN ENGINEERING GROUP

PROJECT NO.

START DATE 9/8/05

FINISH DATE 9/8/05

INSPECTOR DRILLER VINCE GALDOLFO HELPER MIKE MARTHALER RIG MOBIL B-61 HDX

DEPTH (FEET)	SAMPLE NO.	DEPTH (FROM/TO)	SOIL BLOWS / 6" 0"-6"	6"-12"	12"-18"	18"-24"	RECOVERY (INCHES)	ROCK CORE RUN (IN.)	ROCK CORE REC. (IN.)	DEPTH (FROM/TO)	SOIL/ROCK DESCRIPTION & REMARKS	CASING BLOWS
	S1	0/2	24	90	100/3"	SPT REFUSAL	23				TAN GREY F SAND, SOME FC GRAVEL, LITTLE SILT, DRY, VERY DENSE.	
	S2	2/4	100/5"	SPT	REFUSAL		4				GREY FC GRAVEL, SOME SILT, VERY DENSE.	
5	S3	4/6	53	56	51	37	20				OLIVE GREY FM SAND, SOME F GRAVEL, LITTLE SILT, VERY DENSE.	
	S4	6/8	42	57	100/5"	SPT REFUSAL	17				-SAME AS ABOVE SAMPLE-	
10	S5	8/10	72	100/6"	SPT REFUSAL		12					
	S6	10/12	50/1"	SPT	REFUSAL		Ø				NO RECOVERY IN SAMPLER.	
15	S7	15/17	49	66	100/4"	SPT REFUSAL	16				RED GREY FM SAND, LITTLE SILT, F GRAVEL, TRACE CLAY, MOIST, VERY DENSE.	
											BORING TERMINATED @ 16.33' (FT) BELOW GRADE.	
20												
25												
30												
35												

TOOLS & EQUIPMENT USED

CASING SIZE	4"	SPOON SIZE	2"
CASING HAMMER	300 LB	SPOON HAMMER	140 LB
HAMMER FALL - CASING	30"	HAMMER FALL - SPOON	30"
CORE BARREL USED		DRILLING MUD USED	REVERT
CORE BIT USED		UNDISTURBED SAMPLER	
AUGER SIZE		STANDBY TIME	

MISCELLANEOUS ITEMS

GROUND WATER DATA

DATE	TIME	DEPTH (FT.)

OBSERVATION WELL

DEPTH (FT.)	DIAMETER (IN.)	SCREEN LENGTH (FT)

- DRILLER'S LOG -

Bus.: (914) 365-9710 Fax.: (914) 365-9713
CMI Subsurface Investigations, Inc.
375 Western Highway Tappan, New York 10983

BORING NO. B-4

SHEET 1 of 1

BORING LOG

PROJECT ROCKLAND CO. HIGHWAY DEPT. FACILITY
LOCATION OLD NYACK TURNPIKE, SPRING VALLEY, NY
CLIENT MCLAREN ENGINEERING GROUP
INSPECTOR _____ DRILLER VINCE GIARDOLFO HELPER MIKE MARTHALER

PROJECT NO. _____
START DATE 6/9/05
FINISH DATE 6/9/05
RIG MOBIL B-61 HDX

DEPTH (FEET)	SAMPLE NO.	DEPTH (FROM/TO)	SOIL BLOWS / 6" 0"-6"	6"-12"	12"-18"	18"-24"	RECOVERY (INCHES)	ROCK CORE RUN (IN.)	ROCK CORE REC. (IN.)	DEPTH (FROM/TO)	SOIL/ROCK DESCRIPTION & REMARKS	CASING BLOWS
	S1	0/2	13	15	29	27	20				BROWN FM SAND, LITTLE F GRAVEL, SILT, DRY, DENSE.	
	S2	2/4	26	17	16	19	22				GRADING TO FC GRAVEL, LITTLE CLAY.	
5	S3	4/6	10	7	12	28	12				GREY FM SAND, LITTLE SILT, TRACE CLAY, MOIST, MEDIUM DENSE.	
	S4	6/8	20	19	24	100/2"	9				GRADING TO LITTLE CLAY, DENSE.	
10	S5	9/11	23	25	27	31	10				GRADING TO VERY DENSE.	
		/										
		/										
15	S6	15/17	36	34	31	36	22				GREY SANDY SILT, TRACE OF FINE SAND, F GRAVEL, MOIST, VERY DENSE.	
		/										
		/										
20		/										
	S7	20/22	42	37	64	72	18				GREY SILTY SAND, TRACE OF F GRAVEL, MOIST, VERY DENSE.	
		/										
25	S8	26/28	100/6"	SPT	REFUSAL		6				BLACK/GREY FINE SAND AND F GRAVEL, LITTLE SILT, MOIST, VERY DENSE.	
		/									BORING TERMINATED @ 26.5' (FT) BELOW GRADE.	
		/										
30		/										
		/										
		/										
35		/										

TOOLS & EQUIPMENT USED

CASING SIZE	4"	SPOON SIZE	2"
CASING HAMMER	300 LB	SPOON HAMMER	140 LB
HAMMER FALL - CASING	30"	HAMMER FALL - SPOON	30"
CORE BARREL USED	____	DRILLING MUD USED	REVERT
CORE BIT USED	____	UNDISTURBED SAMPLER	____
AUGER SIZE	____	STANDBY TIME	____

MISCELLANEOUS ITEMS _____

GROUND WATER DATA

DATE	TIME	DEPTH (FT.)

OBSERVATION WELL

DEPTH (FT.)	DIAMETER (IN.)	SCREEN LENGTH (FT.)

DRILLER'S LOG

BORING NO. B-4 SHEET 1 OF 1

Bus.: (914) 365-9710 Fax.: (914) 365-9713
CMI Subsurface Investigations, Inc.
375 Western Highway Tappan, New York 10983

BORING NO. B-5

SHEET 1 of 1

BORING LOG

PROJECT ROCKLAND CO. HIGHWAY DEPT. FACILITY
LOCATION OLD NYACK TURNPIKE, SPRING VALLEY, NY
CLIENT McLAREN ENGINEERING GROUP
INSPECTOR _____ DRILLER VINCE GADOLFO HELPER MIKE MARTHALER RIG MOBIL B-61 HDX

PROJECT NO. _____
START DATE 9/8/05
FINISH DATE 9/8/05

DEPTH (FEET)	SAMPLE NO.	DEPTH (FROM/TO)	SOIL BLOWS / 6" 0"-6"	6"-12"	12"-18"	18"-24"	RECOVERY (INCHES)	ROCK CORE RUN (IN.)	ROCK CORE REC. (IN.)	DEPTH (FROM/TO)	SOIL/ROCK DESCRIPTION & REMARKS	CASING BLOWS
	S1	0/2	2	1	6	2	8				DARK BROWN FM SAND, SOME SILT, TRACE OF F GRAVEL, LOOSE.	
	S2	2/4	11	12	16	22	24				BROWN SILTY F SAND, TRACE OF F GRAVEL, DRY, MEDIUM DENSE.	
5	S3	4/6	20	22	28	23	21				TAN FM SAND, SOME SILT, LITTLE FC GRAVEL, DENSE.	
	S4	6/8	13	16	74	18	14					
10	S5	8/10	13	10	29	32	22				OLIVE TAN SILTY F SAND, TRACE OF F GRAVEL, WOOD, DENSE.	
	S6	10/12	27	32	29	26	1				TAN FC GRAVEL, TRACE SILT, F SAND, VERY DENSE.	
15	S7	15/17	32	45	69	100/5"	18				TAN FM SAND, LITTLE SILT, FC GRAVEL, MOIST, VERY DENSE.	
20	S8	20/22	39	42	45	100/5"	23				SAME AS ABOVE SAMPLE.	
25	S9	25/27	69	74	100/6"	SPT REFUSAL	18				- SAME -	
											BORING TERMINATED @ 26.5 (FT) FEET BELOW GRADE.	
30												
35												

TOOLS & EQUIPMENT USED

CASING SIZE	4"	SPOON SIZE	2"
CASING HAMMER	300 LB	SPOON HAMMER	140 LB
HAMMER FALL - CASING	30"	HAMMER FALL - SPOON	30"
CORE BARREL USED	____	DRILLING MUD USED	REVERT
CORE BIT USED	____	UNDISTURBED SAMPLER	____
AUGER SIZE	____	STANDBY TIME	____

MISCELLANEOUS ITEMS _____

GROUND WATER DATA

DATE	TIME	DEPTH (FT.)

OBSERVATION WELL

DEPTH (FT.)	DIAMETER (IN.)	SCREEN LENGTH
20 (FT)	1 1/4 (IN)	10 (FT) SCREEN 10 (FT) RISER

- DRILLER'S LOG -

BORING NO. B-5 SHEET 1 OF 1

Bus.: (914) 365-9710 Fax.: (914) 365-9713
CMI Subsurface Investigations, Inc.
375 Western Highway Tappan, New York 10983

BORING NO. B-6

SHEET 1 of 1

BORING LOG

PROJECT ROCKLAND CO. HIGHWAY DEPT. FACILITY
LOCATION OLD NYACK TURNPIKE, SPRING VALLEY, NY
CLIENT McLAREN ENGINEERING GROUP
INSPECTOR _____ DRILLER VINCE GANDOLFO HELPER MIKE MATHALER RIG MOBIL B-61 HDX

PROJECT NO. _____
START DATE 6/9/05
FINISH DATE 6/9/05

DEPTH (FEET)	SAMPLE NO.	DEPTH (FROM/TO)	SOIL BLOWS / 6" 0"-6"	6"-12"	12"-18"	18"-24"	RECOVERY (INCHES)	ROCK CORE RUN (IN.)	ROCK CORE REC. (IN.)	DEPTH (FROM/TO)	SOIL/ROCK DESCRIPTION & REMARKS	CASING BLOWS
	S1	1/3	21	36	14	27	19				TAN FM SAND, LITTLE FC GRAVEL, TRACE SILT, DRY, DENSE -	
	S2	3/5	19	45	30	38	20				GRADING TO VERY DENSE -	
5	S3	5/7	40	48	42	45	19				SAME AS ABOVE SAMPLE.	
	S4	7/9	23	45	51	56	24				- SAME. -	
10	S5	10/12	32	33	57	100/4"	24				TAN FM SAND, LITTLE FC GRAVEL, SILT, DRY, VERY DENSE.	
15	S6	15/17	14	21	16	17	22				GRADING TO DENSE.	
20	S7	20/22	27	37	27	18	10				OLIVE BROWN FMC SAND, LITTLE F GRAVEL, SILT, MOIST, VERY DENSE.	
25	S8	25/27	30	21	22	30	13				GRADING TO RED BROWN, DENSE.	
30	S9	30/32	100/3"	SPT	REFUSAL		3				GRADING TO VERY DENSE -	
35	S10	35/37	30	32	71	41	24				RED F SAND, LITTLE SILT, DRY, VERY DENSE. BORING TERMINATED @ 37'(FT) BELOW GRADE.	

TOOLS & EQUIPMENT USED

CASING SIZE	4"	SPOON SIZE	2"
CASING HAMMER	300 LB	SPOON HAMMER	140 LB
HAMMER FALL - CASING	30"	HAMMER FALL - SPOON	30"
CORE BARREL USED		DRILLING MUD USED	REVERT
CORE BIT USED		UNDISTURBED SAMPLER	
AUGER SIZE		STANDBY TIME	

MISCELLANEOUS ITEMS

GROUND WATER DATA

DATE	TIME	DEPTH (FT.)

OBSERVATION WELL

DEPTH (FT.)	DIAMETER (IN.)	SCREEN LENGTH (FT.)

DRILLERS LOG - BORING NO. B-6 SHEET 1 OF 1

TEST PIT FIELD NOTES

Job No: 102266.20
Location: Clarkstown, NY
Project Title: Rockland County Highway Facility
Client: Rockland County Highway Department
Performed by: Chris Humphries
Date: 9/6/05 – 9/7/05
Weather: Sunny, 88 F

TEST PIT No.1

0.′ – 1′	Roots & organic material
1′ – 4.5′	Orange brown f-m sand, lt. f-c gravel, lt. silt (medium dense)
4.5′ – 12.5′	Brown f-m sand, lt. f-c gravel, lt. silt (medium dense) No water present

TEST PIT No.2

Test pit was not performed due to dense trees.

TEST PIT No.3

0.′ – 1′	Roots & organic material
1′ – 10′	Drk. brown f sand & silt, lt. f gravel (hard) Water present at 10.5′

TEST PIT No.4

0′ – 1′	Roots & organic material
1′- 10.5′	Brown f-c sand, lt. silt, lt. f-c gravel (medium-dense to dense) Water present at 10′

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On the web: www.mgmclaren.com

TEST PIT No.5

0′ – 1′	Roots & organic material
1′ – 10′	Brown f-c sand fill material, lt. silt, lt. f gravel
10′- 15′	Grey/Dark Brown Silt, lt. f-c gravel
	No water present

TEST PIT No.6

0′ – 1′	Roots & organic material
1′ – 6′	Brown f-c sand fill material, lt. silt, lt. f gravel
	Water present at 5.5′
	Encountered undetermined wire at test pit location approximately 1.5′ below surface.
	Wire composed of several intertwined black wires. Wires were not damaged during excavation. Excavation terminated due to probability that may be underlying pipe below.

TEST PIT No.7

0′ – 1′	Roots & organic material
1′ – 1.5′	Light brown f-c sand
1.5′-2′	Light brown clay, lt. f-c sand
2′-6′	Dark brown silt, lt. f-c sand
	Water present at 5.5′

TEST PIT No.8

0′ – 1′	Roots & organic material
1′ – 9′	Reddish brown f-c sand, lt. f-c gravel
9′-	Red Rock. Could not excavate further with machine used
	No water present

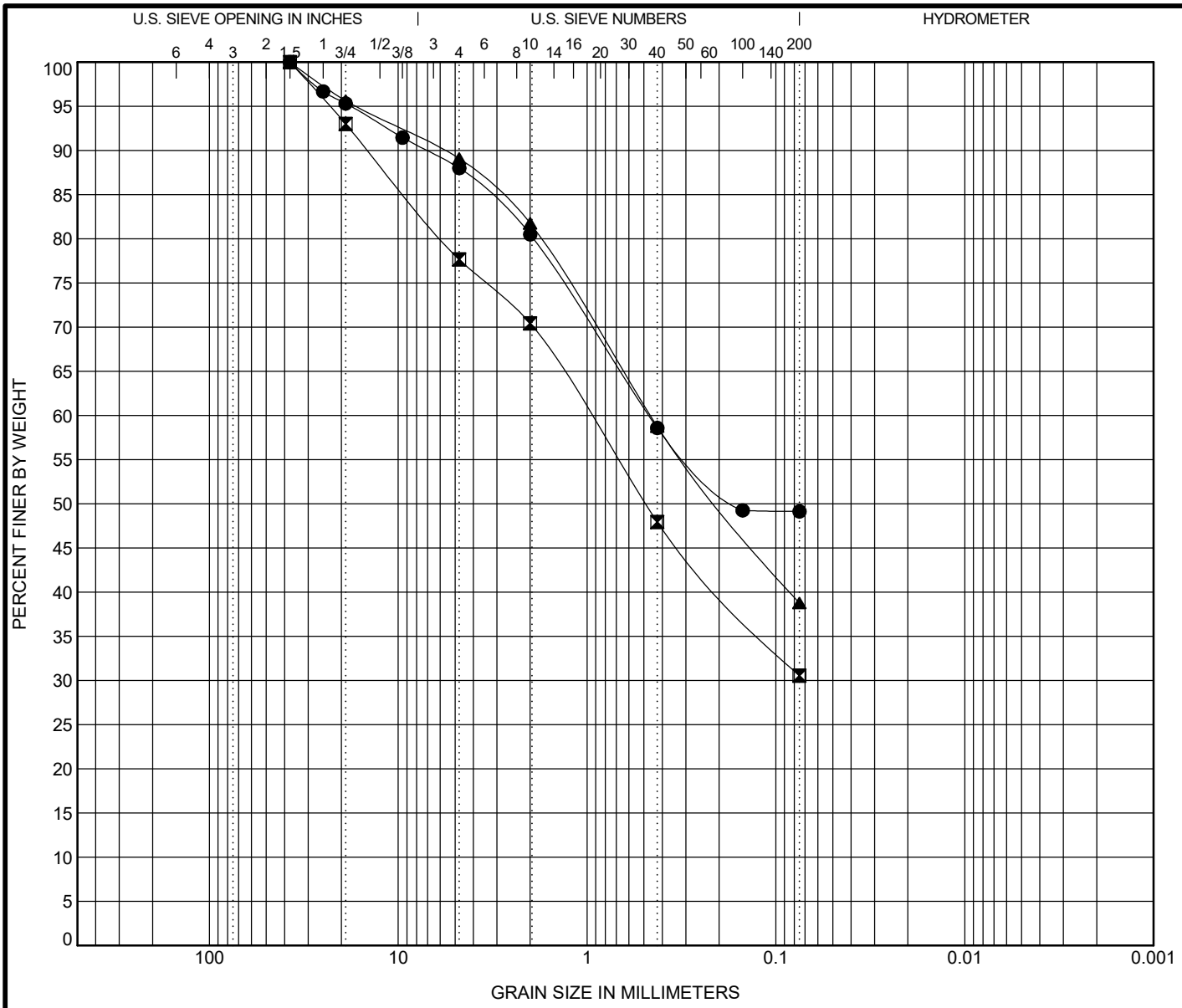
TEST PIT No.9

0′ – 1′	Roots & organic material
1′ – 6′	Fill material
6′-7′	Reddish brown f-c sand, lt. f-c gravel
7′	Red Rock. Could not excavate further with machine used

TEST PIT No.10

0′ – 1′	Roots & organic material
1′ – 3′	Dark brown silt, lt. f-m sand
3′-4′	Reddish brown f-c sand, lt. f gravel
4′	Red Rock. Could not excavate further with machine used
	Encountered stream at 3.5′

APPENDIX III



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample Identification		Classification	WC%	LL	PL	PI	Cc	Cu
●	**PT-1**	**0.0**	**Bwn SAND, and c-f Sand, little c-f Gravel**	**6.2**					
⊠	**PT-2**	**0.0**	**Bwn c-f SAND, some Silt, some c-f Gravel**	**2.4**					
▲	**PT-3**	**0.0**	**Bwn c-f SAND, and Silt, little c-f Gravel**	**2.8**					

	Sample Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay	Source of Material
●	**PT-1**	**0.0**	**37.5**	**0.47**			**12.0**	**38.9**	**49.1**		**Percolation Test 1**
⊠	**PT-2**	**0.0**	**37.5**	**0.975**			**22.3**	**47.1**	**30.6**		**Percolation Test 3**
▲	**PT-3**	**0.0**	**37.5**	**0.463**			**10.9**	**50.3**	**38.8**		**Percolation Test 2**

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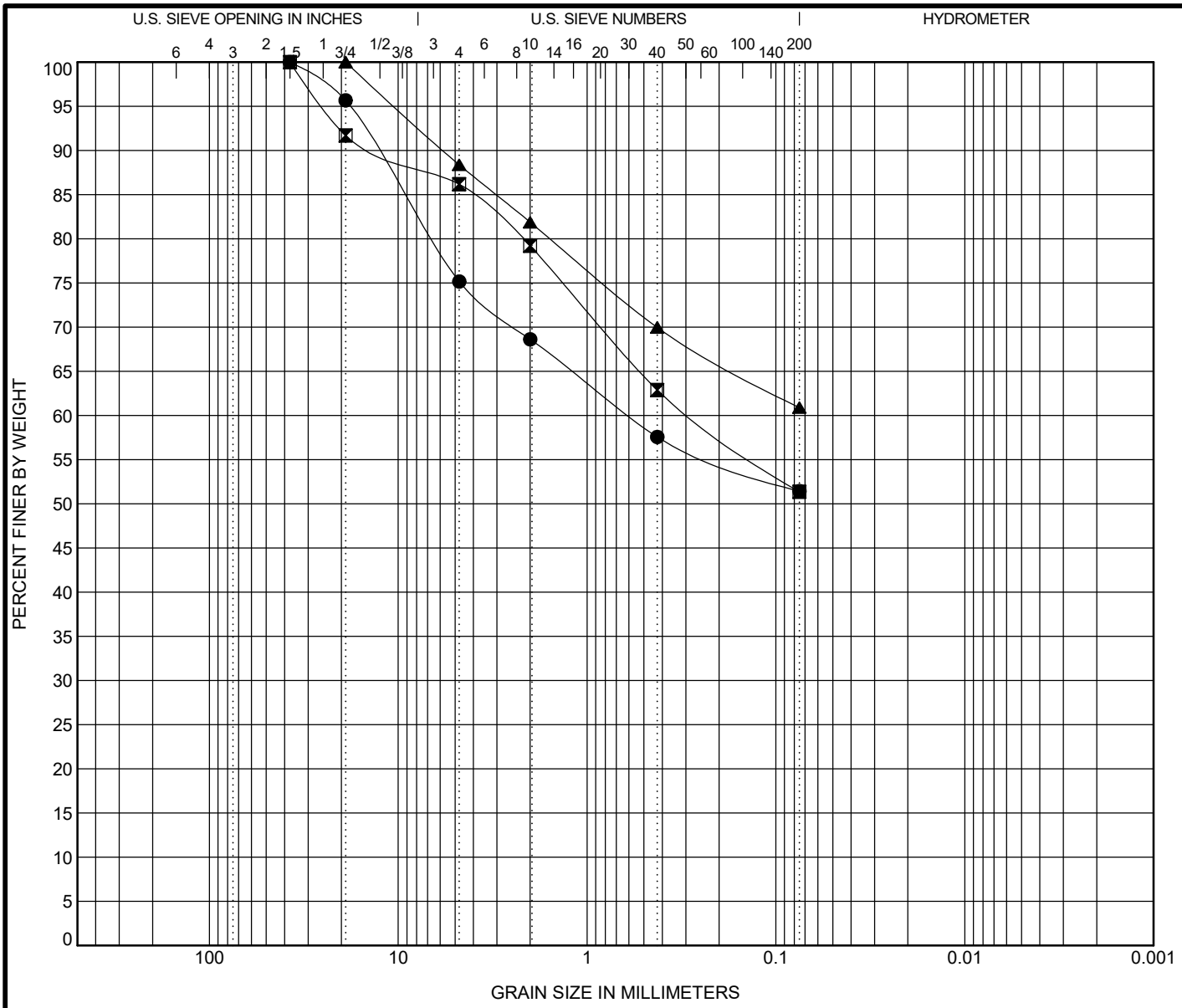
GRAIN SIZE DISTRIBUTION

Project No: **10037.01** Date: **10/11/19**

Project: **Rockland County New Highway Facility**

Location: **Rockland, NY**



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample Identification			Classification	WC%	LL	PL	PI	Cc	Cu
●	TEC-3	20.0	S-8	Bwn SILT, some c-f Gravel, some c-f Sand	8.3					
⊠	TEC-4	2.0	S-2	Bwn CLAYEY SILT, some c-f Sand, little c-f Gravel	9.8					
▲	TEC-4	8.0	S-5	Rd-Bwn SILT, some c-f Sand, little f Gravel	13.8					

	Sample Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay	Source of Material
●	TEC-3	20.0	S-8	37.5	0.597			24.8	23.7	51.4		Boring
⊠	TEC-4	2.0	S-2	37.5	0.275			13.8	34.8	51.4		Boring
▲	TEC-4	8.0	S-5	19				11.6	27.5	60.9		Boring

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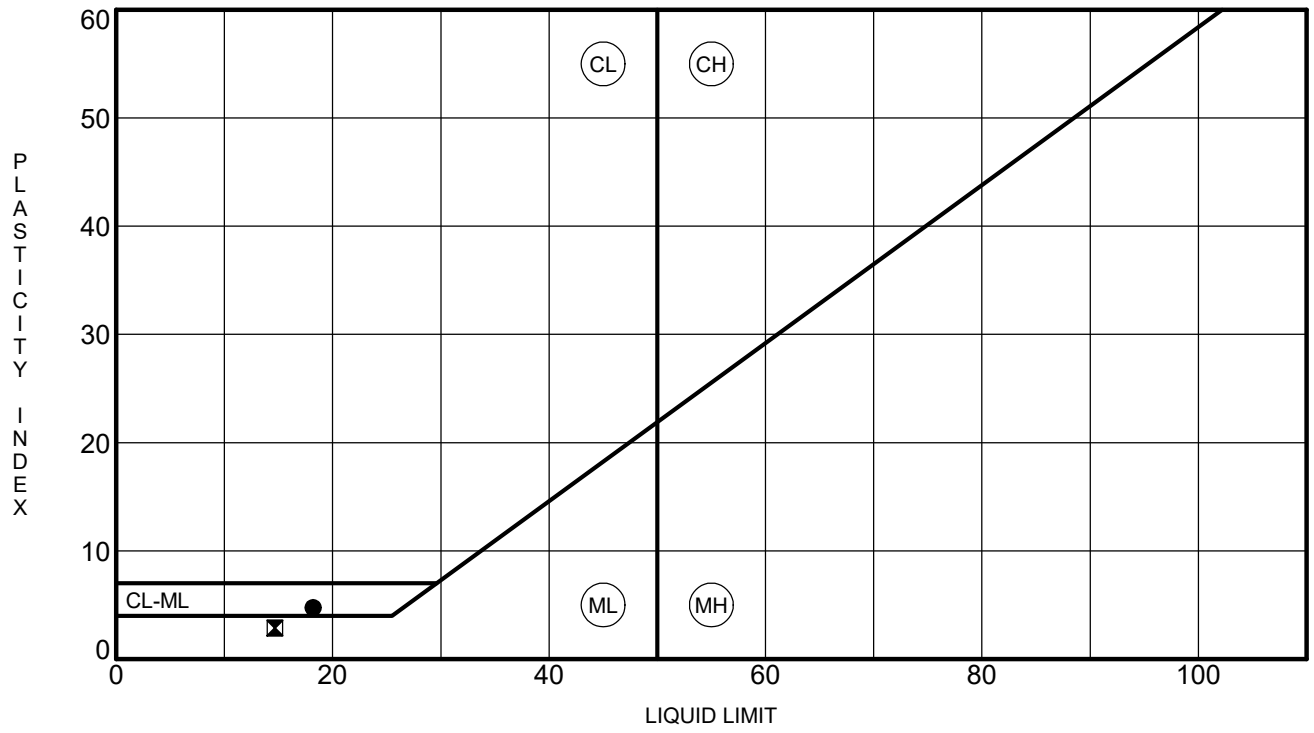
GRAIN SIZE DISTRIBUTION

Project No: **10037.01** Date: **10/11/19**

Project: **Rockland County New Highway Facility**

Location: **Rockland, NY**



Sample Identification				LL	PL	PI	Fines %	WC %	Classification
●	**TEC-1**	**8.0**	**S-5**	**18**	**13**	**5**	**NA**	**13.9**	**Bwn-Tn Clayey Silt w/ Sand and Gravel**
⊠	**TEC-3**	**15.0**	**S-7**	**15**	**12**	**3**	**NA**	**13.7**	**Bwn Clayey Silt**

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ATTERBERG LIMITS' RESULTS

Project No: **10037.01** Date: **10/11/19**

Project: **Rockland County New Highway Facility**

Location: **Rockland, NY**

Boring #	Depth (Ft.)	Sample #	Specimen Description	USCS	Water Content	Liquid Limit	Plastic Limit	Plasticity Index	Penetro-meter (tsf)	Torvane (tsf)	Dry Density (pcf)	Organic Content (%)	pH
			% Gravel : % Sand : % Fines										
PT-1	0.0		Bwn SAND, and c-f Sand, little c-f Gravel 12.0 : 38.9 : 49.1		6								
PT-2	0.0		Bwn c-f SAND, some Silt, some c-f Gravel 22.3 : 47.1 : 30.6		2								
PT-3	0.0		Bwn c-f SAND, and Silt, little c-f Gravel 10.9 : 50.3 : 38.8		3								
TEC-1	8.0	S-5	Bwn-Tn Clayey Silt w/ Sand and Gravel		14	18	13	5					
TEC-3	15.0	S-7	Bwn Clayey Silt		14	15	12	3					
TEC-3	20.0	S-8	Bwn SILT, some c-f Gravel, some c-f Sand 24.8 : 23.7 : 51.4		8								
TEC-4	2.0	S-2	Bwn CLAYEY SILT, some c-f Sand, little c-f Gravel 13.8 : 34.8 : 51.4		10								
TEC-4	8.0	S-5	Rd-Bwn SILT, some c-f Sand, little f Gravel 11.6 : 27.5 : 60.9		14								

SUMMARY OF LAB BORINGS 10037.01.GPJ TECTONIC ENG.GDT 10/11/19

Tectonic

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Telephone: (845) 563-9081 Fax:

Summary of Laboratory Results

Project No: **10037.01** Date: **10/11/19**

Project: **Rockland County New Highway Facility**

Location: **Rockland, NY**

Geotech Laboratories, LLC
Summary of Laboratory Test Results

DATE: 10/24/2005

PROJECT: Rockland County Highway

LOCATION:

CLIENT: CMI Subsurface Investigations, Inc.

SAMPLE DESCRIPTION				SOIL CHARACTERISTICS								PERFORMANCE					
Boring No.	Sample No.	Depth (ft)	Identification	Classification	Dry Density (pcf)	Natural Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Grain Size	Specific Gravity	Organic Content	California Bearing Ratio	Compaction	Permeability	Consolidation	Unconfined Compression	Triaxial Compression
B-1	S-3		Silty sand	SM		6.1			*								
B-1	S-7		Silty sand	SM		10.9			*								
B-1	S-9		Silty sand	SM		9.8			*								
B-1	S-13		Silty sand	SM		8.2			*								
B-2	S-9		Silty sand with gravel	SM		11.7			*								
B-2	S-14		Silt with sand	ML		19.9			*								
B-3	S-3		Sity gravel with sand	GM		10.8			*								
B-3	S-5		Silty sand	SM		8.9			*								
B-4	S-2		Silty sand	SM		9.6			*								
B-4	S-6		Silty sand	SM		9.4			*								
B-5	S-2		Silty sand with gravel	SM		12.1			*								
B-5	S-5		Silty sand	SM		13.6			*								

* See Attached Sheet(s)

Geotech Laboratories, LLC
Summary of Laboratory Test Results

DATE: 10/24/2005

PROJECT: Rockland County Highway

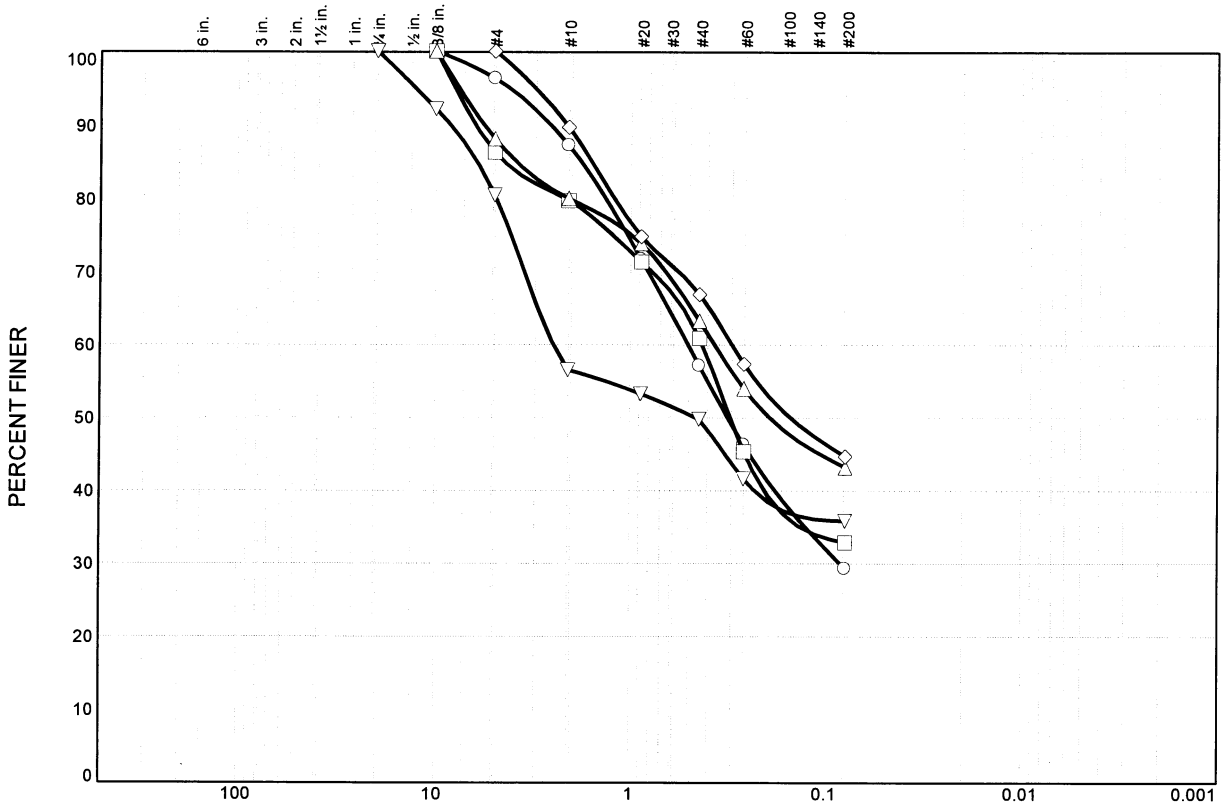
LOCATION:

CLIENT: CMI Subsurface Investigations, Inc.

SAMPLE DESCRIPTION				SOIL CHARACTERISTICS								PERFORMANCE					
Boring No.	Sample No.	Depth (ft)	Identification	Classification	Dry Density (pcf)	Natural Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Grain Size	Specific Gravity	Organic Content	California Bearing Ratio	Compaction	Permeability	Consolidation	Unconfined Compression	Triaxial Compression
B-5	S-7		Silty sand with gravel	SM		9.1			*								
B-6	S-7		Silty sand with gravel	SM		10.5			*								
B-6	S-10		Silty sand	SM		9.2			*								

* See Attached Sheet(s)

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	
○	0.0	0.0	3.8	9.1	30.3	27.9	28.9
□	0.0	0.0	13.8	6.6	19.0	28.1	32.5
△	0.0	0.0	12.0	8.2	16.8	20.2	42.8
◇	0.0	0.0	0.0	10.4	23.0	22.3	44.3
▽	0.0	0.0	19.7	24.1	6.8	14.0	35.4

SOIL DATA

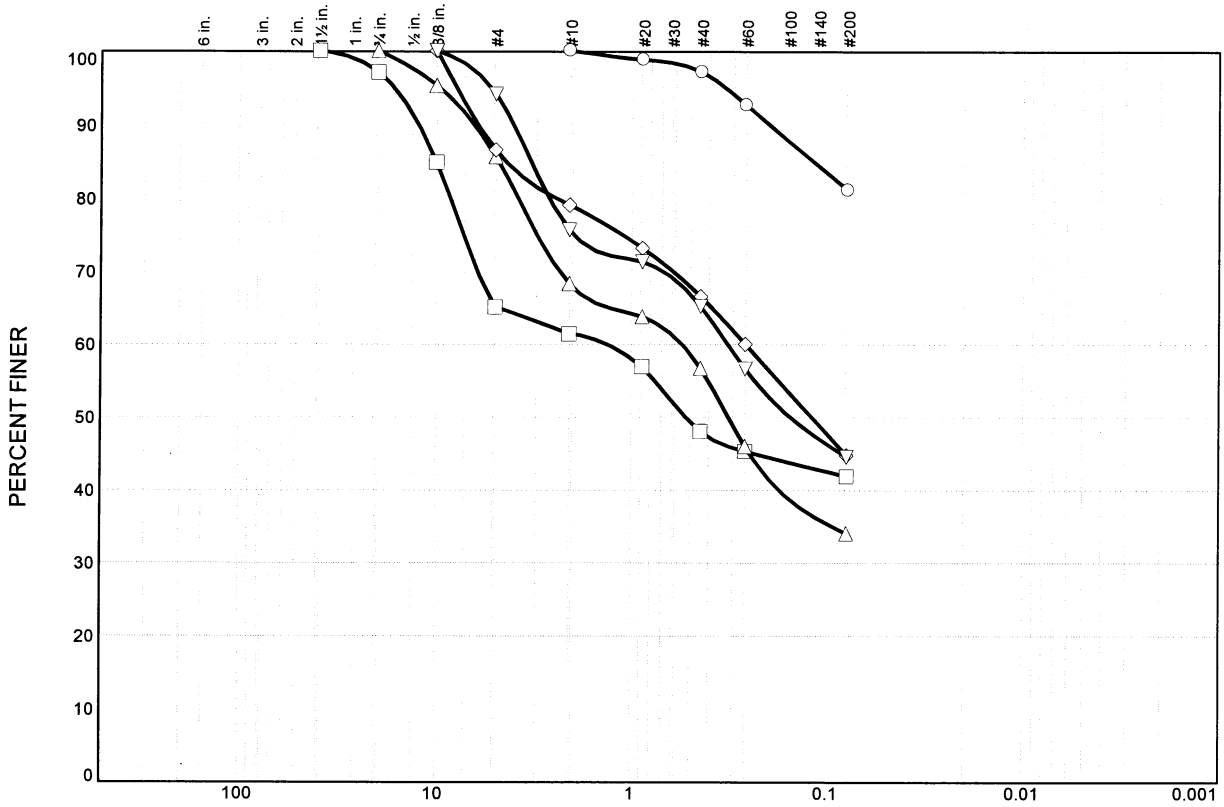
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-1	S-3		Silty sand	SM
□	B-1	S-7		Silty sand	SM
△	B-1	S-9		Silty sand	SM
◇	B-1	S-13		Silty sand	SM
▽	B-2	S-9		Silty sand with gravel	SM

Geotech Laboratories, LLC

Client: CMI Subsurface Investigation
Project: Rockland County Highway

Project No.: 101005 **Figure** 1

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	
○	0.0	0.0	0.0	0.0	2.9	16.2	80.9
□	0.0	2.9	32.2	3.7	13.5	6.2	41.5
△	0.0	0.0	14.5	17.4	11.7	22.8	33.6
◇	0.0	0.0	13.6	7.5	12.6	21.9	44.4
▽	0.0	0.0	5.9	18.7	10.5	20.7	44.2

SOIL DATA

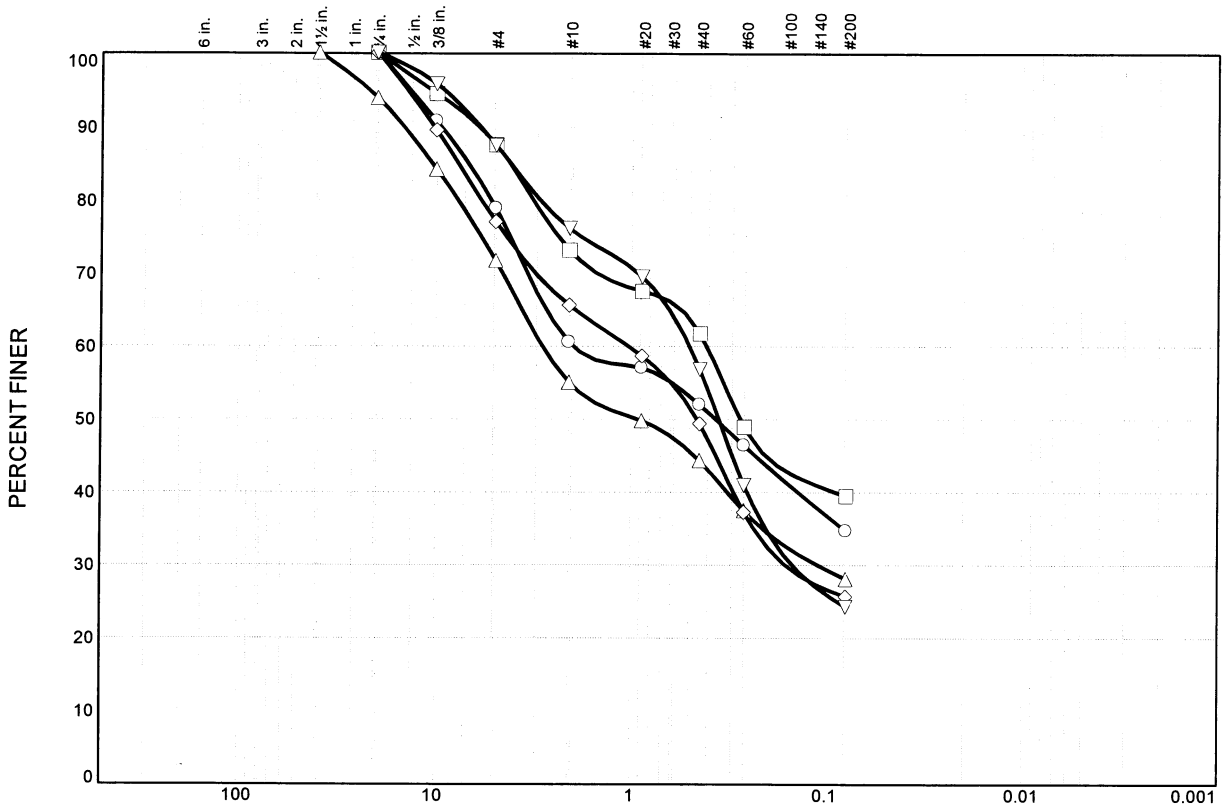
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-2	S-14		Silt with sand	ML
□	B-3	S-3		Silty gravel with sand	GM
△	B-3	S-5		Silty sand	SM
◇	B-4	S-2		Silty sand	SM
▽	B-4	S-6		Silty sand	SM

Geotech Laboratories, LLC

Client: CMI Subsurface Investigation
Project: Rockland County Highway

Project No.: 101005 **Figure** 2

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines
		Coarse	Fine	Coarse	Medium	Fine	
○	0.0	0.0	21.3	18.4	8.6	17.4	34.3
□	0.0	0.0	12.6	14.5	11.5	22.3	39.1
△	0.0	6.2	22.3	16.7	10.8	16.3	27.7
◇	0.0	0.0	23.2	11.4	16.3	23.8	25.3
▽	0.0	0.0	12.7	11.4	19.4	32.7	23.8

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-5	S-2		Silty sand with gravel	SM
□	B-5	S-5		Silty sand	SM
△	B-5	S-7		Silty sand with gravel	SM
◇	B-6	S-7		Silty sand with gravel	SM
▽	B-6	S-10		Silty sand	SM

Geotech Laboratories, LLC

Client: CMI Subsurface Investigation
Project: Rockland County Highway
Project No.: 101005

Figure 3

Our Story

For the past 30 years, Tectonic has delivered quality professional services in a timely and cost effective manner by pooling its talented staff into project teams that think, act, and perform as one integral unit. By carefully listening and collaborating with its clients, the firm is able to identify the key issues and assure stakeholder objectives are met in the final deliverables. Through innovating and adopting technological advances, the firm is able to generate unique solutions to improve our nation's deteriorating infrastructure and build safe sustainable communities.

As the world evolves, and its challenges grow more complex, Tectonic continues to innovate and provide the practical solutions and exceptional customer service its clients have trusted since its founding.

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