SECTION 230000 - GENERAL MECHANICAL

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The work shall include furnishing, installing and testing the equipment and materials specified in other sections of the Mechanical Specifications and shown on the Drawings. It is the intent of these Specifications that the mechanical systems shall be suitable in every way for the intended usage. All material and all work which may be reasonably implied as being incidental to the work of this Division shall be furnished at no extra cost.

B. Instructions to Bidders, General Conditions of the Contract, Supplementary General Conditions and Division 1 Specifications Sections bound herewith are a component part of Division 23 specifications. Comply with all provisions, details and instructions of these sections in the accomplishment of work covered under Division 23.

C. Furnish all labor, materials and equipment and incidentals required to make ready for use complete mechanical systems as shown on the Drawings and specified herein.

D. Where Sub-Contracts are used to perform portions of the work, division of labor between sub trades is the responsibility of the Contractor.

E. The general scope work includes, but is not limited to, furnishing, coordinating, and installing the following:
   1. Controls and wiring.

F. Visit all areas of the site, buildings and structures (as applicable) in which work under these sections is to be performed. Inspect carefully the existing conditions prior to bidding. Bid submission is evidence that the Contractor has examined the site and existing conditions, understands conditions under which the work will be performed, and takes full responsibility for complete knowledge of all factors governing the work.

G. Schedule all service interruptions in existing facilities at the Owner’s convenience with 24 hours (minimum) notice. Obtain prior approval for each interruption.

H. Thoroughly test all mechanical systems at the completion of work and make any minor correction changes or adjustments necessary for all the proper functioning of the system and equipment. All workmanship shall be of the highest quality; substandard work will be rejected.

1.2 SUBMITTALS

A. Procedures for submittals: Submit under provisions of relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.

> Transmit each shop drawing submittal with provided Shop Drawing Submittal Cover Form, attached as Appendix B, for each item of equipment/material or each specification section/paragraph

B. Clearly indicate proposed equipment and/or materials substitutions in shop drawings. Summarize all deviations from the specified quality, functionality, appearance or performance of proposed equipment and/or materials in the preface of each submittal. Include documentation to support deviations.

C. Provide descriptive data on all materials and equipment as required to ascertain compliance with Specifications.

D. Design layout shown on drawings is based on physical sizes of reputable equipment manufacturers. If equipment other than models indicated is installed, any resulting conflicts with space, maintenance access, clearances or codes are the responsibility of the Contractor to correct at his expense.

E. Where specific models and manufacturers of materials and equipment are specified, substitutions as allowed by the specifications and State law will be considered. Substitutions must be equivalent in quality, function, suitability and arrangement to specified equipment. Engineer to have final authority as to equivalency of substitutions.

F. Equipment model numbers noted in these specifications or on the drawings are intended to establish a minimum standard of quality and do not necessarily relate to specific options or arrangement as shown. Provide equipment with all standard features and optional features as stated and arranged as shown on the drawings.

1.3 REGULATORY REQUIREMENTS

A. Perform Work in accordance with all applicable state and local codes, standards and regulations.

B. Furnish all materials and labor which is be required for compliance with codes, standards and regulations, whether specifically mentioned in these specifications or shown on the drawings.

C. Obtain required construction permit from the authority having jurisdiction and arrange, at the proper time, for all inspections required by such authority. Pay all permit and inspection costs required.

1.4 COORDINATION OF WORK

A. Contractor is responsible for coordination of work between trades. Provide fully complete and functional systems.

B. Compare mechanical drawings and specifications with the drawings and specifications for other trades.

C. Coordinate mechanical installation with the work of other trades. Report any pertinent discrepancies to the Engineer and obtain written instructions for any necessary revisions. Before starting any construction, make proper provisions to avoid interferences in a manner approved by the Engineer. No extras will be allowed for rework of uncoordinated installations.

D. Determine exact route and location of each mechanical item prior to fabrication and/or installation. Adjust location of ducts, piping and equipment, etc., to accommodate interferences anticipated and encountered.

E. Right of Way: General priority for right of way is as follows:

1. Items located per regulatory requirement.
2. Piping with pitch requirement (plumbing drains, etc.).
3. Ductwork.
4. Piping without pitch requirement.
5. Electrical wiring (conduits, etc.).

F. Arrange all work to permit removal (without damage to other parts) of any equipment requiring periodic replacement.

G. Provide clearance and easy access to any equipment which requires periodic maintenance. Arrange ducts, piping and equipment to permit ready access to valves, cocks, traps, starters, motors, control components, etc., and to clear the opening of swinging doors and access panels.

1.5 EQUIPMENT AND MATERIALS (GENERAL)

A. Provide all new materials unless specifically indicated otherwise.

B. Manufacturers and models listed in drawings and specifications are used for layout and to convey to bidders the general style, type, character and quality of product desired. Listed examples are used only to denote the quality standard of product desired and are not intended to restrict bidders to a specific brand, make, manufacturer or specific name.

C. Adjust layout, system connections and coordinate with other trades as required to properly install equivalent products.

D. Where equivalent products are submitted, include all associated costs related to substitution in bid.

E. Furnish materials bearing the manufacturer’s name and trade name. Provide UL label where a UL standard has been established for the particular material.

F. Furnish standard products of manufacturers regularly engaged in production of equipment types required for the work. Use the manufacturer's latest approved design.

G. Use the same manufacturer for equipment and materials of the same general type throughout the work to obtain uniform appearance, operation and maintenance.

H. Protect equipment and materials from dirt, water, chemical or mechanical injury and theft at all times during construction. Provide covers or shelter as required.

I. If materials or equipment are damaged at any time prior to final acceptance of the work, repair such damage at no additional cost. If materials or equipment are damaged by water, provide replacement no additional cost.

J. Follow manufacturer's directions completely in the delivery, storage, protection and installation of all equipment and materials. Notify the Engineer in writing of any conflicts between any requirements of the contract documents and manufacturer's directions. Obtain written instructions before proceeding with the work. The Contractor is responsible for correction of any work that does not comply with the manufacturer's directions or written instructions from the Engineer at no additional cost.

K. Repair any damage to factory applied paint finish using touch-up paint furnished by the equipment manufacturer. Repaint entire damaged panel or section per the field painting specifications in Division 9 at no additional cost.

1.6 OPERATION AND MAINTENANCE MANUALS

A. Refer to individual mechanical sections and Division 1.

1.7 PAINTING

A. Protect sensors, controllers, etc. against painting. Do not install thermostats, devices or trim until painting is complete.

1.8 LOCATIONS AND MEASUREMENTS

A. Location of mechanical work is shown on the drawings as accurately as possible. Field verify all measurements to insure that the work suits the surrounding structure, trim, finishes and/or construction. Provide adjustment as necessary.

B. Make minor relocations of work prior to installation as required or as directed by the Engineer at no additional cost.

1.9 SUPERVISION

A. Contractor to provide an authorized and competent representative to constantly supervise the work from the beginning to completion and final acceptance. Insofar as possible, keep the same foreman and workmen throughout the project duration.

B. Representatives of Engineer, Owner, and local inspection authorities will make inspections during the progress of the work. Contractor to accommodate such inspections and correct deficiencies noted.

1.10 QUALITY AND WORKMANSHIP

A. Contractor to employ skilled tradesmen, laborers and supervisors. Final product to present a neat, well finished, and professional installation.

B. Remove and replace any work considered substandard quality in the judgement of the Engineer.

1.11 CLOSING IN WORK

A. Do not cover up or enclose work until it has been inspected, tested and approved by authorities having jurisdiction over the work. Uncover any such work for inspection and/or test at no additional cost. Restore the work to its original condition after inspection and/or test at no additional cost.

1.12 CUTTING AND PATCHING

A. Perform all cutting and patching necessary to install work under this Division.

B. Perform cutting and patching in professional, workmanlike manner.

C. Arrange work to minimize cutting and patching.

D. Do not cut joists, beams, girders, columns or any other structural members without written permission from the Engineer.

E. Cut opening only large enough to allow easy installation of piping, wiring or ductwork.

F. Patching material to match material removed.

G. Restore patched surface to its original appearance at completion of patching.

H. Where waterproofed surfaces are patched, maintain integrity of waterproofing.

I. Remove rubble and excess patching materials from the premises.

1.13 INTERPRETATION OF DRAWINGS

A. Drawings and specifications under this Division are complementary each to the other. Provide any work specified herein and/or indicated on the drawings.

B. Drawings are diagrammatic and indicate generally the location of fixtures, piping, devices, equipment, etc. Follow drawings as closely as possible, but arrange work to suit the finished surroundings and/or trim.

C. The words “furnish”, “provide”, and/or “install” as used in these drawings and specifications are interpreted to include all material and labor necessary to complete the particular item, system, equipment, etc.

D. Any omissions from either the drawings or specifications are unintentional. Contractor is responsible for notifying the Engineer of any pertinent omissions before submitting a bid. Complete and working systems are required, whether every small item of material is shown and specified or not.

1.14 ACCESSIBILITY

A. Locate all equipment which must be serviced, operated, or maintained in fully accessible positions. Equipment to include, but not be limited to, valves, traps, cleanouts, motors, controllers, and dampers. If required for accessibility, furnish access doors for this purpose. Minor deviations from drawings may be made to allow for better accessibility. Lack of access doors on drawings does not relieve Contractor of responsibility to provide access doors, if needed to properly service equipment.

B. Coordinate exact locations and size of access panels for each concealed device requiring service.

C. Access panels: Steel construction with 16 gauge frames and 18 gauge panels, factory primed with rust inhibiting paint, finish paint by Contractor. Provide suitable UL listed doors where installed in rated construction.

D. Coordinate access panel locations with architectural construction.

E. Access panels are not required for access to work located above a lift-out “T” bar type ceiling.

1.15 ELECTRICAL WORK IN CONNECTION WITH MECHANICAL CONTRACTS

A. Comply with Division 26. Any required Division 23 electrical work not specifically specified to be furnished by Division 26 Contractor shall be provided by Division 23 Contractor.

B. All electrical work performed Division 23 shall comply with Division 26 specification requirements.

C. Coordinate electrical interface of supplied mechanical equipment with electrical system. Division 26 electrical work for mechanical systems is based on values scheduled on mechanical drawings. Division 23 Contractor is responsible for any costs to modify the contracted electrical work to service equipment with electrical characteristics different than those scheduled.

1.16 MECHANICAL WORK IN CONNECTION WITH OTHER CONTRACTS

A. Provide mechanical services as required for items furnished by other contractors or vendors as shown on the Drawings. Actual requirements may vary from Drawings. Coordinate with equipment installed. Make final connections only after approval of the other contractor or vendor, in the contractor's or vendor’s presence.

1.17 ALTERNATE BIDS

A. Alternate Bids, IF ANY, are described in relevant sections of the General and Supplemental General Conditions and Division 1 Specification Sections.

1.18 PROJECT RECORD DRAWINGS

A. Submit under provisions of relevant sections of the General and Supplemental General Conditions and Division 1 Specification Sections.

B. As the work progresses, legibly record all field changes on a set of project contract drawings, herein after called the “record drawings.”

C. Record drawings shall accurately show the installed condition of mechanical work.

1.19 PHASING OF THE WORK

A. Schedule work in accordance with the relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.

1.20 PROJECT CLOSEOUT

A. Submit under provisions of relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 230000

SECTION 230020 – MECHANICAL DEMOLITION

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Selective mechanical demolition.

1.2 PROJECT CONDITIONS

A. Conduct demolition to minimize interference with adjacent and occupied building areas.

B. Cease operations immediately if structure appears to be in danger and notify Engineer. Do not resume operations until directed.

PART 2 - PRODUCTS

2.1 PATCHING MATERIALS

A. As specified in individual Sections.

PART 3 - EXECUTION

3.1 PREPARATION

A. Demolition Drawings are based on casual field observation and existing record documents. Survey the affected areas before submitting bid proposal. Report discrepancies to the Architect/Engineer before disturbing the existing installation.

B. Provide, erect, and maintain temporary dust screens, safeguards, barricades, signage and similar measures, for protection of the public, Owner, Contractor's employees, and existing construction to remain. Provide protective barriers indicated in the contract drawings.

C. Protect existing materials and existing improvements which are not to be demolished.

D. Prevent movement of structure; provide temporary bracing and shoring required to ensure safety of existing structure.

3.2 DEMOLITION

A. Demolish mechanical work as indicated. Secure utilities as required to prevent spills, leakage, etc.

B. Demolish in an orderly and careful manner. Protect existing work to remain. Do not cut or remove any structural members.

C. Terminate all demolition work in a neat finished manner.

D. Conceal or enclose abandoned work within building construction except as specifically noted.

E. Remove demolished materials from site except where specifically noted otherwise. Do not burn or bury materials on site.

F. Remove materials as Work progresses. Upon completion of Work, leave areas in clean condition.

G. Coordinate cutting and patching requirements.

END OF SECTION 230020

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for 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.

1.2 COORDINATION

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

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

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

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

2.3 POLYPHASE MOTORS

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

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

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

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

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

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

2.4 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. 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.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pre-galvanized, hot-dip galvanized, or electro-galvanized.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.2 SHIELDS

A. For Clevis Hangers: Shield shall cover lower 180 degrees of pipe.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

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

C. Install building attachments 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.

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

E. 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.

F. Insulated Piping:

1. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

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

2. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

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

3. 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.

3.2 ADJUSTING

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

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

3.3 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 galvanizing-repair paint to comply with ASTM A780/A780M.

3.4 HANGER AND SUPPORT SCHEDULE

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

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

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

D. Use carbon-steel pipe hangers and supports and attachments for general service applications.

E. 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. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.

F. 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.

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

1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
4. C-Clamps (MSS Type 23): For structural shapes.
5. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
6. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
7. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

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

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

H. 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.

END OF SECTION 230529

SECTION 230548.13 - VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device component.
3. Annotate to indicate application of each product submitted and compliance with requirements.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Minimum deflection as indicated on Drawings.
4. Pad Material: Oil- and water-resistant rubber.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION OF VIBRATION CONTROL DEVICES

A. Provide vibration control devices for systems and equipment where indicated in Equipment Schedules on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

B. Installation of vibration isolators must not cause any change of position of equipment resulting

3.3 ADJUSTING

A. Adjust isolators after system is at operating weight.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 230548.13

SECTION 230553 - IDENTIFICATION 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. Equipment labels.
2. Pipe labels.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Comply with ASME A13.1.
3. Background Color: Comply with ASME A13.1.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Labels shall include equipment number, area(s) served (use actual room numbers used at the facility-not architectural room numbers), substantial completion date

(S.C.), extended warranty period, number and size of filters and capacity. The following are examples of labelling to be used:

Rooftop Units:	RTU01 (Classrooms 1, 2 and 3) S.C.: 11/16/2005 Filters: 2 @ 24 in. x 24 in. x 1 in. Capacity: 3,400 CFM @ 0.8" ES

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

B. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Size letters according to ASME A13.1 for piping.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels at exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for unit. Where flow pattern is not obvious, mark each pipe at branch.
3. Near major equipment items and other points of origination and termination.
4. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Pipe Label Color Schedule:

1. Natural Gas Piping: Comply with ASME A13.1, unless otherwise indicated.

END OF SECTION 230553

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Steam and Condensate drain piping, indoors.
2. Chilled-water piping, indoors.
3. Heating hot-water piping, indoors.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

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

D. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.

1. Preformed Pipe Insulation with Jacket: Type II, Class 2, with factory-applied ASJ-SSL jacket.
2. Fabricated shapes in accordance with ASTM C450, ASTM C585, and ASTM C1639.
3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

E. Calcium Silicate: Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.

1. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.2 INSULATING CEMENTS

A. Glass-Fiber Insulating Cement: Comply with ASTM C195.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. 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.

C. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F

D. ASJ Adhesive Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.5 SEALANTS

A. Joint Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
4. Color: White or gray.

B. ASJ Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.6 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   a. Moisture Barrier for Indoor Application: 1-mil- thick, heat-bonded polyethylene and kraft paper.
   b. Factory-Fabricated Fitting Covers:
      1) Same material, finish, and thickness as jacket.
      2) reformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.9 TAPES

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

1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.10 SECUREMENTS

A. Bands:

1. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.

2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless steel.

PART 3 - EXECUTION

3.1 EXAMINATION

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

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

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

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

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

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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

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

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

D. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular

surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. 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 over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless steel bands at 12-inch intervals, and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When prefabricated insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install pipe insulation, quads, hex sections, or beveled lag segments, adhered together, of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.7 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.9 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Match existing

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

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

1. Underground piping.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Service: Steam and condensate.

1. Operating Temperature: 450 deg F and lower.
2. Insulation Material: Mineral fiber or Cellular glass, with jacket.

3. Insulation Thickness: Apply the following insulation thicknesses:

    a. Steel Pipe, Runouts up to 2": 1".
    b. Steel Pipe, 2" and less: 1-1/2".
    c. Steel Pipe, 2-1/2" to 6": 2".

4. Field-Applied Jacket: Aluminum.
5. Vapor Retarder Required: No.
6. Finish: None.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Piping, Exposed:

1. PVC, Color-Coded by System: 20 mils thick.

END OF SECTION 230719

SECTION 230913 - INSTRUMENTATION AND CONTROL DEVICES 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.

B. Section 230906, which specifies the work of the Niagara N4 Framework and graphics System Integrator and the delineation of work between the BAS Contractor and the System Integrator.

C. Section 230923, which specifies the requirements for direct digital controllers provided under Division 23.

D. Section 230924, which specifies the requirements for OEM direct digital controllers provided under Division 23.

1.2 SUBMITTALS

A. General: Submittals shall demonstrate compliance with technical requirements by reference to each subsection of this specification. Where a submitted item does not comply fully with each and every requirement of the Specifications, the submittal shall clearly indicate such deviations. Identification requirements for non-complying features of items are very specific.

B. Manufacturer's Data: Submit manufacturer's technical product data and installation instructions for all components including the following to demonstrate compliance with the Contract Documents.
   1. Catalog cut sheets of all equipment used. This includes, but is not limited to sensors, actuators, valves, and dampers.
   2. Catalog cut sheets of air measuring stations used for the volumetric control system. Include as a separate volumetric control section velocity transmitters, static pressure transmitters, and flow chart for sequence of operation.
   3. Control air supply components, and sizing computations for compressors, receivers and main air piping.

C. Operation and Maintenance (O/M) Manuals:
   1. General description and specifications for all sensors and final control elements.
   2. Complete troubleshooting procedures and guidelines for all sensors and final control elements.
   3. Documentation of all required maintenance and repair/replacement procedures

1.3 WARRANTY

A. Conform to provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections.

PART 2 - PRODUCTS

2.1 ELECTRONIC SENSORS

A. General: Provide all remote sensors and instrumentation as required for the control system. All sensors shall have accuracies as stated hereinafter. Electronic sensors shall include integral transmitter and provide input analog input signal as either 4-20 mA or 0-10 VDC over the full range specified below.

B. Sensor Accuracy and Range: Each sensor, as hereinafter specified, shall have accuracy and range as follows:

Sensed/Measured Variable	Sensor Characteristics Required	
	Measurement Accuracy	**Range**
Space Temperature	±1°F	+50°F- +85°F
Outside Air Temperature	±2°F	-30°F- +130°F
Relative Humidity (indoor air)	±5% RH	20% - 80% RH
Relative Humidity (outdoor air)	±2% RH	10% - 95% RH
Ducted Air Temperature	±1°F	+40°F- +140°F
Airflow (terminal)	±10% of full scale	
Airflow (duct measuring stations)	±5% of full scale	
Airflow (fan total)	±5% of full scale	
Air Pressure (ducts)	±0.1 in. w.g.	0 - 5.0 in. w.g.
Air Pressure (space)	±0.01 in. w.g.	-0.25 - 0.25 in. w.g.
Water Temperature		
- Chilled Water	±1°F	+20°F- +70°F
- Hot Water	±1°F	+50°F- +250°F
Water Pressure	±2% of full scale	
Water Differential Pressure	±2 psig	0-30 psig
Water Flow	±5% of full scale	
Steam Pressure	±2% of full scale	0-25 psig, low pressure 0-200 psig, high pressure
Steam Flow	±5% of full scale	

2.2 TEMPERATURE SENSORS:

A. Space Sensors: Space sensors shall RTD type with integral transmitter within wall-mounted enclosures with blank covers and no temperature display. No setpoint adjustment by occupants shall be provided **unless specifically indicated on the Drawings or if project is to be constructed to meet the requirements of the USGBC LEED Rating System**. Where setpoint adjustment is required, range of adjustment shall be limited to +/- 2 deg F from setpoint defined by control sequences.

B. Duct- or Plenum-Mounted Dry Bulb Sensors:

1. Sensors located within AHUs or ductwork/plenums attached thereto and used as part of a temperature control sequence shall be RTD type averaging sensors with integral transmitter and a sensing element incorporated in a copper capillary with a minimum length to provide 1 ft of capillary per square foot of airflow area. Where the airflow area exceeds 20 sf, provide multiple sensors and average inputs from sensors as AI point.
2. Sensors located within BCUs, FCUs, or TUs or in ductwork/plenums attached thereto and used only for temperature monitoring, shall be one of the two following types, as applicable:
    a. When airflow area is 2 sf or less, provide probe type 10k ohm NTC, Type II or Type III, thermistor sensor with all metal enclosure that includes mounting bracket with insulation stand-offs, as required. Probe shall be ¼" diameter, stainless steel construction, and have length sufficient to monitor at least 60% of the dimension in the plane of installation.
    b. When airflow area exceeds 2 sf, provide averaging type 10k ohm NTC, Type II or Type III, thermistor sensor with all metal enclosure that includes mounting bracket with insulation stand-offs, as required. Capillary shall be of sufficient length to provide 1 ft of capillary per square foot of airflow area and capillary brackets shall be included.
    c. Where airflow area exceeds 20 sf, provide multiple sensors wired in a series-parallel configuration in accordance with the manufacturer's recommendations to provide multiple average inputs from sensors as AI point.

C. Duct-Mounted Dew Point Sensors: Provide sensor/transmitters designed for duct installation to provide both dewpoint and dry bulb temperature output. Sensors shall incorporate both an RH sensor and an RTD temperature sensor, with a microprocessor that computes the dew point temperature. Humidity sensor shall utilize a platinum or ceramic capacitive sensing element that is impervious to damage by (1) humidity levels exceeding 95% RH and (2) wetting by surface condensation. Measurement range shall be 10 - 95% RH within a temperature range of 40ºF to 140ºF. Provide a linear 4-20mA output signal for dewpoint temperature and a 4-20 mA output signal for dry bulb. temperature. Sensor shall be Vaisala Model HMS82TD or equivalent.

D. Hydronic Pipe Insertion Sensors: Stem or tip sensitive types, as required. Sensing elements shall be hermetically sealed. Stem and tip construction shall be 304 stainless steel, copper, glass or epoxy. All external trim material shall be corrosion resistant designed for the intended application. Sensor pipe wells shall be of bronze, stainless steel, copper, or monel materials. Heat transfer compounds shall be compatible with the sensors.

2.3 HUMIDITY SENSORS

A. Indoor Air Relative Humidity Sensors: Analog type with polymer element for comfort conditions monitoring and platinum element for critical areas including laboratories, hospital procedure rooms, etc. Space sensors shall have blank covers and no humidity display and no setpoint adjustment unless specifically indicated on the drawings. Duct sensors shall meet the requirements specified below for outdoor relative humidity sensors.

B. Outdoor Air Relative Humidity Sensors: Relative humidity sensors installed outdoors or in HVAC ductwork shall utilize a ceramic capacitive sensing element that is impervious to damage by (1) humidity levels exceeding 95% RH and (2) wetting by rain or surface condensation. Measurement range shall be 10 - 95% RH within a temperature range of -40ºF to

140ºF. Sensors installed in outdoors shall include a weatherproof enclosure and have dip switches to select sensor analog output signal as 4-20 mA or 0-10 VDC.

2.4 OCCUPANCY SENSORS

A. "Event" Occupancy Ventilation Initiation Switches: Where indicated, provide tubular key operated momentary contact ON/shunt OFF, SPST switch mounted in recessed wall receptacle box with plate to match adjacent space sensors. Switch shall have maintained OFF, springing back from ON when activated. Switch shall be Seco-Larm Model SS095 or equivalent. Provide switch label engraved "EVENT VENTILATION."

2.5 CARBON DIOXIDE SENSORS

A. Carbon Dioxide (CO2) Sensors: Sensors shall be non-dispersive infrared (NDIR) type, ether single-lamp single-wavelength or single-lamp dual wavelength configuration, designed specifically for air diffusion measurement of CO2 in the range of 0 to 2000 ppm. Sensors shall provide output, 0-10 VDC or 4-20 mA, in direct proportion to CO2 concentration.
   1. Sensor accuracy shall be within +/- 60 ppm (10%) across the range of 400 to 1000 ppm at 25°C, 50%RH, and 14.7 psia air conditions.
   2. Sensor shall have test gas inlet port and be provided with manufacturer's detailed, written calibration procedures for using CO2 calibration gas samples.
   3. Sensors shall be calibrated at the factory prior to shipment using a minimum of two calibration gas samples, one a 950-1050 ppm and one at either 0 ppm or 450-550 ppm, with the concentration of the calibration gas known to within +/- 2%. Provide factory sensor test/calibration reports for review by the A/E.
   4. Sensors shall not incorporate "automatic baseline adjustment" logic.
   5. Sensor sensitivity to atmospheric conditions shall not exceed the following:
      a. Humidity +/- 0.3 ppm/%RH
      b. Temperature +/- 0.1 ppm/°C
      c. Pressure +/- 5.0 ppm/ in. Hg

2.6 STATUS SENSORS

A. Motor Status Sensor: Status of pumps and fans shall be proven by adjustable current sensing relays. Provide user adjustable time delays (10 seconds default) to prevent false alarms during starting/stopping of motor.

B. Flow status of pumps and fans, 1/2 hp and larger, shall be proven by adjustable current sensing relays. Provide software resident time delays to prevent false alarms during starting/stopping, including printout and application programs.

2.7 PRESSURE SENSORS

A. Pressure and Differential Pressure Sensors/Switches: Pressure sensing elements shall be corrosion resistant Bourdon tubes, bellows diaphragm or piezoelectric type and shall have the following features:
   1. Adjustable high and low limits.

2. Suitability for operation in an ambient temperature range of 30 140 degrees F.
3. Accuracy within 5 percent of full scale.
4. Pressure and differential pressure switch type units shall consist of a SPDT switch with adjustable setpoint high/low settings. Switches shall be snap action type contacts designed for the application. For switches serving as binary input to the DDC system, contacts shall be short radius gold or rhodium plated. For switches serving as an element of interlock wiring circuits, contacts shall be rated suitable for the load. Switch type units shall operate automatically and, unless indicated to have manual reset, reset automatically when conditions return to normal.

B. Pressure and differential pressure sensors:
1. Air differential pressure sensors shall be rated for up to 12" WG high pressure; direct acting linear output 4 to 20 mA.
2. Water differential pressure sensors shall have a stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; direct acting linear output 4 to 20 mA.
3. Pressure sensors for gas, liquid, or steam service shall be direct acting; range suitable for system; linear output 4 to 20 mA.
4. Sensors on steam lines shall be protected by pigtail siphons installed between the sensor and the line, and shall have an isolation valve installed between the sensor and pressure source.

2.8 AIRFLOW SENSORS

A. Duct, Plenum, and Outdoor Air Intake Airflow Measuring Stations
1. Airflow measuring stations shall measure airflow by pitot tube traverse method or by the thermal dispersion airflow method.
2. Pitot tube method stations shall consist of an array of static and total pressure sensors, factory positioned and connected in parallel, to produce an equalized velocity pressure. The measured velocity pressure shall be converted to airflow (cfm) with accuracy within ± 2% of the full scale throughout the velocity range from 200 to 4000 fpm.
3. Thermal dispersion method stations shall utilize precision thermistors arranged to measure airflow rate and temperature at multiple sensing locations and relate the thermal transfer rate of a heated element to a total airflow rate (cfm). Ensure senor accuracy within ± 2% of reading shall be obtained through individual sensor characterization over a range of 0 to 5,000 FPM in wind tunnels calibrated to volumetric airflow standards. Sensor shall include a flow integration filter.
4. The maximum resistance to airflow shall not exceed 0.3 times the velocity head for the duct or stations and 0.6 times the velocity head for the fan stations. The unit shall be suitable for continuous operation up to a temperature of 250 degrees F.
5. Where application is measurement of outdoor airflow at air-handling unit inlet, station shall incorporate bellmouth inlet.

B. Fan Inlet Airflow Measuring Station: Provide airflow monitoring device within the inlet cone of centrifugal fans or inlet bell of tubeaxial/vaneaxial fans where indicated on the Drawings. Air monitoring device shall be pitot tube type or thermal dispersion type, as follows:
1. Pitot tube type shall consist of an array of total and static pressure flow sensors constructed of aluminum or copper and mounted at opposing 90-degree positions around the fan inlet. Flow sensors shall be manifolded together to produce measured velocity pressure that is converted to airflow (cfm) within accuracy range specified herein below.

The measured velocity pressure shall be converted to airflow (cfm) with accuracy within ± 2% of the full scale throughout the velocity range from 200 to 4000 fpm.

2. Thermal dispersion type shall utilize precision thermistors to arranged to measure airflow rate and temperature at multiple sensing locations and relate the thermal transfer rate of a heated element to total airflow rate (cfm). Ensure senor accuracy within ± 2% of reading shall be obtained through individual sensor characterization over a range of 0 to 5,000 FPM in wind tunnels calibrated to volumetric airflow standards. Sensor shall include a flow integration filter
3. Air monitoring station shall not obstruct the fan inlet nor have any effect on fan air performance or sound power levels.

2.9 WATER SENSORS

A. Water Flow Meter and Transmitter (Nutating Disk Type): For up to 2" NPS, water flow meter shall be positive displacement, nutating disk type.

B. Water Flow Meter and Transmitter (Insertion Electromagnetic Type): Meter shall be insertion electromagnetic type suitable for flow measurement for fluids with electrical conductivity between 20 and 60,000 micro-Seimens per centimeter. Meter shall be mounted on a 2" NPS full port isolation valve and include calibrated scale to allow precise positioning of the flow element to the required insertion depth within plus or minute 0.05 inch. Transmitter shall be integral with flow meter. All wetted metal components shall be Type 316 stainless steel. Operating power shall be nominal 24 VDC. Sensor shall have the following performance characteristics:
   1. Ambient conditions: -40 to 140 degrees F, 5 to 100 percent humidity.
   2. Operating limits: 400 psig, 250 degrees F, 0.25 to 20 feet per second flow velocity.
   3. Minimum turn down ratio: 10 to 1.
   4. Accuracy: within 1% of reading.
   5. Repeatability: plus or minus 0.25% of reading.
   6. Velocity to flow conversion and 4-20 mA output signal proportional to water flow rate in gpm.
   7. Install sensor in "hot tap" configuration with full port ball or gate type isolation valves so that it can be removed/reinstalled without draining the piping.

C. Water Flow Meter and Transmitter (Insertion Turbine Type): Meter shall be insertion turbine type with turbine element, retractor and preamplifier/transmitter mounted on a 2" NPS full port isolation valve; calibrated scale shall allow precise positioning of the flow element to the required insertion depth within plus or minute 0.05 inch. Meter shall utilize a single turbine in pipe sizes 2" NPS and small and dual turbines in 2-1/2" NPS and larger. Rotational sensing of each turbine shall be accomplished by sensing electronic impedance change. Turbine bearings shall be sapphire jewel bearings. All wetted metal components shall be Type 316 stainless steel. Operating power shall be nominal 24 VDC. Sensor shall have the following performance characteristics:
   1. Ambient conditions: -40 to 140 degrees F, 5 to 100 percent humidity.
   2. Operating limits: 300 psig, 250 degrees F, 0.5 to 40 feet per second flow velocity.
   3. Turn down ratio: 10 to 1.
   4. Accuracy: 1% of actual flow within the flow velocity range of 3-30 fps; within 0.5% of actual reading at calibrated velocity.
   5. Repeatability: plus or minus 0.25% of reading.

6. Velocity to flow conversion and 4-20 mA output signal proportional to water flow rate in gpm.
7. Install sensor in "hot tap" configuration with full port ball or gate type isolation valves so that it can be removed/reinstalled without draining the piping.

D. Water Flow Sensors (Insertion Pitot Tube Type): Multi-port averaging type flow sensor mounted on a two-inch full port isolation valve and designed to sense the velocity of a fluid flowing in a pipe and produce a pressure output that is proportional to the fluid velocity. Flow sensor shape shall allow flow separation at a fixed point independent of the flow rate, pressure, or temperature so that a stable flow coefficient is maintained over a wide range of Reynolds numbers. All wetted metal components shall be Type 316 stainless steel. Operating power shall be nominal 24 VDC. Sensor shall have the following performance characteristics:
1. Ambient conditions: -40 to 140 degrees F, 5 to 100 percent humidity.
2. Operating limits: 300 psig, 250 degrees F.
3. Minimum turn down ratio: 10 to 1.
4. Accuracy: 1% of actual flow within the flow velocity range of 10-100% of design.
5. Repeatability: plus or minus 0.1% of reading.
6. Velocity pressure to flow conversion and 4-20 mA output signal proportional to water flow rate in gpm.
7. Install sensor in "hot tap" configuration with full port ball or gate type isolation valves so that it can be removed/reinstalled without draining the piping.

2.10 STEAM SENSORS

A. Steam Flow Sensors (Vortex Shedding type): Vortex shedding device incorporating wing type sensor designed for installation between two flanges and amplification technology for high signal-to-noise ratio, with Type 316 stainless steel body and working parts. Sensor shall have the following performance characteristics:
1. Ambient conditions: -40 to 175 degrees F.
2. Process conditions: Maximum 125 psi saturated steam.
3. Turn down ratio: 20 to 1.
4. Repeatability: plus or minus 0.1 percent.
5. Output signal: 0-20 mA output signal proportional to steam flow rate in lbs/hr.

B. Steam Flow Sensors (Orifice Plate type): Flow meter shall consist of orifice flanges, and stainless steel orifice plate designed for indicated steam flow rate, pressure, and piping size and transmitters. Provide shut off and pressure equalizer valves and condensate chamber with isolation valves. Connect transmitter to condensate chamber with seamless copper tubing. Provide dual differential pressure transmitters to yield 8-to-1 flow turndown ratio and 0-20 mA output signal proportional to steam flow rate in lbs/hr.

C. Steam Condensate Flow Meter/Transmitter: Provide positive displacement type flow meter with cast iron body and bronze trim specifically designed for the temperature and pressures of the service, complete with properly calibrated horizontal non-setback register with extension, reading in "pounds". Provide remote indication via transmitter with 4-20 mA output signal directly proportional to the condensate flow rate. Use totalizing software to maintain hourly, daily, and monthly condensate flows.

2.11 HYDRONIC SENSORS

A. Hydronic BTU Metering System: The entire system shall be manufactured and calibrated by a single supplier and shall consist of a flow sensor, two temperature sensors, a BTU meter, temperature thermowells, and all required installation elements. A certificate of N.I.S.T. traceable calibration shall be provided with each system. The BTU meter shall provide the following points both at the integral LCD and as outputs to the building control system: Energy Total, Energy Rate, Flow Rate, Supply Temperature and Return Temperature. System shall utilize serial network protocol conforming to BACnet® MS/TP or BACnet/IP and comply with the requirements of Section 230924. Each BTU meter shall be factory programmed for its specific application, and shall be re-programmable using the front panel keypad with no special interface device or computer required.

1. Temperature sensors shall be loop-powered current based (mA) sensors and shall be bath-calibrated and matched for the specific temperature range for each application. The calculated differential temperature used in the energy calculation shall be accurate to within +0.15°F (including error from individual temperature sensors, sensor matching, input offsets, and calculations).
2. Water flow sensor shall be inline (full bore) electromagnetic type complete with integral or remote electronics module. Connections to the piping shall be ANSI flanges. The flow tube shall be epoxy coated steel; the sensing electrodes shall be Type 316 stainless steel; the liner shall be polypropylene or ebonite for chilled or ambient water service and PFTE for hot water service. Each flow sensor shall be individually wet-calibrated to within ± 0.2% of reading from 3 to 33 feet per second velocity. A certificate of calibration shall be provided with each flow sensor. Output signals shall be 4-20 mA and programmable pulse. The flow meter shall be capable of measuring bi-directional flow. For installations in non-metallic pipe, install grounding rings between flanges.
3. Hydronic BTU metering system shall be Onicon System-10-BAC-IP Btu Meter utilizing F-3200 Series flow meter, or equivalent.

2.12 CONDENSATE SENSORS

A. Condensate Level Sensor: For each FCU/BCU/AHU, provide a plenum-rated water level detection device, conforming to UL 508, consisting of one or more moisture sensors and a N.O. dry contact to serve as a binary input point connected to the building control system to disable mechanical cooling and initiate an alarm in the event the condensate drain is blocked. Device shall include adjustable 1-3 minute time delay before opening to reduce short term nuisance shutdowns. Device shall be mounted on the FCU/BCU/AHU, with remote sensor(s) installed in the equipment's factory-installed primary drain pan, located at a point higher than the pan's primary drain line connection and below the overflow rim of the pan. Sensor(s) shall be retained by clips and/or adhesive tape.

Exceptions: Where the primary drain pan is too shallow or otherwise designed so that sensor(s) cannot be located as required, a drain pan overflow sensor, installed in the pan's secondary drain line connection, may be used. Where an auxiliary drain pan is required, as indicated on the Drawings, provide water level detection device with sensor(s) installed at the lowest possible level in the auxiliary drain pan.

2.13 UTILITIES MONITORING

A. Electrical Power Monitoring: Where available, facility electrical energy consumption information should be obtained via pulse output from utility-owned kWh meter. Where utility metering is unavailable or for required sub-metering , provide electrical power monitoring where indicated on the Drawings, as follows:
   1. Current sensing: Current transformers, coupled with a current transmitter, shall be used to provide an output directly proportional to the current amperage:
      a. Current transformers shall be split core type, UL/CSA Recognized, and completely encased in non-conductive material. Select transformer to provide appropriate current ratio with 99% accuracy at 5 A full-scale output.
      b. Current transmitters shall be self-powered with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A full scale, with internal zero and span adjustment and 99% full-scale accuracy at 500 ohm maximum burden. Unit shall meet ANSI/ISA S50.1 requirements and be UL listed.
   2. Voltage Sensing: Voltage transformers, coupled with a voltage transmitter, shall be used to provide an output directly proportional to the voltage:
      a. Voltage transformers shall be totally enclosed, UL/CSA Recognized, 600 VAC rated, and complete with built-in fuse protection. Units shall be 99.5% accurate over full scale at 24 VAC and a 5 VA load.
      b. Voltage transmitters shall be self-powered single-loop (two wire) type, 4-20 mA output with zero and span adjustment. Ranges shall include 100-130 VAC, 200-250 VAC, 250-330 VAC, and 400-600 VAC full scale with 99% accuracy with 500 ohm maximum burden. Units shall be UL listed, 600 VAC rated, and meet ANSI/ISA S50-1 requirements.
   3. Power Monitoring: Units shall be three-phase type furnished with three-phase disconnect/shorting switch assembly, UL listed voltage transformers, and UL listed split core current transformers. Provide selectable rate pulse output for kWh reading and a 4-20 mA output for kW reading. Monitors shall operate with 5 A current input with a maximum error of 2% at 1.0 power factor or 2.5% at 0.5 power factor.

B. Fuel Oil Flow Monitoring: Provide nutating disk type, positive displacement inline flow meter(s) where indicated on the Drawings. Where unused oil is returned to supply tanks, both the supply flow and return flow shall be metered in order to determine net oil consumption. Meters shall comply with the following:
   1. Fuel oil flow readings shall be in gallons.
   2. Flow accuracy shall be 1.0% or greater.
   3. Meter shall have a turndown rating of 10:1 or greater.
   4. Support one of the two following methods to communicate flow rate to the DDC system:
      a. Pulse output at 50ms or slower in direct proportion to fuel oil flow in gallons for interface to facility direct digital control system for flow monitoring and totalization.
      b. Analog output consisting of 0-10 VDC or 4-20 ma signal in direct proportion to fuel oil flow rate in gallons for interface to facility direct digital control system for flow monitoring and totalization.

C. Natural/Propane Gas Flow Monitoring: Where available, facility gas consumption information shall be obtained via pulse output from utility-owned gas meter. Where pulse output from existing utility-owned meter is not available or for required sub-metering, provide inline diaphragm type gas meter where indicated on the Drawings, as follows:

1. Meter accuracy shall be rated within +/- 2.0% of full flow.
2. Support one of the two following methods to communicate flow rate to the DDC system:
   a. Pulse output at 50ms or slower in direct proportion to gas flow in cubic feet for interface to facility direct digital control system for flow monitoring and totalization.
   b. Analog output consisting of 0-10 VDC or 4-20 ma signal in direct proportion to gas flow rate in cubic feet for interface to facility direct digital control system for flow monitoring and totalization.

D. Service Water Monitoring: Where available, facility water consumption information shall be obtained via pulse output from utility-owned water meter in direct proportion to water flow in gallons for interface to facility direct digital control system for flow monitoring and totalization. Where pulse output from utility-owned meter is not available or for required sub-metering, provide water flow sensor as hereinbefore specified where indicated on the Drawings,. Provide flow monitoring and totalization based on 0-20 mA output signal in direct proportion to flow rate in gallons per minute.

2.14 ELECGTRIC CONTROLS ELEMENTS

A. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

B. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.
   1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.

C. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.
   1. Bulbs in water lines with separate wells of same material as bulb.
   2. Bulbs in air ducts with flanges and shields.

D. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.

E. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

F. Fire-Protection ("Firestat") Thermostats: Manual reset on-off thermostat with fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature. Firestat shall be listed and labeled for the application.

G. Hydronic Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

H. Hydronic Surface-Mounted Thermostat ("Aquastat"): Snap-acting, single-pole, single-throw, auto-reset switch that opens if temperature rises above adjustable high temperature setpoint or falls below adjustable low temperature setpoint, as indicated by the application.

I. Electric, Low-Limit Duct Thermostat ("Freezestat): Snap-acting, single-pole, single-throw, manual-reset switch that opens if temperature sensed across any 12 inches of bulb length is equal to or below set point of 40□F.
   1. Bulb Length: Minimum 20 feet.
   2. Quantity: One thermostat for every 20 sq. ft. of coil surface.
   3. Where multiple high limit thermostats are required, the they shall be wired in series so that any one thermostat will result in the system shutdown as indicated on the Drawings.

J. Water Flow Switches: Provide differential pressure switches as hereinbefore specified.

2.15 FINAL CONTROL ELEMENTS AND OPERATORS:

Control Dampers: Provide dampers with parallel blades for 2 position control, opposed blades for modulating control.

A. Outdoor Air Dampers: Dampers shall be constructed for coastal environment (salt water) corrosion resistance of Type 316 stainless steel (blades, frame, shafts, and linkage) or aluminium with clear anodized finish (blades and frame) with Type 316 stainless steel shafts and linkage. Dampers shall be rated Leakage Class I at 250-deg F according to ANSI/AMCA 500-D. When flow velocity is less than 2000 fpm, blades may be single thickness or airfoil type. When the flow velocity exceeds 2000 fpm, blades shall be airfoil type.

B. Return, Relief, Exhaust Air Dampers: Dampers shall be constructed of 0.108-inch-minimum thick G90 galvanized steel or 0.125-inch-minimum thick, extruded-aluminium frames with holes for duct mounting; damper blades shall not be less than 0.064-inch-thick steel with maximum blade width of 8 inches and maximum length of 48 inches. Secure blades to 1/2-inch-diameter axles with oil-impregnated sintered bronze blade bearings, blade-linkage hardware, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of each blade. Dampers shall be constructed with zinc-plated shafts and hardware exposed to the airstream.

> **Exception:** ***Dampers installed in dishwasher exhaust ductwork, return air ductwork in natatoriums, or in other wet locations shall be constructed of Type 316 stainless steel, including blades, frames, shafts and damper hardware exposed to the airstream.***

C. Operating Temperature Range: From minus 40 to plus 250 deg F.

D. Edge Seals: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for Leakage Class I according to ANSI/AMCA 500-D.

E. Smoke Control Systems: Control dampers in a smoke control system shall comply with ANSI/UL 555S and leakage rates shall be as follows:
   1. Return Air: Leakage Class I at 250□F according to ANSI/AMCA 500-D.
   2. AHU Isolation: Leakage Class II at 250□F according to NSI/AMCA 500-D.

F. Damper Sizing:
   1. Two-position dampers shall be sized to match duct or opening size, as applicable.
   2. Modulating dampers utilized as part of an airside economizer cycle shall be sized in accordance with ASHRAE Guideline 16.

G. Control Valves: Valve bodies shall be designed for not be less than 125 psig working pressure or 150% of the operating pressure, whichever is greater. Class 125 bronze body valves and Class 150 stainless steel valves shall comply with ASTM B16.5. Cast iron components shall meet the requirements of ASTM A126, Class B.Select and size control valves as hereinafter specified and submit complete valve selection list with shop drawings.

H. Hydronic Control Valves:
   1. General: Control valve body, packing, and trim shall be designed to withstand the system static head plus the greater of 150% of the maximum pump head or the pump cut-off head at the maximum temperature and velocity of the controlled medium and have no stem lift and leak-by at close-off.
   2. All valves 1-1/2" NPS and smaller shall be brass or bronze bodied with Type 316 stainless steel internal trim (including seats, seat rings, and valve stems). Non-metallic parts of valves shall be designed for 250-degree F operating temperature. Valves shall be packless construction or equipped with pressure sealed molded packing and backseating ring. Dual temperature valves shall be specifically designed for the service.

I. Three-Way Modulating Control Valves:
   1. Valves shall be of the modulating globe or ball type and have linear position vs. flow characteristic; total flow through the valve shall remain constant regardless of the valve stem position.
   2. Valve rangeability shall be at least 50:1

J. Two-Way Pressure Dependent Modulating Control Valves:
   1. Valves shall be modulating globe or ball type and have equal percentage position vs. flow characteristic.
   2. Valve rangeability shall be at least 100:1.

K. Two-Way Pressure Independent Modulating Control Valves:
   1. Valves shall consist of flow regulating balancing valve, modulating temperature control valve, and differential pressure control device within a single valve assembly that shall have equal percentage position vs. flow characteristic.
   2. Valves shall maintain flow rate dictated by the input control signal over the full flow range of 0-100% to maintain flow within ±5 % accuracy, automatically compensating for system pressure changes from 5 psig up to at least 50 psig.

L. Control Valve Sizing:
   1. Two-position control: Valves shall be line size. Select valve for minimum wide open pressure drop.
   2. Modulating 3-Way Control: Minimum valve pressure drop at full flow shall be the greater of 10 feet of water [4 psig] or the pressure drop through the heat exchanger.
   3. Modulating 2-Way Control: Valves shall be sized to operate at no less than 70% available stroke at maximum flow rate. Select control valve Cv to provide control valve authority of at least 0.3 when authority is defined as the pressure drop through the valve at full flow divided by flow through the valve at minimum (0 gpm) flow. Minimum valve pressure

drop at full flow shall be the greater of 10 feet of water [4 psig] or the pressure drop through the heat exchanger and piping (including valves, specialties, etc.) serving it.

M. Steam Control Valves:
1. Valves 1-1/2" NPS and smaller shall be brass or bronze bodied with Type 316 stainless steel internal trim (including seats, seat rings, and valve stems). Non-metallic parts of valves shall be designed for 400-degree F operating temperature. Valves shall be packless construction or equipped with pressure sealed molded packing and backseating ring. Dual temperature valves shall be specifically designed for the service.
2. Valves 2" NPS and larger shall have flanged carbon steel bodies with Type 316 stainless steel internal trim (including seats, seat rings, and valve stems). Non-metallic parts of valves shall be designed for 400-degree F operating temperature. Valves shall be packless construction or equipped with pressure sealed molded packing and backseating ring. Dual temperature valves shall be specifically designed for the service.

N. Modulating Steam Control Valves:
1. Valves shall have equal percentage position vs. flow characteristic for service pressure of 15 psig or less and linear characteristic for service pressures greater than 15 psig.
2. Valve rangeability shall be at least 100:1

O. Steam Control Valve Sizing:
1. Two-position control: Size valve for pressure drop at full flow equivalent to 20 percent of inlet gauge pressure.
2. Modulating control: Size valve for pressure drop at full flow equivalent to 80 percent of inlet gauge pressure with acoustic velocity limitation.

P. Damper and Valve Operator/Actuators: Unless indicated otherwise on the Drawings, all actuators shall have fail-safe operation via a mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.

Q. Electronic Damper and Valve Operator/Actuator: Shall be direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque. For valves, size actuator for torque required for valve tight close off at pressures defined above. For dampers, size actuator for running torque calculated as follows:
1. Parallel-Blade Dampers: 7 inch-lb/sq. ft. of damper.
2. Opposed-Blade Dampers: 5 inch-lb/sq. ft. of damper.
3. Dampers with Face Velocities exceeding 1000 fpm: Increase running torque by 2.0.
4. Couplings shall be V-bolt and V-shaped, with toothed cradle.
5. Provide electronic overload or digital rotation-sensing circuitry.
6. Actuator shall operate with proportional input signal of 2-V to 10-V dc or 4 to 20 mA
7. Rated temperature operating range for actuators shall be -20 deg F to +120 deg F for conventional applications and -20 to +250 deg F for smoke or fire/smoke damper application.
8. Actuator shall have the following operational characteristics:
    a. Actuator full stroke time requirement shall not exceed 12 seconds to open or 5 seconds to close when applied to control smoke dampers or cooling tower bypass valves less than 6" NPS.
    b. Actuator full stroke time requirement shall not exceed 30 seconds to open or close when applied to control cooling tower bypass valves 6" NPS or large size.

R. Electric Two-Position Damper Operator/Actuator: Provide a bi-directional, 120-V operator with spring return, size actuator for running torque calculated as follows:
   1. Parallel-Blade Dampers: 7 inch-lb/sq. ft. of damper.
   2. Opposed-Blade Dampers: 5 inch-lb/sq. ft. of damper.
   3. Dampers with Face Velocities exceeding 1000 fpm: Increase running torque by 2.0.

S. Position Indicator: Actuators shall be provided with a compact, adjustable visual position indicator attached to the actuator. As a damper or valve is cycled, the position indicator shall rotate, causing a cylinder to rotate inside a second cylinder with "display windows." When the damper or valve is open, the word "OPEN" shall be displayed in the two windows located 180° apart. When the damper or valve is closed, the word "CLOSED" shall be displayed. Between the two extremes, the display shall be scaled in degrees (0-90).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Sensors and Controls:
   1. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short circuiting or other conditions. Line protect all wiring that comes from external sources to the site from lightning and static electricity.
   2. Label or code each field wire at each end. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color code cable with cable diagrams may be used to accomplish cable identification.

B. Temperature Sensors:
   1. Install all sensors and instrumentation according to manufacturer’s written instructions. Temperature sensor locations shall be readily accessible, permitting quick replacement and servicing of them without special skills and tools.
   2. Low-limit thermostats ("freezestats") shall be located at an elevation at or above the top of the coil being protected and the capillary element installed in a serpentine arrangement across the face of the coil starting at the top and ending at the bottom.
   3. Mount sensors rigidly and adequately for the environment within which the sensor operates.
   4. Sensors used in mixing plenum or in air-handling unit hot and cold decks shall be of the averaging of type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
   5. Pipe-mounted temperature sensors shall be installed in wells completely filled with thermal conducting material.
   6. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.

C. Duct Pressure/Airflow Sensors/Switches:
   1. Sensors shall be connected to pressure or airflow monitoring stations.

D. Duct, Plenum, and Outdoor Air Intake Airflow Monitoring Stations.
   1. Each airflow measuring station shall be installed as located and detailed on the Drawings in accordance with the manufacturer's minimum installation conditions for the indicated application and shall not amplify the sound level. **Install duct-mounted airflow**

monitoring stations or sensors a minimum of 5 duct diameters up stream and 8 duct diameters downstream or 6 feet, whichever is greater, from fittings and other obstructions.

E. Pipe Pressure or Differential Pressure Sensors/Switches:
   1. Mount pressure sensor a minimum of 5 pipe diameters upstream and 5 pipe diameters downstream or 2 feet, whichever is greater, from fittings and other obstructions.
   2. Install snubbers and isolation valves on steam pressure sensing devices.

F. Actuators:
   1. Mount damper and valve actuators according to manufacturer's written instructions.
   2. Damper actuators shall be located outside of the airstream.
   3. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.
   4. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.

G. Pipe Flow Switches:
   1. Install differential pressure switch according to manufacturer's written instructions.
   2. Mount switch a minimum of 5 pipe diameters up stream and 5 pipe diameters downstream or 2 feet, whichever is greater, from fittings and other obstructions.
   3. Assure correct flow direction and alignment.

H. Pipe Flow Meters/Sensors:
   1. Install flow meters according to manufacturer's written instructions.
   2. Mount flow meter a minimum of 5 pipe diameters up stream and 10 pipe diameters downstream or 2 feet, whichever is greater, from fittings and other obstructions.
   3. Assure correct flow direction and alignment.

3.2 FIELD TEST AND INSPECTIONS

A. Upon completion of installation of each sensor or final control element, field inspect and mechanically and electrically test for proper function.

END OF SECTION 230913

230923 – DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to the work of this section.

B. **Section 230906, which specifies the work of the Niagara N4 Framework and graphics System Integrator and the delineation of work between the BAS Contractor and the System Integrator**.

C. Section 230913, which specifies the requirements for sensors, devices, actuators, and final control elements utilized by the DDC system.

D. Section 230924, which specifies the requirements for original equipment manufacturer (OEM) controllers/gateways provided under Division 23.

1.2 QUALITY ASSURANCE

A. Single Source Responsibility of Supplier: The controls system vendor shall be responsible for the complete installation and proper operation of the control system. The vendor must be licensed as an "unlimited electrical contractor" in the state of North Carolina, shall have a factory-certified trainer on staff, and provide 5 day per week technical support. ***Acceptable vendors and DDC systems are limited to the following***:

1. Johnson Controls, Inc. (395 North Green Meadows Drive, Wilmington, NC 28443) BACnet Metasys controllers.
    a. Exceptions:
        1) Controllers shall have the capability of utilizing any non-proprietary sensor and operator complying with Section 230913.
        2) "User Licences for CCT" shall be provided as required for support full system utilization by New Hanover County Schools maintenance and operations staff.
2. Schneider Electric (2600 Perimeter Park Drive, Suite 150, Morrisville, NC 27560). BACnet SmartStruxure Controllers:
    a. Exceptions:
        1) Controllers shall have the capability of utilizing any non-proprietary sensor and operator complying with Section 230913.
        2) **"Sensor Link" (S-Link) sensors and communications is prohibited unless specifically approved by NHCS prior to bid.**
        3) "User Licences for toolset" shall be provided as required for support full system utilization by New Hanover County Schools maintenance and operations staff.
3. Brady Services Inc (6736 A Netherlands Drive Wilmington, NC 28405)

"Trane Symbio" Controllers:

a. Controllers shall have the capability of utilizing any non-proprietary sensor and operator complying with Section 230913.
b. "User Licences for TU" shall be provided as required for support full system utilization by New Hanover County Schools maintenance and operations staff.

B. Equipment and Materials: Equipment and materials shall be catalogued products of manufacturers regularly engaged in production and installation of HVAC control systems. Products shall be manufacturer's latest standard design and have been tested and proven in actual use.

1.3 GUARANTEE PERIOD SERVICES

A. Maintenance of Control Hardware: The Contractor shall inspect, repair, replace, adjust, and calibrate, as required, associated peripheral equipment, and control units. The Contractor shall then furnish a report describing the status of the equipment, problem areas (if any) noticed during service work, and description of the corrective actions taken. The report shall clearly certify that all software is functioning correctly.

B. Maintenance of Control Software: The Contractor shall maintain all software. In addition, all factory or sub-vendor upgrades to software shall be added to the systems, when they become available, at no additional cost to the Owner during the warranty period.

C. Service Period: Calls for service by the Owner shall be honored within 24 hours and are not to be considered as part of routine maintenance during the warranty period.

D. Service Documentation: A copy of the service report associated with each routine service visit or Owner-initiated service call shall be provided to the Owner and the A-E with 10 days after the date of each service call.

1.4 SUBMITTALS

A. General: Submittals shall demonstrate compliance with technical requirements by reference to each subsection of this specification. Where a submitted item does not **comply fully** with each and every requirement of the Specifications, the submittal shall clearly indicate such deviations.

B. Submittals required by this sub-section, and the required dates for each submittal, shall be finalized at a pre-submittal meeting, to be scheduled within 30 days of the date of the Notice to Proceed, and shall be provided in three phases:

1. Phase I submittals shall consist of DDC engineering shop drawings, network diagrams, including valve and damper schedules with sizing calculations, control system schematics, and sequences of operation, including setpoints, alarm limits, and schedules; product data for all control devices required under Section 230913; DDC system hardware and software as required below; and any other submittals determined during the pre-submittal conference. **Phase I submittals must be submitted and reviewed as early in project schedule as possible to avoid delays in actual installation.**
2. Phase II submittals shall be the close-out submittals as required below. Phase II submittals are required before the date of Final Completion inspection.

C. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

D. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

E. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

F. 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. Bill of materials of equipment indicating quantity, manufacturer, and model number.
3. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequences of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. DDC System Hardware:

    a. Wiring diagrams for control units with termination numbers.
    b. Schematic diagrams and floor plans for field sensors and control hardware.
    c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
    d. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.

G. Samples for Initial Selection: For each color available for each type of thermostat, sensor, etc. cover exposed to view with factory-applied color finishes.

H. Data Communications Protocol Certificates: **Certify that each proposed DDC system component complies with ASHRAE Standard 135-2012 and is BACnet Laboratory tested and certified.**

I. Closeout Submittals:

a. Operation and Maintenance Data: Include the following:

    1) Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
    2) Interconnection wiring diagrams with identified and numbered system components and devices.
    3) Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
    4) Calibration records and list of set points.
    5) Software and Firmware Operational Documentation: Include the following:

a) Software operating and upgrade manuals.
b) Program Software Backup: On a magnetic media or compact disc, complete with data files.
c) Device address list.
d) Printout of software application and graphic screens.
e) Software license.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Provide a peer-to-peer networked, stand-alone, distributed processing global Direct Digital Control (DDC) System utilizing flat communications scheme. DDC system shall be BACnet/IP based, complying with ANSI/ASHRAE Standard 135-2012 protocol, and communicating using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

B. 23 09 06 "Niagara N4 Framework System Integrator" Contractor is responsible for:

1. NHCS IP Drop for JACE Controller
2. JACE Controller and licenses
3. Enclosure and Power supply for JACE
4. JACE Integration to existing N4 server
5. Graphics on N4 server
6. **Schedules and Alarms on N4 server**

C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected by a Local Area Network (LAN) to distributed processing, standalone control units (CUs) operating in a multiuser, multitasking environment and programmed to control HVAC and other systems, as shown on the Drawings. The CUs provided by the BAS contractor shall be provided with appropriate default set points and default network variable inputs as required for adequate stand-alone operation. However, it is both the BAS contractor and System Integrator's responsibilities to closely coordinate their respective tasks and schedules to provide a complete and fully functioning system in a timely and seamless fashion as if delivered by one entity.

D. DDC system shall use ANSI/ASHRAE Standard 135-2012 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol. Comply with ANSI/ASHRAE Standard 135-2012 for all controls hardware and software.

2.2 MAINTENANCE OFFICE FILE SERVER AND WORKSTATIONS

A. The Owner maintains a Niagara 4 file server, network, and client workstations located at the NHCS Maintenance Office, 2418 Carolina Beach Road, Wilmington, NC. The owner's System Integrator is responsible for the Building Level Control Unit as specified in Section 23 09 06 "Niagara N4 Framework System Integrator."

B. Access to the Owner's WAN by the DDC system vendor, except via supervised access using Join.me Basic, is ***prohibited***.

2.3 SCOPE OF WORK

A. Object and Point Naming Requirements:

1. Full English language data addressing and presentation: BACnet objects/points shall be identified within a particular BACnet device by a 32-bit numeric "object identifier" defined in accordance with ANSI/ASHRAE Standard 135-2012. Each object/point shall also be referenced by individual writable "object name" of 50 characters or less assigned by the Contractor utilizing the following naming convention:

a. Format object/point names in terms of "**FACILITY.SYSTEM.POINT**." "Facility" shall be the name or identifying abbreviation for the facility as provided by the Owner. "System" shall be the name or identifying abbreviation for the HVAC system, subsystem, or component matching **exactly the system, subsystem, and component identifier used within the Contract Documents**. "Point" name abbreviations shall be as follows:

Point Description	**Point Name**
Air Flow	AirFlow
Air Static Pressure	AirSP
Air Velocity Pressure	AirVP
Chilled Water Supply, Return Temperature	CHWSTemp CHWRTemp
Condenser Water Supply, Return Temperature	CDWSTemp CDWRTemp
Control Valve, 2-Way Configuration	CV2W
Control Valve, 3-Way Configuration	CV3W
Differential Temperature	DTemp
Heat Pump Water Loop Supply, Return Temperature	HPWSTemp HPWRTemp
Hot Water Supply, Return Temperature	HWSTemp HWRTemp
Hydronic Differential Pressure	DiffPres
Hydronic or Steam Pressure	Pres
Hydronic Return Temperature	RetTemp
Hydronic Energy (BTU), Chilled Water and Hot Water	CHWBtu HWBtu
Mixed Air Temperature, Humidity, Enthalpy	MATemp MAHum MAEnth
Outdoor Air Temperature, Humidity, Enthalpy	OATemp OAHum OAEnth
Percent Open	PctOpn
Percent Output	PctOpt
Power	kW
Return Air Temperature, Humidity, Enthalpy	RATemp RAHum RAEnt
Space Temperature, Humidity, Enthalpy	SpaceTemp SpaceHum

Point Description	Point Name
	SPEnth
Speed	RPM
Status, Alarm or Failure	Alarm
Status, Occupied/Unoccupied	Occ or Unocc
Status, On/Off	On or Off
Status, Open/Closed	Open or Closed
Supply Air Temperature	SATemp

b. Where a required point name abbreviation or identifier is not readily show within the Contract Documents, the Contractor shall submit a Request for Information to the A/E.

c. Object/point descriptions used for applications such as graphics, reports, alarms, etc. shall be same as the object/point name as specified above.

d. Engineering units shall be the English ("inch-pound") system.

2. Interactive operation and help messages.

3. Organize points into logical groups or “systems” and an information penetration scheme that provides quick and simple method for maintenance staff to determine HVAC conditions and problems at any school, as follows:

4. Fill-in-the-blanks programming.

5. On-line data file programming.

B. BACnet object and property status and control.

C. Automatic restart of field equipment on restoration of power.

D. Application editors for controllers and schedules.

2.4 JOB CONDITIONS (ENVIRONMENTAL CONDITIONS OF OPERATION)

A. LAN hardware shall be designed to operate in ambient conditions of 65 to 90 degrees F at 20 to 80 percent RH, non-condensing.

B. Digital control equipment shall comply with the following:

1. Digital control equipment shall be designed to operate in ambient conditions of 35 to 120 degrees F at a relative humidity of 0 to 95 percent non-condensing.

2. Control units as hereinafter specified shall operate properly with power fluctuations of plus 15 percent to minus 10 percent of nominal supply voltage.

C. Electric and electronic equipment shall be properly mounted and organized in a grounded and Listed NEMA 1 cabinet (panel). Cabinets or enclosures shall protect equipment from dust, liquids or accidental blows.

2.5 DIRECT DIGITAL CONTROL UNITS

A. General: Multiple digital control units (CUs), shall be provided. ***CUs shall be fully field programmable and the use of firmware-based application specific controllers (ASCs) is prohibited.*** All control functions shall be resident in the CUs, including those involved in facility-wide strategies.

1. **Exception**: When approved by NHCS for a specific application, an ASC may be utilized, provided the ASC programming, including firmware, enables the proposed ASC to fully comply with the specified I/O points and sequence of operation indicated on the Drawings.

B. Control Units: Modular, comprising processor board with programmable, non-volatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Control units shall fully comply with the system architecture and communication requirements specified hereinbefore.
2. Units shall monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
3. Stand-alone mode control functions shall operate regardless of network status. Functions include the following:

    a. Global communications.
    b. Discrete/digital, analog, and pulse I/O.
    c. Monitoring, controlling, or addressing data points.
    d. Software applications, scheduling, and alarm processing.
    e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

C. Control Modes: Control loops shall be able to utilize any of the following control modes:

1. Two position (e.g., on-off, slow-fast)
2. Proportional (P), proportional plus integral (PI), or proportional plus integral plus derivative (PID), applied as follows:

Controlled Variable	**Control Mode**
Space Temperature	P
Mixed Air Temperature	PI
Coil Discharge Temperature	PI (cooling), P (heating)
Hot Water Supply Temperature	P
Airflow	PI (with wide proportional band and fast reset rate) or PID
Fan Static Pressure	PI
Humidity	P (PI throttling range is less than 5%)
Dewpoint Temperature	P (PI throttling range is less than 2 F)

3. For any unlisted application, the control mode shall be as approved by the A-E.

D. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.

4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

E. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in over-voltage and over-current protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

F. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

G. Diagnostic Devices:

1. Each CU shall be supplied with connections to which maintenance personnel can connect a portable laptop computer for data display, setpoint modification, and reloading and modification of controller programs.
2. Provide software installed on Owner's laptop computers required to troubleshoot local HVAC equipment operation and control. It shall be possible for the user to completely operate the controller via the laptop and completely exercise all valves and dampers via the laptop, display values in complete engineering units for setting analog control values, reading digital status, setting control parameters, commanding digital loads, and setting analog alarm limits. Full read-write capability shall be provided.

H. Control Functions: All control functions shall execute within the standalone control units via DDC algorithms. The operator shall be able to customize control strategies and sequences of operations defining the appropriate control loop algorithms and choosing the optimum loop parameters. Each CU shall include the following standalone functions:

1. Direct Digital Control algorithms and control sequences are to be CU resident and be capable of standalone operation. All DDC programs shall be custom written as required to meet the performance criteria spelled out in the sequence of operation paragraphs for each controlled mechanical system. PID control mode shall be employed as appropriate to the application and per sequences or operation.
2. Enable/Disable: All CU resident DDC programs shall be capable of being enabled or disabled from any workstation. In the enable mode all DDC loops shall be active and output signals shall be routed to the final control elements. In the disable mode all DDC

loop calculations shall continue but outputs to actuators shall be suppressed. (When disabled, control outputs shall stay in the same state or position as commanded from the central or until they are manually set to automatic.)

3. Integral Windup Prevention: To eliminate integral windup, all PID programs shall automatically invoke integral windup prevention routines whenever the controlled unit is off, under manual control or under control of a system or time initiated program, or when the controlled unit is in the process or starting or stopping.

I. Default Value Operation: All CU's shall be capable of being programmed to utilize stored default values for assured fail-safe operation of critical processes. Default values shall be invoked upon sensor failure or, if the primary value is normally provided by the central or another CU, by loss of communication between CUs. Individual application software packages shall be structured to assume a fail-safe condition upon loss of input sensors. Loss of an input sensor shall result in output of a sensor-failed message at the central control and command station. Each CU shall have capability for local readouts of all functions.

2.6 APPLICATION SOFTWARE

A. Provide the following programs in addition to control algorithms defined on the drawings:

1. Optimum Start: Optimum start program shall automatically delay equipment startup based on outdoor temperature, space temperature, and system response to assure that comfort conditions are reached exactly at scheduled occupancy time. The program is to operate in both heating and cooling cycles. An adaptive algorithm is to be employed which automatically adjusts according to past experience. Algorithm shall be tested and updated every day. The program shall automatically assign longer lead times for weekend and holiday shutdowns. Space temperature input is to be the highest value of zones served in the cooling mode and the lowest of zones served in the heating mode. It shall be possible to assign occupancy start times on a per air handler unit basis. Modification of assigned occupancy start times shall be possible via the central operator's terminal.
2. Event Initiated Programs (EIP): Event initiators may be any digital data point in the system, real time values, or any analog alarm limit. The EIPs shall be structured so that one initiator may set and reset the EIP as it goes from normal to off-normal and back to normal, or one initiator may set the program and a second initiator reset the program, or reset may be manual via the console keyboard. Setting an EIP shall cause a series of start or stop commands to assigned loads to be executed to EIP's points. EIP’s shall have priority assignments to allow them to override other programs in the set mode when desired. The operator shall have read-write capability for initiator load and priority assignment.

B. Alarm Initiation and Response:

1. All AI points shall have user-defined upper and/or lower condition limits. If user-defined limits are not defined, ***default limits shall be initially set as follows***:

Space temperature	5ºF below low setpoint of comfort zone or 5ºF above high setpoint of comfort zone
Space humidity	≥70% RH
AHU mixed air low limit	≤38ºF
Cooling coil leaving air	≥60ºF
Heating coil leaving air	≤90ºF
CHW supply	≥48ºF

HW supply	≤120ºF
Low pressure steam supply	5 psig below setpoint
High pressure steam supply	15 psig below setpoint

2. Monitor and display "status" (on/off, high/low, open/closed, etc.) of each DI point. Motor on/off status shall be indicated by current sensing relays with field-adjustable trigger point to provide DI "switch", as hereinafter specified. Monitor and display "position" of an AO point (valve or damper percent open, motor speed percent of full speed, etc.)

3. An alarm shall be initiated whenever any of the following conditions occur:

   a. Any AI point high or low limit alarm setpoint is exceeded.
   b. Any DI status condition does not correspond to the DDC command condition (i.e., damper is closed when occupied/unoccupied schedule requires damper to be open, motor is operated in "hand" rather than "auto" mode, etc.)
   c. Any AI or DI device fails or goes "out of range".
   d. Any AO device fails to respond to DDC command condition.
   e. If any AO control loop continues to cycle its output more than 40% of its range (user adjustable) 3 or more times in any 60 minute internal.
   f. For variable air volume AHUs, if any supply fan or return/relief fan speed AO output signal remains above 95% for more than 8 hours (user adjustable) accumulated per "on" period for 3 or more consecutive "on" periods.
   g. If any AHU coil control valve(s) AO output signal remains above 95% for more than accumulated 8 hours (user adjustable) per "on" period for 3 or more consecutive "on" periods.
   h. If any humidifier valve AO output signal remains above 85% for more than accumulated 8 hours (user adjustable) per "on" period for 3 or more consecutive "on" periods.
   i. During "on" periods, if any cooling coil chilled water return temperature is greater than design for more than 4 hours during which coil chilled water supply temperature was at or below design setpoint temperature.

C. Automatic Restart Programming:

1. When a power failure is detected in any phase, the DDC system shall command all electrical equipment served by the failed power source "off".
2. If the associated CU is powered by normal or emergency power, it may monitor its own power source as an indication of power status.

   a. If the CU is powered by uninterruptible power supply (UPS), or if it is not capable of monitoring its own power for use in sequences, Contractor shall provide at least one voltage transformer (three phase when applicable) for each facility for the DDC system to monitor for power status.

3. When the DDC system detects normal or emergency power has been restored to the failed power source, all equipment served by that source that was commanded "off" shall be automatically restarted. Restart shall be sequenced by the CU network restart program with a 5 second interval between starts to minimize inrush current.

D. Air Flow and Pressure Control:

1. Air flow and static pressure shall be controlled via CUs with inputs from air flow control measuring stations and static pressure inputs as specified in Section 230913. Controller

outputs shall be true analog output signals. Pulse width modulation outputs are not acceptable. The airflow control programs shall be standard factory tested programs that are documented in the literature of the control manufacturer.

2. Duct Static Pressure Control: Systems shall consist of one or more static pressure sensors as specified in Section 230913 and transmitters, along with relays or auxiliary devices as required to produce a complete functional system. The span of the transmitter shall not exceed two times the design static pressure at the point of measurement. The output of the transmitter shall be true representation of the input pressure with plus or minus 0.1-inch wg of the true input pressure.

    a. For systems with multiple major "trunk" supply ducts, furnish a static pressure transmitter for each trunk duct. The transmitter signal representing the lowest static pressure shall be selected as the input signal to the CU.
    b. The CU shall receive the static pressure transmitter signal and shall provide a control output signal to the supply fan capacity control device using control modes hereinbefore specified.

E. Additional application control requirements shall be met as required by the DDC control logic diagrams on the Drawings.

2.7 CABLING AND WIRING

A. DDC Cabling: Cabling between buildings shall be fiber optic. Network cabling within buildings shall be shielded twisted pair or fiber optic. Cabling or wiring between control units and I/O point devices shall be as follows:

Application	**Cable/Wire Type and Min. Gauge (AWG)**
Digital Input Wiring	24 gauge, twisted pair
Analog Input Wiring	24 gauge, shielded twisted pair
Digital Output Wiring	24 gauge stranded for 24V 18 gauge stranded for 120V
Analog Output Wiring	24 gauge, twisted pair

B. Data Cable:

1. Twisted shielded cables shall have FFEP insulation in thermoplastic jacket, with #24 AWG stranded conductors, minimum. Shield shall be tinned, soft-copper strands formed into a braid or equivalent foil. Shielding coverage on conductors shall not be less than 100 percent.
2. Multimode fiber optic cables shall be 62.5/125 micron Class Ia Graded Index Multimode Optical Fiber**,** OFNR, OFNP, Outdoor or Indoor / Outdoor (I/O) NEC Rating, FDDI Compliant.

    a. Coating Diameter: 250 Microns
    b. Core Eccentricity: 7.5% maximum (1.5% typical)
    c. Numerical aperture: .275 plus or minus .015
    d. Attenuation: 3.5 dB/km @ 850 NM / 1.50 dB/km @ 1300 NM
    e. Bandwidth: 160 MHz at 850 NM / 500 MHz @ 1300 NM
    f. Fiber connectors: ST .75 dB maximum insertion loss
    g. Cable bend radius: 10 times diameter

3. Single mode fiber optic cables shall be 8.3/125 micron Class IVa Dispersion-Unshifted Single-mode Optical Fiber, OFNR, OFNP, Outdoor or Indoor / Outdoor (I/O) NEC Rating, FDDI Compliant.

    a. Coating Diameter: 250 Microns
    b. Core Eccentricity: 7.5% maximum (1.5% typical)
    c. Attenuation: 0.5 dB/km @ 1310 NM/1550 NM
    d. Zero dispersion wavelength 1300 -1320 NM
    e. Cable bend radius: 10 times diameter

C. Control and Interlock Wiring: All 24V-120V control and interlock wiring shall comply with the following:

1. Conductors:

    a. All wire and conducting components shall be THWN stranded copper.
    b. Conductors shall be continuous from device to device and no splices shall be made except within device or junction boxes. ***Wire nuts and crimp slices are prohibited.*** Junction boxes may be utilized where required.
    c. Control wiring shall be color-coded in accordance with reviewed submittals.
    d. Where conductors pass through a junction box or connect to a device, the conductor and the box shall be tagged to indicate the circuit and/or terminal number shown on the submittal drawings.

2. Raceway: Provide electrical metallic tubing (EMT), minimum 3/4" size. Fittings shall be steel insulated throat compression type. ***Set screw fittings, fittings constructed of alloys of aluminium or fittings of the indenter type are prohibited.*** Flexible metallic raceway may be utilized for the last 24" up to the connection point for devices, sensors, etc.
3. Routing of Raceway: Exposed raceway shall line up work true to adjacent surfaces and be placed in a workmanlike manner. Raceway shall be run at right angles to building lines; this requirement does not apply to raceway located below concrete placed as a part of this project. Raceway shall be sturdily supported and separated in a manner satisfactory to the A/E; raceway shall not be supported by the ceiling grid or ceiling grid support wires. In general, all raceway is to be concealed and routed overhead, below the floor, or in walls except in electrical or mechanical equipment rooms. Raceway in such rooms may be surface mounted.
4. Device Boxes: Device boxes for use in sheetrock or paneled surfaces shall be of galvanized steel, 4 inches square of a depth necessary to contain the intended device(s) and associated conductors. Boxes shall be sized to have no less than the minimum volume as required by the NEC. Boxes must be flush mounted and accommodate device(s) and all wires and connections without crowding. Boxes shall be furnished with a suitable plaster ring of the depth required to match the wall (or ceiling) material. Where the surface material or covering is combustible the front edge of the plaster ring shall be absolutely flush with the surface. Where the wall material is non-combustible, the front of the plaster must be recessed into the wall no further than 3/16 inch. Device boxes for flush mounted use in masonry walls shall be of the concrete tight masonry type sized for the number of device(s) and conductors. In locations where surface mounting of device boxes is permitted on masonry walls, provide 1/2 inch raised cover and suitable plaster ring.
5. Junction Boxes: Junction boxes shall be of galvanized steel of size, type, and shape for intended use and having adequate volume as required by NEC. All junction boxes shall

be concealed unless specifically permitted elsewhere in these Specifications or on the Drawings. Boxes must be supported from the building structure without dependence on support of conduit, fixture support wires, ceiling support wires, or similar items.

6. Device and/or Junction Box Wall Penetrations: All wall penetrations at device or equipment locations must be protected in such a manner that the fire rating of the wall is maintained. ***It is the responsibility of the Contractor to assure that fire and smoke integrity of all walls is maintained at all penetration points***.

PART 3 - EXECUTION

3.1 EXISTING DDC SYSTEM/COMPONENTS DEMOLITION

A. Where an existing DDC system is required to be removed to provide for installation of a new DDC system, careful attention to demolition and salvage is required. **Four** of each type of existing DDC components, including but not limited to controllers, sensors, valve and damper operators, etc. ***shall be removed without damage and turned over to the Owner***.

B. Thermostats and sensors containing mercury shall be disposed in accordance with EPA Resource Conservation and Recovery Act (RCRA). Contractor shall refer to EPA web site for handling procedures for disposal and spill management of projects containing mercury.

C. Remove all abandoned wiring, raceway, and any related items, both exposed and concealed. Where existing raceway is concealed in concrete or masonry, remove wiring as required above and abandon in place. Cut abandoned raceway off ½" into wall, ceiling, or floor to allow patching to completely cover cut off end of raceway.

D. Repair surfaces and finishes to match existing surrounding surfaces or finish in all areas where items are removed. After repairs are made no evidence of previous use of surfaces shall be visible.

E. Provide touch-up painting as required where new items are installed adjacent to existing items to remain.

1. Clean new, damaged, and/or disturbed areas and apply primer, intermediate, and finish coats at each location.
2. Surface preparation and timing of application of successive coats of paint shall be in accordance with paint manufacturer's instructions.
3. Use zinc-rich paint to repair damage to galvanized finishes. Follow written instructions of paint manufacturer.
4. Repair paint finishes for other items, surfaces, or equipment as necessary. Follow written instructions of paint manufacturer.

F. Provide blank cover plates to match device plates used in the adjoining areas where outlet, device, junction, or other boxes are to remain,

3.2 INTERFACE WITH OEM CONTROLLERS

A. Section 230924 addresses specific requirements for equipment or subsystem original equipment manufacturer (OEM) controllers that must interface with a facility DDC system. The OEM is responsible for coordination between the DDC system sub-contractor and OEM unit controls

provided to ensure that required control interface is implemented, resulting in full interoperability between OEM unit controls and the DDC system.

3.3 INSTALLATION

A. Provide skilled technicians, properly trained and qualified for the work and directed by experienced engineers.

B. Except for short apparatus connections, run raceway parallel to or at right angles to the building structure. Conceal raceway and tubing in finished spaces. Do not run raceway concealed under insulation or inside ducts. Mount control devices, tubing and raceway located on ducts or apparatus with external insulation on standoff supports to avoid interference with insulation.

C. Run wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing. Rack connections bridging a cabinet door along the hinge side and protect from damage. Provide grommets, sleeves or vinyl tape to protect plastic tubing or wires from sharp edges of panels, raceway, and other items.

D. Cabling and Wiring Installation:

1. All control cabling and interlock wiring shall be installed in raceway.
    a. Exception: Where Class 2 wiring is located in concealed and accessible locations, including supply or return air plenums, plenum-rated cables complying with NFPA 262 may be installed without raceway, provided that:
2. Circuits meet NFPA 70 Class 2 (current-limited) requirements.
3. All cables shall be UL-listed for the application.
4. **Do not install Class 2 wiring in raceway containing Class 1 wiring.** Boxes and panels containing high voltage (120 V+) may not be used for low voltage wiring except for the purpose of interfacing the two via relays, transformers, etc.
5. Shielded, twisted pair cable shielding shall be grounded at each connection point.
6. Fiber Optic Cable:
    a. Route all interior cables in raceway within walls and inaccessible ceiling spaces.
    b. Use nylon bushings at top of conduit where stubbed in accessible ceiling spaces.
    c. Support all cables using J type hooks where open cable is permitted.
    d. Route all fiber optic cable in raceway with innerducts. The innerducts shall contain a pull string, if no fiber is pulled at the time of the installation of the duct.
    e. All conduit where fiber optic cable is installed shall be sized to maintain the manufacturer's recommended bend radius of fiber optic cables. As a minimum, conduit shall be provided with long radius elbows.
    f. All cables shall be terminated using appropriate termination equipment.
    g. Fiber Termination Panels: Provide a rack mountable, modular cabinet capable of terminating up to 24 type ST multimode fiber cables. Panels shall be as manufactured by Ortronics, Amp, Siecor, or Superior.
    h. Fiber Optic Testing: Upon completion of the passive optical cable system, the system must be tested to ensure compliance with the design and link loss specifications. The tests include:
        1) Power Meter Tests: For building risers, power meter tests are required.
        2) End-to-End Attenuation Testing: Tests shall be completed on each fiber span at both operational wavelengths:

a) 850/1310 nm multimode
b) 1550 nm single mode

3) Testing in one direction is required. Link attenuation does not include any active devices or passive devices other than cable, connectors and splices (e.g., link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers. Test results should be retained for inclusion into the documentation package.
4) Connector loss readings of each completed connector should be recorded using an OTDR at 850 and 1310 nm in one direction.
5) Optical time domain reflectometer (OTDR) signature traces of each terminated fiber should be recorded at 850 nm and 1310 nm for fiber continuity purposes. OTDR testing is mandatory for runs longer than 2 km.
6) Final report shall be compiled which records system configuration, fiber labels, cable routes and "as built" details. Loss measurements with calibrated light source and power meter shall be included. OTDR traces shall also be included when requested in advance.

E. Smoke detectors and/or fan shutdown relays initiated by a fire alarm system shall be integrated into the control system and sequence of operation as indicated and/or required.

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports after completion of DDC system installation:

1. After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.

B. Test and adjust controls and safeties.

1. Test calibration of control units by disconnecting input sensors and stimulating operation with compatible signal generator.
2. Test each control point through its full operating range to verify that safety and operating control set points are as required.
3. Test each control loop to verify stable mode of operation and compliance with sequence of operation.
4. Test each system for compliance with sequence of operation.
5. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check temperature instruments and material and length of sensing elements.
8. Check control valves. Verify that they are installed for flow(s) in the correct direction(s).
9. Check DDC system as follows:

a. Verify that DDC controller power supply is from emergency power supply, if applicable.
b. Verify that wires at control panels are tagged with their service designation and approved tagging system.

10. Verify that spare I/O capacity has been provided.

a. Verify that DDC controllers are protected from power supply surges.

11. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 CALIBRATION AND ADJUSTMENT

A. General:

1. Make two-point calibration test for both linearity and accuracy for each analog instrument.
2. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

B. Control System Inputs and Outputs:

1. Check analog inputs at 50 and 100 percent of span.
2. Check analog outputs using milliampere meter at 50 and 100 percent output.
3. Check digital inputs using jumper wire.

C. Check digital outputs using ohmmeter to test for contact making or breaking.

1. Check resistance temperature inputs at 0 and 100 percent of span using a precision-resistant source.

D. Flow:

1. Set differential pressure flow transmitters for 0 and 100 percent of span.
2. Manually operate flow switches to verify that they make or break contact.

E. Pressure:

1. Calibrate pressure transmitters at 0 and 100 percent of span.
2. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

F. Temperature:

1. Calibrate resistance temperature transmitters at 0 and 100 percent of span using a precision-resistance source.
2. Calibrate temperature switches to make or break contacts.

G. Stroke of valves and dampers: Follow the manufacturer's recommended procedure, so that valve or damper is 0 and 100 percent closed.

H. Provide diagnostic and test instruments for calibration and adjustment of system.

I. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

J. Adjust initial pressure, temperature, humidity, etc. setpoints in coordination with TAB sub-contractor.

3.6 HVAC SYSTEMS OPERATION VERIFICATION

A. After installation, calibration, and adjustment of DDC system, the DDC system vendor shall verify the performance of the DDC as follows:

1. Verify Gas Sensor Accuracy: Select 100% of the installed gas concentration sensors for testing:

a. Carbon Dioxide (CO_2): Prior to placing the DDC system in operation, sensors shall be tested and recalibrated as needed in accordance with the manufacturer's written procedures. Calibration shall use a minimum of two calibration gas samples, one a 950-1050 ppm and one at either 0 ppm or 450-550 ppm, with the concentration of the calibration gas known within +/- 2%. *Sensors that cannot be calibrated to within +/- 60 ppm of calibration gas CO_2 concentrations at each test point shall be replaced*. The replacement sensor shall then be calibrated. Provide sensor test/calibration reports for review by the A/E.

b. Refrigerant: Test sensor calibration factor using a diluted sample of refrigerant gas at or near sensor full scale concentration level in strict accordance with the manufacturer's calibration procedure. Re-calibrate or replace sensor if calibration factor cannot be maintained within the range of 0.95-1.05. Provide sensor test/calibration reports for review by the A/E.

2. Verify Non-Gas Sensor Accuracy: Select at least 10% of the installed temperature, humidity, pressure, airflow, etc. sensors, including at least one of each sensor type, for testing. If calibration of 10% or more of this sample is found to be incorrect, select an additional 10% of the installed sensors for testing. **If calibration of 10% or more of this second sample is found to be incorrect, test/calibrate all sensors**.

a. Sensor calibrating instruments shall be used in checkout of the overall performance. The sensors of these instruments shall be placed at the proximity of DDC system sensors to indicate the conditions of the controlled media (air, water, etc.). A preliminary evaluation shall be made as to the suitability of having the DDC system sensors checked in-place or they may be placed in simulated environment. If the response times of the two sensors (DDC system sensor and calibration sensor) are similar, testing may be performed with the sensors in place. If the conditions of the controlled media change slowly, testing may also be performed with the sensors in place. However, if the conditions of the controlled media change rapidly and the time responses of the two sensors vary considerably, testing shall be done with the sensors placed in a known environment such as a temperature bath.

b. Verification procedures: Verification of sensor accuracy shall be made using the following procedures. Compare readings for each sensor from the calibration instrument and the DDC system to determine if the measurement accuracy meets the requirements of Section 230913.

1) Temperature: Use a multi-point verification check at various points in the operating range (including minimum, typical, and maximum), utilizing a

calibrated thermometer and Dewar flask or a calibrated portable drywell (±0.5ºF) temperature probe calibrator.

2) Relative Humidity: Use a single point calibrator or portable environmental chamber that has been lab calibrated with a NIST traceable dew point monitor (±3% RH).
3) Fluid Flow: Use a portable ultrasonic flow meter (UFM) to spot check flows. The meter's flow profile compensation shall be turned off and the acceptable deviation between the measuring flow meter and the UFM be restricted to ±5% for applications with less than 10 pipe diameters of straight length pipe upstream of the UFM. If variable flow conditions exist, both the flow and the flow profile will need to be evaluated at a range of conditions. See ASHRAE Standard 150, Annex D, for a detailed method.
4) Air Flow: Utilize calibrated pitot tube or propeller anemometer traverses in at least two planes upstream of the air flow monitoring station. For VAV systems, test airflows over a range of at least five flow rates between 20% and 100% of design flow.
5) Pressure: Use a multi-point verification check at various points in the operating range (including minimum, typical, and maximum) with a calibrated dead weight tester or an electronic pressure calibrator for ranges above atmosphere, or an accurate digital pressure gage for ranges below atmosphere.
6) Differential pressure: Use a dead weight tester or electronic calibrator or a Magnehelic gauge with a pressure bulb to their high-pressure side to apply a known pressure at various points in the operating range (including minimum, typical, and maximum).
7) Very Low Differential Pressure: Use a micromanometer or digital manometer of narrow range to spot check pressures at various points in the operating range (including minimum, typical, and maximum). The manometer must be zeroed. A hand pump/bleed valve set-up can be used to apply the small pressures required to the high sides. The manometer is adjusted and the instrument readings are compared at the high and low point. The temperature of the manometer fluid should be used to adjust its readings to the standard temperature conditions of the transmitter.

3. Verify Final Control Element Functionality: Test each final control element operator to ensure performance in accordance with Section 230913 and the control sequences defined on the Drawings. Test shall include full range of movement, stability through that range, and power and/or control signal failure performance. Operators found to be non-functional in any way shall be replaced.
4. Verify Operator And System Functionality:

    a. In support of System Integrator, verify DDC system command software by issuing commands at the operator’s console and via browser interface and observing display, printer output, or HVAC equipment responses. The following software operation shall be verified:

        1) Software for checking input commands and issuing error messages. Enter various correct and incorrect commands.
        2) System and point addressing check. Enter command to display I/O data. Verify all data points defined on the drawings and/or required by the specifications.

3) Start-stop or enable-disable of HVAC equipment or DDC system control points. Enter commands to start/stop selected HVAC equipment, and to disable and enable selected points.
4) Operator override/automatic mode. Enter command to change selected automatic control under DDC system to manual and vice versa.
5) Display format. Enter commands to display data and graphics on terminal and graphic display. Check display content for adequacy and clarity as specified.
6) Ability to modify, cancel and confirm operator's commands. Verify by entering commands.
7) Set-point adjustment and limiting. Enter commands to adjust set points of controllers and range limits of the controlled media. Verify by display. Also enter commands to adjust set-points outside their range limits. DDC system shall display error messages.
8) System access and access level control. Try to log on to system with both incorrect and correct ID codes. Try to enter different commands with different access level of the operators. The responses of the DDC system shall be as specified.
9) Start/stop equipment. Enter command to start or stop selected equipment. Also reset time to initiate automatic mode. Verify responses by observation of equipment and DDC system display.
10) Change parameter of points. Enter commands to change parameters of selected points such as high and low limit alarms, scale factor, etc. to test the adequacy of software.

b. In support of System Integrator, verify graphic display of each HVAC system and component. Confirm that the graphic is in accordance with the design data and reviewed submittals, includes all data points required, displayed data is correct and in the correct format and units, and changes in point conditions or status are accurately updated. Evaluate the refresh rate of data display.

c. In support of System Integrator, verify report generation (status, profile, energy, etc.) by entering commands to generate reports such as all points, trend, total display of a system, timed display, and other specified reports. Examine the report content for general format, system/point code, time interval of reporting, point status/value/unit, energy amount/rate/unit, status of control and set time (manual or automatic), and other specification required information.

1) Check for proper operation of system status reports, including point status reviews which would include information such as points currently in alarm, points removed from alarm checking, points off of scan, etc.
2) Test alarm reporting by initiating alarm conditions of different points at different alarm levels in sequence to examine alarm reports. The reports shall show alarm location and device, alarm time, cause of alarm, current status of the point, etc. as required in the specifications. When alarm conditions are removed the printer shall print updated status report. Also verify audible alarm operations in accordance with specification requirements. Then initiate alarm conditions at different levels at the same time to check alarm priority.

d. Trending performance shall be tested by creating trend logs for each control sequence and monitoring the trend reports throughout the period that each control sequence is tested.

5. Test Control Sequences: The test procedures described below do not check the details of the software, rather, they try to verify the final output as indicated by the field equipment. Before testing ,each program the required input and output of the program and those listed in the contract specifications shall be compared to make sure that the program covers the specified operations. Verification of HVAC equipment operation (such as equipment status or temperature of space air) may be done by either (1) actual observation of equipment status and test instruments, or (2) obtaining DDC system reports if the accuracy of these reports has been verified previously.

    a. Basic Functional Tests: Through the user interface conduct the following series of tests:

        1) Raise/lower space temperature setpoints in software to verify if the system responds in accordance with design requirements.
        2) Raise/lower AHU discharge temperature setpoints and verify control valve and damper positions.
        3) Raise/lower static pressure setpoints and verify variable speed drive or vortex damper control.
        4) Initiate a high priority, off-hours alarm and verify that the remote notification procedures are carried out correctly.
        5) Verify that the interface with system safeties allow operation of dampers, etc., if safety conditions are met.
        6) Conduct an emergency start-up after power failure test. Verify that all systems return to automatic control.
        7) Verify DDC system maintains required outside air requirements under low airflow conditions.
        8) Disconnect communication cable to the DDC system and verify if the DDC panel can control the respective system (stand-alone control).
        9) Disconnect a sample of DDC space-temperature sensors and verify control sequence default.

    b. Test HVAC Systems Sequences of Operation: Through the user interface very control of HVAC systems as follows:

        1) Scheduled on/off and occupied/unoccupied control. Verify that input includes start/stop times and days for specified equipment. As applicable, verify that input includes occupied/unoccupied times and days. Verify input for time delays of specified equipment. Check holiday/vacation effect. Log operations for at least three days to confirm that systems and components start and stop in accordance with defined schedules.
        2) Optimum start-stop control. Verify that the required input includes space temperature, outdoor temperature, occupied time and days of the week, and the response time of the air handling equipment, on an individual system by system basis. For each air handler, log space temperature for at least three days to confirm that space is at required temperature by the start of the occupied period.
        3) Occupied-Unoccupied control. Confirm that required input data is provided. To test control, change the setback time from occupied to unoccupied time and confirm that HVAC systems respond to the setback mode. If system is an air-handling system, the outside air damper should close and the fan should cycle to maintain the setback temperature setpoint.

a) Change the setback temperature setpoint to 5°F higher than the actual space temperature. The system should operate to increase the space temperature to the new setpoint condition. For air-handlers, the outside air damper should remain closed.

4) Economizer cycle control: If the outdoor air temperature is above the discharge air temperature setpoint, but below the defined 100% outdoor air changeover temperature setpoint, verify that the outside air damper is fully open, the return air damper is fully closed, and that the air-handler discharge air temperature is maintained by modulation of the chilled water control valve.
5) Heating/cooling coil discharge temperature reset: Verify that the required input points are provided and that the coil discharge air temperature setpoint is in accordance with the input conditions and the sequence of operation defined on the control drawings.
6) Hot water temperature reset: Verify that the required input points are provided and that the heat exchanger supply hot water temperature setpoint is in accordance with the input conditions and the sequence of operation defined on the control drawings.
7) Chilled water temperature reset: Verify that the required input points are provided and that the chilled water supply temperature setpoint is in accordance with the input conditions and the sequence of operation defined on the control drawings.
8) Water source heat pump loop temperature control: Verify that the required input points are provided and that the loop water supply temperature setpoints are in accordance with the input conditions and the sequence of operation defined on the control drawings.

3.7 OWNER INSTRUCTION AND TRAINING

A. General: The Contractor is responsible for instructing Owner's personnel, including the following:

1. Instruction in the operation of HVAC systems, subsystems, and equipment via new DDC system
2. Training in operation, maintenance, and trouble-shooting of new DDC system.

B. Program Structure: Develop an instruction and training program that includes both classroom instruction and "hands-on" demonstrations.

C. Training Modules: Develop a learning objective and teaching outline for each instruction and training module, taking into consideration the level of proficiency of Owner's maintenance staff. Include a description of specific skills and knowledge that each participant is expected to master.

1. **Exception**: Training is required to be accomplished onsite. However, at the option of NHCS, some of or all the training required below may be accomplished for selected NHCS personnel at the DDC system vendor’s offsite training facility. The cost for offsite training shall be the responsibility of NHCS.
2. For each instruction and training module, include instruction for the following, as applicable to the system, subsystem, equipment, or component:

a. Documentation: Review the following items in detail:

1) Operations manuals.
2) Maintenance manuals.
3) Project record documents.
4) Warranties, bonds, and guarantees.
5) Maintenance service agreements and similar continuing commitments.

b. Emergencies: Include the following, as applicable:

1) Instructions on meaning of warnings, trouble indications, and error messages.
2) Shutdown instructions for each type of emergency.
3) Operating instructions for conditions outside of normal operating limits.
4) Sequences for DDC system.
5) Special operating instructions and procedures.

c. Operations: Include the following, as applicable:

1) Start-up procedures.
2) Equipment or system break-in procedures.
3) Routine and normal operating instructions.
4) Regulation and control procedures.

d. Control sequences:

1) Safety procedures.
2) Normal start-up and shutdown instructions.
3) Operating procedures for emergencies.
4) Operating procedures for system, subsystem, or equipment failure.
5) Required sequences for electric or electronic control systems.
6) Special operating instructions and procedures.

e. Adjustments: Include the following:

1) Alignments.
2) Routine adjustments, tightening, etc.
3) Noise and vibration adjustments.
4) Economy and efficiency adjustments.

f. Maintenance and Repairs: Demonstrate the following:

1) Inspection procedures.
2) Troubleshooting and diagnostic instructions.
3) Test and inspection procedures.
4) Repair instructions.
5) Disassembly; component removal, repair, and replacement; and reassembly instructions.
6) Review of spare parts needed for operation and maintenance.

D. Training Execution:

1. Owner will furnish an instructor to describe Owner's operational philosophy.
2. Owner will furnish Contractor with names and positions of participants to attend instruction and training, not to exceed 10 individuals.
3. Provide instruction at mutually agreed on times scheduled at least four (4) weeks in advance through the A/E. For systems, subsystem, and/or equipment that requires seasonal operation, provide required instruction at start of each season.

4. Conduct training on-site in the completed and fully operational facility in classroom/conference space provided by the Owner and using the actual systems, subsystems, and equipment installed.
5. Conduct training using final operation and maintenance data submittals as the training reference material. If additional training materials are utilized, they shall be incorporated as an appendix to the operation and maintenance data submittals.
6. Provide documentation that Owner instruction and training has taken place. Provide record of dates, topics, and duration of each training session, the names of Owner's staff who participated, and a signed review form by each participant.

END OF SECTION 230923

SECTION 231123 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping joining materials.
4. Manual gas shutoff valves.
5. Motorized gas valves.

1.2 ACTION SUBMITTALS

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

B. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

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

B. Natural-Gas System Pressure within Buildings: 0.5 psig or less.

C. Seismic Performance: Natural-gas piping system is to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

2.2 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.

2.3 PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

2.4 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

2.5 MANUAL GAS SHUTOFF VALVES

A. General Requirements for Metallic Valves: Comply with ASME B16.33.

1. CWP Rating: 125 psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Tamperproof Feature: Locking feature for valves indicated in "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
5. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

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

1. Body: Bronze, complying with ASTM B584.
2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.

5. Packing: Threaded-body packnut design with adjustable-stem packing.
6. Ends: Threaded.
7. CWP Rating: 600 psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.6 MOTORIZED GAS VALVES

A. Electrically Operated Valves: Comply with UL 429.

1. Pilot operated.
2. Body: Brass or aluminum.
3. Seats and Disc: Nitrile rubber.
4. Springs and Valve Trim: Stainless steel.
5. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
6. NEMA ICS 6, Type 4, coil enclosure.
7. Normally closed.
8. Visual position indicator.

PART 3 - EXECUTION

3.1 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

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

C. 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. Locate valves for easy access.

E. Install piping free of sags and bends.

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

G. Verify final equipment locations for roughing-in.

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

I. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

J. Extend relief vent connections for line regulators to outdoors and terminate with weatherproof vent cap.

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

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

M. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment.

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

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

3.2 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance.

B. Install regulators with maintenance access space adequate for servicing and testing.

3.3 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

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

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration

B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

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

3.5 CONNECTIONS

A. Install piping adjacent to appliances to allow service and maintenance of appliances.

B. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

C. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.6 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.7 FIELD QUALITY CONTROL

A. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.

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

C. Prepare test and inspection reports.

3.8 INDOOR PIPING SCHEDULE

A. Aboveground piping: Steel pipe with malleable-iron fittings and threaded joints.

3.9 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves: Two-piece, full-port, bronze ball valves with bronze trim

END OF SECTION 231123

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:

1. Hydronic specialty valves.
2. Air-control devices.
3. Strainers.
4. Connectors.

B. Related Requirements:

1. Section 230523.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
2. Section 230523.14 "Check Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.4 CLOSEOUT SUBMITTALS

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

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

B. 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 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
2. Ball: Brass or stainless steel.
3. Plug: Resin.
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. Automatic Flow-Control Valves:

1. Body: Brass or ferrous metal.
2. Flow Control Assembly, provide either of the following:

    a. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
    b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psig differential pressure.

3. Combination Assemblies: Include bronze or brass-alloy ball valve.
4. Identification Tag: Marked with zone identification, valve number, and flow rate.
5. Size: Same as pipe in which installed.
6. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
7. Minimum CWP Rating: 175 psig.
8. Maximum Operating Temperature: 200 deg F.

2.2 AIR-CONTROL DEVICES

A. 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.

B. Diaphragm-Type ASME Expansion Tanks:

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: 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.

C. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. 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.

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 60-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig.

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.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

C. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

D. Install expansion tanks where indicated on plans.

1. 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.

    a. Install tank fittings that are shipped loose.
    b. 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.

2. 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.

END OF SECTION 232116

SECTION 232213 - STEAM AND CONDENSATE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel pipe and fittings.
2. Joining materials.

B. Related Requirements:

1. Section 232216 "Steam and Condensate Heating Piping Specialties" for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Welding certificates.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

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

B. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: 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. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
   1. LP Steam and Condensate Piping: less than 15 psig.
   2. Makeup-Water Piping: 80 psig and 150°F.
   3. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in piping applications articles.

C. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in piping applications articles.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in piping applications articles.

E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A234/A234M, wall thickness to match adjoining pipe.

G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

   1. Material Group: 1.1.
   2. End Connections: Butt welding.
   3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.3 JOINING MATERIALS

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

   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless otherwise indicated.

      a. Full-Face Type: For flat-face flanges.
      b. Narrow-Face Type: For raised-face flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel of type to match pipe unless otherwise indicated.

C. 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.

D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

A. Steam Piping, NPS 2 and Smaller: Schedule 40 steel pipe, with threaded joints using Class 125 cast-iron fittings.

B. Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40 steel pipe, with welded joints using Schedule 40 wrought-steel welding fittings and Class 150 wrought-steel flanges.

C. Condensate Piping, NPS 2 and Smaller: Schedule 80 steel pipe, with threaded joints using Class 125 malleable-iron fittings.

D. Condensate Piping, NPS 2-1/2 through NPS 12: Schedule 80 steel pipe, with welded joints using Schedule 80 wrought-steel welding fittings and Class 150 wrought-steel flanges.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:

1. Shutoff Duty: Gate and ball valves.
2. Throttling Duty: Globe and ball valves.

3.3 ANCILLARY PIPING APPLICATIONS

A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

B. Vacuum-Breaker Piping: Outlet, same as service where installed.

C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.4 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

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

H. Install piping to allow application of insulation.

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

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS 3/4 port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

R. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

S. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 ft.
2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.

3.5 INSTALLATION OF STEAM AND CONDENSATE PIPING SPECIALTIES

A. Comply with requirements in Section 232216 "Steam and Condensate Heating Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for installation of hangers, supports, and anchor devices.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 ft. long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 ft. or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 ft. or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

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

D. Install hangers for fiberglass piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support horizontal piping within 12 in. of each fitting.

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

G. Support vertical runs of fiberglass piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 PIPE JOINT CONSTRUCTION

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

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

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

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

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

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

3.8 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.9, "Building Services Piping," and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Prepare test and inspection reports.

END OF SECTION 232213

SECTION 235223 - CAST-IRON BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes field-assembled, gas-fired, cast-iron boilers, trim, and accessories for generating steam.

1.3 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other Work.
   1. Wiring Diagrams: Detail power, signal, and control wiring.

C. Source quality-control test reports.

D. Startup service reports.

E. Operation and Maintenance Data: For cast-iron boilers to include in emergency, operation, and maintenance manuals.

F. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of cast-iron boilers and are based on the specific system indicated.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. ASME Compliance: Fabricate and label cast-iron boilers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. ASHRAE/IESNA 90.1 Compliance: Cast-iron boilers shall have minimum efficiency according to Table 10-8.

E. I=B=R Compliance: Cast-iron boilers shall be tested and rated according to HI's "Testing and Rating Standard for Heating Boilers," with I=B=R emblem on a nameplate affixed to boiler.

F. UL Compliance: Test cast-iron boilers to comply with UL 795, "Commercial-Industrial Gas Heating Equipment."

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace controls and heat exchangers of cast-iron boilers that fail in materials or workmanship within specified warranty period.

B. Warranty Period for Controls: Two years from date of Substantial Completion.

C. Warranty Period for Heat Exchangers: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Weil-McLain; a United Dominion Company.
2. Peerless Heater Company (The).
3. Smith Cast Iron Boilers.

2.2 PACKAGED CAST-IRON BOILERS

A. Description: field-assembled cast-iron boiler with cast-iron sections sealed pressure-tight, and held together with tie rods; including insulated jacket and flue-gas vent connection. Ship cast-iron sections disassembled with all materials and equipment for field assembly.

B. Maximum Pressure Rating: Steam, 15 psig.

C. Boiler Characteristics and Capacities:

1. Heating Medium: Steam.
2. Maximum :Pressure 15 PSI
3. Operating Pressure: 10 PSI Max
4. Steam Flow Rate:
5. Minimum Efficiency: 82%
6. Number of Passes: One

7. Water Capacity: Refer to schedule on drawings.
8. AGA Output Capacity: Refer to schedule on drawings.

2.3 COMPONENTS

A. Cast-Iron Section Design: Wet base single pass, joined using high-temperature sealant to seal flue-gas passages not in contact with heating medium, O-ring gaskets or fiber roping, and held together with short tie rods. Drain and blowdown tappings.

1. Vertical to horizontal flue gas travel and a horizontal flue way cast into each section and back section to serve as an integral flue gas collector.
2. Crown inspection tappings with brass plugs.

B. Combustion Chamber: Ceramic fiber combustion chamber not permitted. Equipped with flame observation ports, front and back. Seal flue-gas passages between cast-iron sections with fiber rope and high-temperature sealant.

1. Combustion Chamber Access: Refractory lined, hinged, front.

C. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures and powder-coated protective finish.
2. Insulation: Minimum 1-inch.
3. Access: For cleaning between cast-iron sections

2.4 FORCED-DRAFT GAS BURNER

A. Burner: One piece cast aluminum housing, stainless-steel, flame-retention diffuser for natural gas.

1. AGA Input: Refer to schedule on drawings.
2. I=B=R Input: Refer to schedule on drawings.
3. Gas Input: Refer to schedule on drawings.

B. Blower: Forward-curved, centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.

1. Refer to Division 15 Section "Motors" for general requirements.
2. Minimum Motor Sizes: Refer to schedule on drawings.
3. RPM: 3450.
4. Electrical Characteristics: Refer to schedule on drawings.
5. Full-Load Amperes: Refer to schedule on drawings.
6. Minimum Circuit Ampacity: Refer to schedule on drawings.
7. Maximum Overcurrent Protection: Refer to schedule on drawings.

C. Gas Train: Control devices and low-high-low control sequence shall comply with requirements in IRI.

D. Pilot: Interrupted-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

2.5 STEAM BOILER TRIM

A. Pressure Controllers: Operating, firing rate, and high limit with manual reset.

B. Safety Relief Valve:

1. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

   a. Pressure Setting: 15 PSI

2. Bronze Safety Valves: Class 250, forged copper-alloy disc; fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.

   .

C. Pressure Gage: Minimum 3-1/2-inch diameter, 0- to 30-psig range.

D. Water Column: Minimum 12-inch glass gage with shutoff cocks.

E. Drain Valves: Minimum NPS 3/4 or nozzle size with hose-end connection.

1. Tappings NPS 2 and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
2. Tappings NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

2.6 BURNER OPERATING CONTROLS

A. Description: To maintain safe operating conditions, burner safety controls limit the operation of burner.

1. Low-Water Cutoff Switch: Float type shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.
2. Pilot and main flame failure.
3. High gas pressure
4. Alarm Bell: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

2.7 BOILER OPERATING CONTROLS

A. Boiler operating controls shall include the following devices and features:

1. Control Transformer: 115 V.
2. Operating Pressure Control: Factory wired and mounted to cycle burner.

3. Low-Water Cutoff and Pump Control: Cycle feedwater pump(s) for makeup water control.
4. Sequence of Operation: Electric, factory-fabricated, and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
5. Sequence of Operation: Electric, factory-fabricated, and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
6. Sequence of Operation: Electric, factory-fabricated, and 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 200 deg F; at 60 deg F outside-air temperature, set supply-water temperature at 140 deg F temperature.

    a. Include automatic, alternating-firing sequence for multiple boilers.

B. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control steam pressure set point and display boiler status and alarms.

2.8 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory fire tested with report, adjust burner to show oxygen, carbon dioxide, oxides of nitrogen, and carbon monoxide in flue gas and to achieve combustion efficiency.

B. Allow Owner access to source quality-control testing of cast-iron boilers. Notify Owner 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, 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 boiler performance, maintenance, and operations.

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

3.2 BOILER INSTALLATION

A. Install boilers level on concrete base. Concrete base is specified in Division 15 Section "Basic Mechanical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.

B. Concrete Bases: Anchor boilers to concrete base.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Vibration Isolation: Rubber pads with a minimum static deflection of 0.25 inch.

D. Install gas-fired boilers according to NFPA 54.

E. Assemble boiler sections in sequence and seal between each section.

F. Assemble and install boiler trim.

G. Install electrical devices furnished with boiler but not specified to be factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect gas piping full size to boiler gas-train inlet with union.

C. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.

D. Install piping from safety valves to nearest floor drain.

E. Connect breeching full size to boiler outlet. Refer to Division 15 Section "Breechings, Chimneys, and Stacks" for venting materials.

F. Install piping adjacent to boiler to allow service and maintenance.

G. Ground equipment according to Division 16 Section "Grounding and Bonding."

H. Connect wiring according to Division 16 Section "Conductors and Cables."

I. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to test, inspect, and adjust boiler components and equipment installation and to perform startup service.

B. Perform installation and startup checks according to manufacturer's written instructions.

C. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.

D. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.

E. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen, and carbon monoxide in flue gas and to achieve combustion efficiency.

G. Adjust initial temperature set points.

H. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

I. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

J. Prepare written report that documents testing procedures and results.

3.5 DEMONSTRATION

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

END OF SECTION 235223

SECTION 260500 - GENERAL ELECTRICAL

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The Instructions to Bidders, General Conditions of the Contract, Supplementary General Conditions and Division 1 bound herewith are a component part of this Division of the specifications and shall apply to this Division with equal force and shall be consulted in detail for instructions pertaining to the work.

B. Furnish all labor, materials and equipment and incidentals required to make ready for use complete electrical systems as shown on the Drawings and specified herein.

C. It is the intent of these Specifications that the electrical systems shall be suitable in every way for the service required. All material and all work which may be reasonably implied as being incidental to the work of this Division shall be furnished at no extra cost.

D. The work shall include, but not be limited to, furnishing, coordinating, and installing the following:

1. Electrical distribution system for power, lighting, receptacles, and miscellaneous power as shown on the contract drawings.
2. Electrical receptacle systems as shown on the contract drawings.
3. Grounding.
4. Other special requirements and/or systems where shown.

E. Each bidder (or Representative) shall, before preparing a proposal, visit all areas of the existing site. If the work includes demolition, restoration, renovation and/or addition; then existing buildings and structures should be carefully inspected. The submission of the proposal by this Bidder shall be considered evidence that the Bidder (or Representative) has visited the site and noted the locations and conditions under which the work will be performed and that the Bidder takes full responsibility for a complete knowledge of all factors governing the work.

F. All power interruptions to existing equipment shall be at the Owner’s convenience with 24 hours (minimum) notice. Each interruption shall have prior approval.

G. The work shall include complete testing of all equipment and wiring at the completion of work and making any minor correction changes or adjustments necessary for all the proper functioning of the system and equipment. All work shall be of the highest quality; substandard work will be rejected.

1.2 SUBMITTALS

A. Shop drawings shall be submitted for all equipment, apparatus, and other items as required by the Engineer. Submit under provisions of relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Submittals are required for all materials shown in the individual specifications sections.

C. Submittals are required for materials used for penetrations of rated assemblies and for seismic restraints.

D. All shop drawings and submittals shall be submitted at the same time. Partial shop drawing and submittals will be rejected and not processed. Materials, equipment, and long lead items that require special handling, if identified and requested by the contractor, will be processed separately.

E. Proposed equipment and/or materials substitutions shall be clearly indicated in shop drawings. All deviations from the specified quality, functionality, appearance or performance of the proposed equipment and/or materials shall be clearly summarized in the preface of each submittal.

F. The project shall be bid based on the equipment listed in these specifications and on the drawings. After award of the Electrical Contract the Contractor may wish to substitute equipment other than that specified, subject to approval. The Electrical Contractor shall bear the "burden of proof" for demonstrating substitute equipment equivalency and suitability.

G. The Electrical Contractor shall be required to replace installed "equivalent" equipment if the operation of this equipment does not meet the full design intent of the specified system.

H. Physical size of equipment used in the design layout are those of reputable equipment manufacturers. The Contractor is responsible for providing equipment which will fit the space provided. If the Contractor elects to use other manufacturer's equipment, any resulting conflicts with space clearance or codes shall be the responsibility of the Contractor to correct at the Contractor's expense.

I. The Contractor assumes all responsibility for providing code clearances. Submit a scale drawing of each electrical equipment room showing exact size and location of all proposed electrical equipment with code clearances and working space clearly indicated.

1.3 COORDINATION OF WORK

A. It is understood and agreed that the Contractor is, by careful examination, satisfied as to the nature and location of the work, the conformation of the ground, the character, quality and quantity of the materials to be encountered, the general and local conditions and all other matters which can and may affect the work under this contract. The Contractor shall be held responsible for visiting the site and thoroughly familiarizing himself with the existing conditions and also any contractual requirements as may be set forth in the other Divisions of these Specifications. No extras will be considered because of additional work necessitated by obvious job conditions that are not indicated on the drawings.

B. The Contractor shall compare the electrical drawings and specifications with the drawings and specifications for other trades, and shall report any discrepancies between them to the Engineer and obtain written instructions for changes necessary in the electrical work. The electrical work shall be installed in cooperation with other trades installing interrelated work. Before installation, the Contractor shall make proper provisions to avoid interferences in a manner approved by the Engineer. All changes required in the work of the Contractor caused by neglect to do so shall be made at the expense of the Contractor.

C. Location of electrical raceways, switches, panels, equipment, fixtures, etc., shall be adjusted to accommodate the work to interferences anticipated and encountered. The Contractor shall determine the exact route and location of each electrical raceway prior to make up and assembly.

1. Right of Way: Lines which pitch shall have the right of way over those which do not pitch. For example, steam, condensate and plumbing drains shall normally have right of way. Lines whose elevations cannot be changed shall have the right of way over lines whose elevations can be changed.
2. Offsets and changes in direction of electrical raceways shall be made as required to maintain proper headroom and to clear pitched lines whether or not indicated on the drawings. The Contractor shall furnish and install elbows, pull boxes, etc., as required to affect these offsets, transitions, and changes in directions. Conflicts between electrical raceways, fixtures, etc., and ductwork or piping which cannot be resolved otherwise, will be resolved by the Engineer.

D. Installation and Arrangements: The Contractor shall install all electrical work to permit removal (without damage to other parts) of any equipment requiring periodic replacement or maintenance. The Contractor shall arrange electrical raceways and equipment to permit ready access to valves, cocks, traps, starters, motors, control components, etc., and to clear the opening of swinging and overhead doors and of access panels.

1.4 EQUIPMENT AND MATERIALS (GENERAL)

A. In compliance with North Carolina General Statute 133.3, the Engineer has, wherever possible, specified the required performance and design characteristics of all materials utilized in this construction. In some cases it is impossible to specify the required performance and design characteristics and when this occurs the Engineer has specified three or more examples of equal design or equivalent design, establishing an acceptable range for items of equal or equivalent design. Cited examples are used only to denote the quality standard of product desired and do not restrict bidders to a specific brand, make, manufacturer or specific name and are used only to set forth and convey to bidders the general style, type, character and quality of product desired. Equivalent products will be acceptable.

B. Substitution of materials, items, or equipment of equal or equivalent design shall be submitted to the Engineer for approval or disapproval. Equal or equivalent shall be interpreted to mean an item of material or equipment, similar to that named and which is suitable for the same use and capable of performing the same functions as that named, the Engineer being the judge of equality.

C. The materials used in all systems shall be new, unused and as hereinafter specified and shall bear the manufacturer's name, trade name and UL label in every case where a standard has been established for the particular material. Equipment furnished under this specification shall be essentially the standard product of manufacturers regularly engaged in the production of the required type of equipment, and shall be the manufacturer's latest approved design. All materials where not specified shall be of the very best of their respective kinds. Samples of materials or manufacturer's specifications shall be submitted for approval as required by the Engineer.

D. Protection: Electrical equipment shall at all times during construction be adequately protected against damage Equipment shall be tightly covered and protected against dirt, water and chemical or mechanical injury and theft. Electrical equipment shall not be stored out-of-doors. Electrical equipment shall be stored in dry, permanent shelters. If an apparatus has been damaged, such damage shall be repaired at no additional cost. If any apparatus has been subject to possible injury by water, it shall be replaced at no additional cost to the Owner. At the completion of the work, fixtures, equipment, and materials shall be cleaned and polished thoroughly and turned over to the Owner in a condition satisfactory to the Engineer. Damage or defects, developing before acceptance of the work shall be made good at the Contractor's expense.

E. Any damage to factory applied paint finish shall be repaired using touch-up paint furnished by the equipment manufacturer. The entire damaged panel or section shall be repainted per the manufacturer's specifications, at no additional cost to the Owner.

F. Where materials such as wiring devices and plates, fire alarm equipment, paging system components, etc. are specified to match existing, provide materials to match existing equipment in finish, color, capacity, ratings, operating characteristics, performance, etc.

G. Delivery and Storage: Equipment and materials shall be delivered to the site and stored in original containers, suitably sheltered from the elements, but readily accessible for inspection by the Engineer until installed.

H. Equipment and materials of the same general type shall be of the same make throughout the work to provide uniform appearance, operation and maintenance.

I. Manufacturer's directions shall be followed completely in the delivery, storage, protection, and installation of all equipment and materials. The Contractor shall promptly notify the Engineer, in writing, of any conflicts between any requirements of the Contract Documents and the manufacturer's directions and shall obtain the Engineer's written instructions before proceeding with the work. Should the Contractor perform any work that does not comply with the manufacturer's direction or such written instructions from the Engineer, the Contractor shall bear all costs arising in correcting the deficiencies.

1.5 OPERATION AND MAINTENANCE MANUALS

A. Submit under relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. The Contractor shall provide two compilations of catalog data, bound in suitable loose leaf binders, for each manufactured item of equipment used in the electrical work. These shall be presented to the Engineer for transmittal to the Owner before the final inspection is made. Data shall include printed installation, operation and maintenance instructions for each item, indexed by product with heavy sheet dividers and tabs. All warranties shall be included with each item. Each manufacturer's name, address and telephone number shall be clearly indicated.

C. Shop drawings with Engineer's "as noted" markings are not acceptable for the above. "Approved" shop drawings are acceptable if adequate information is contained therein. Generally, shop drawings alone are not adequate.

1.6 PAINTING

A. All painting will be performed by the General Contractor for the project, unless specifically indicated otherwise.

B. The Electrical Contractor shall clean all exposed electrical work for painting. Should the Electrical Contractor delay in installing exposed conduit and outlets until the General Contractor has begun painting, the Electrical Contractor shall be required to paint all exposed electrical work at the Electrical Contractor's own expense. Such painting will be accomplished in accordance with the detailed specifications for the Project.

C. Conductors exposed in boxes and cabinets shall be protected against painting. Devices, cover plates, trims, etc., for panelboards and cabinets shall not be installed until painting has been completed.

D. The Electrical Contractor shall be responsible for touch up painting that may be required for electrical material or apparatus furnished with factory applied finish.

1.7 LOCATIONS AND MEASUREMENTS

Outlets and appliances are shown and located on the drawings as accurately as possible. All measurements shall be verified on the project and in all cases the work shall suit the surrounding trim, finishes and/or construction. The locations of outlets for special appliances shall be installed so that when extended, they are flush with the finished wall or ceiling and permit the proper installation of fixtures and/or devices. Heights of all outlets shown on the drawings are approximate only. Slight relocations of outlets, devices and equipment shall be made by the Contractor as required or as directed by the Engineer at no additional cost to the Owner.

1.8 QUALITY OF WORK

All work shall be executed as required by this specification and the accompanying drawings and shall be done by skilled mechanics, and shall present a neat, trim, and mechanical appearance when completed. All work shall be performed as required by the progress of the job.

1.9 SUPERVISION

A. The Contractor shall personally, or through an authorized and competent representative, constantly supervise the work from the beginning to completion and final acceptance. So far as possible, the Contractor shall keep the same foreman and mechanics throughout the project duration.

B. During the progress of the work, it shall be subject to inspection by representatives of the Engineer, the Owner, and local inspection authorities, at which time the Contractor shall furnish such required information and data on the project as requested.

C. The Electrical Contractor shall coordinate the electrical work with other Contractors and cooperate in the preparation and maintenance of a master schedule for the completion of the project.

1.10 CLOSING IN WORK

Work shall not be covered up or enclosed until it has been inspected, tested and approved by the authorities having jurisdiction over this work. Should any of the work be enclosed or covered up before such inspection and test, the Contractor shall uncover the work at the Contractor's expense; after it has been inspected, tested and approved, the Contractor shall restore the work to its original condition.

1.11 REFERENCE STANDARDS

A. All electrical equipment, materials, and installation shall be in accordance with the latest edition of the following codes and standards:
   1. American Association of Edison Illuminating Companies (AEIC)
   2. American National Standards Institute (ANSI)
   3. American Society for Testing and Materials (ASTM)

4. Building Officials Code Administrators (BOCA)
5. Energy Code 90.1 (ASHRAE/IES)
6. Institute of Electrical and Electronic Engineers (IEEE)
7. Insulated Cable Engineers Association (ICEA)
8. International Code Council (ICC)
9. International Conference of Building Officials (ICBO)
10. National Electrical Code (NEC) 2011 edition
11. National Electrical Contractor's Association (NECA)
12. National Electrical Installation Standards (NEIS)
13. National Electrical Manufacturer's Association (NEMA)
14. National Electrical Safety Code (NESC)
15. National Fire Protection Association (NFPA)
16. North Carolina State Building Code (NCSBC)
17. North Carolina Construction Manual with GS as listed (NCCM)
18. Occupational Safety and Health Act (OSHA)
19. Requirements of the Americans with Disabilities Act (ADA), latest edition.
20. Underwriters Laboratories Inc (UL)
21. Southern Building Code Congress International (SBCCI)
22. Toxicity Characteristics Leaching Procedure (TCLP)
23. North Carolina Energy Conservation Code

B. All electrical equipment and material shall be listed by Underwriters Laboratories, Inc., and shall bear the appropriate U.L. listing mark or classification marking. Equipment, materials, etc. utilized not bearing a U.L. certification shall be field or factory U.L. certified prior to equipment acceptance and use.

C. Where reference is made to one of the above standards, the revision in effect at the time of the bid opening shall apply.

1.12 ENCLOSURE TYPES

Unless otherwise specified herein or shown on the Drawings, electrical enclosures shall have the following ratings:

1. NEMA 1 for dry, indoor locations.
2. NEMA 3R for outdoor locations, rooms below grade (including basements and buried vaults), "DAMP" and "WET" locations.
3. NEMA 4X for locations subject to corrosion when specifically noted.

1.13 CORROSION PROTECTION

All equipment and hardware subject to exposure to the elements and/or not installed in a conditioned space shall be fabricated of non-metallic materials, hot dip galvanized after fabrication or stainless steel. The requirements of preceding section entitled "Delivery and Storage" shall be strictly followed. Touch up any scratched metallic surfaces immediately to prevent corrosion. Apply cold galvanizing compound to all galvanized surfaces damaged during installation, i.e., cutting, etc. Ferrous, rusted or corroded materials shall be replaced before final acceptance of the work.

1.14 CODES, INSPECTION AND FEES

A. All equipment, materials and installation shall be in accordance with the requirements of the local authority having jurisdiction.

B. The Electrical Contractor shall obtain all necessary permits and pay all fees required for permits and inspections of electrical work.

C. The Electrical Contractor shall contact Code Officials to schedule any and all required inspections.

1.15 TESTS AND SETTINGS

A. Test all systems furnished under Division 26 and repair or replace all defective work. Make all necessary adjustments to the systems and instruct the Owner's personnel in the proper operation of the systems.

B. Make the following minimum tests and checks prior to energizing electrical equipment:
1. Mechanical inspection, testing and settings of all circuit breakers, disconnect switches, motor starters, control equipment, etc., for proper operation.
2. Check all wire and cable terminations. Verify to the Engineer that connections meet the equipment torque requirements.
3. Check rotation of motors, obtain permission from other contractors to start motor, and proceed to check for proper rotation. If the motor rotates in the wrong direction, correct it. Take all necessary precautions not to damage any equipment.
4. Provide all instruments and equipment for the tests specified herein.

C. All testing shall be scheduled and coordinated by the Contractor. Notify the Owner at least two (2) weeks in advance of conducting tests. The Contractor shall have qualified personnel present during all testing.

D. All tests shall be completely documented with the time of day, date, temperature, and all other pertinent test information. All required documentation of readings indicated shall be submitted to the
Engineer prior to, and as one of the prerequisites for, final acceptance of the project.

E. Electrical Distribution System Tests: All current carrying phase conductors and neutrals shall be tested as installed, and before load connections are made, for insulation resistance and accidental grounds. This shall be done with a 500-volt megger. The following procedures shall be as follows:
1. Minimum readings shall be one million (1,000,000) ohms or more for #6 AWG wire and smaller; 250,000 ohms or more for #4 AWG wire or larger. Measurement to be taken between conductors and between conductor and the grounded metal raceway.
2. After all fixtures, devices and equipment are installed and all connections completed to each panel, the Contractor shall disconnect the neutral feeder conductor from the neutral bar and take a megger reading between the neutral bar and grounded enclosure. If this reading is less than 250,000 ohms, the Contractor shall disconnect the branch circuit neutral wires from this neutral bar. The Contractor shall then test each one separately to the panel until the low reading ones are found. The Contractor shall correct troubles, reconnect and retest until at least 250,000 ohms from the neutral bar to the grounded panel can be achieved with only the neutral feeder disconnected.

3. The Contractor shall send a letter to the Engineer certifying that the above has been done and tabulating the megger readings for each panel. This shall be done at least four (4) days prior to final inspection.
4. At inspection, the Contractor shall furnish a megger and show Engineer's representative that the panels comply with the above requirements. The Contractor shall also furnish a clamp type ammeter and a voltmeter and take current and voltage readings as directed by the representatives.
5. At inspection, the Contractor shall furnish ladders, required tools, and mechanics to open fixtures, boxes, panels, or any other equipment to enable the Engineer's representatives to see into any parts of the installation that may be requested.

1.16 SLEEVES AND FORMS FOR OPENINGS

A. Anchor bolts, sleeves, inserts, supports, etc., that may be required for electrical work shall be furnished, located and installed by the Electrical Contractor. The Electrical Contractor shall give sufficient information (marked and located) to the General Contractor in time for proper placement in the construction schedule. Should the Electrical Contractor delay or fail to provide sufficient information in time, then the Electrical Contractor shall cut and patch construction as necessary and required to install electrical work. Such cutting and patching will be done by the General Contractor but paid for by the Electrical Contractor.

B. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all necessary slots for electrical work and form before concrete is poured.

C. Where exact locations are required by equipment for stubbing-up and terminating conduit concealed in floor slabs, request shop drawings, equipment location drawings, foundation drawings, and any other data required to locate the concealed conduit before the floor slab is poured.

D. Where such data is not available in time to avoid delay in scheduled floor slab pours, the Engineer may elect to allow the installations of such conduits to be exposed. No additional compensation for such change will be allowed and written approval must be obtained from the Engineer.

E. Seal all openings, sleeves, penetration, and slots as specified and as shown on the Contract Drawings.

1.17 CUTTING AND PATCHING

A. For the purposes of the Electrical Contract, "cutting and patching" shall be defined as that work required to introduce new electrical work into existing construction. Work required to install or fit electrical boxes, conduit, enclosures, equipment, etc. into new construction is not "cutting and patching".

B. The Electrical Contractor shall perform all cutting and patching necessary to install all equipment as required under his contract and shall re-establish all finishes to their original condition where cutting and patching occur.

C. All cutting and patching shall be done in a thoroughly workmanlike manner.

D. Core drill holes in existing concrete floors and walls as required.

E. Install work at such time as to require the minimum amount of cutting and patching.

F. Do not cut joists, beams, girders, columns or any other structural members without first obtaining written permission from the Engineer.

G. Cut opening only large enough to allow easy installation of the conduit.

H. Patching is to be of the same kind of material as was removed.

I. The completed patching work shall restore the surface to its original appearance.

J. Patching of waterproofed surfaces shall render the area of the patching completely waterproofed.

K. Remove rubble and excess patching materials from the premises.

L. Raceways and ducts penetrating rated floor, ceiling or wall assemblies shall be properly sealed in accordance with the corresponding Underwriters Laboratories approved method utilizing approved and listed materials.

1.18 INTERPRETATION OF DRAWINGS

A. The Electrical drawings and specifications are complementary each to the other and what may be called for by one shall be as binding as if called for by both. The drawings are diagrammatic and indicate generally the location of outlets, devices, equipment, wiring, etc. Drawings shall be followed as closely as possible; however, all work shall suit the finished surroundings and/or trim.

B. Do not scale electrical drawings.

C. Where the words “furnish and install” or “provide” are used, it is intended that this contractor shall purchase and install completely any and/or all material necessary and required for this particular item, system, equipment, etc.

D. Where the words “the Contractor” or “this Contractor” appear in either the Electrical Drawings or Division 26 Specifications, it shall mean the Electrical Contractor.

E. Any omission from either the drawings or these specifications are unintentional, and it shall be the responsibility of this Contractor to call to the attention of the Engineer any pertinent omissions before submitting a bid. Complete and working systems are required, whether every small item of material is shown and specified or not.

F. Where no specific material or equipment type is mentioned, a high-quality product of a reputable manufacturer may be used provided it conforms to the requirements of these specifications. These materials shall be listed or labeled by a Third-Party Testing Agency accredited by the NCBCC to label electrical equipment.

G. The electrical drawings show the general arrangement of raceways, equipment, fixtures, and appurtenances and shall be followed as closely as actual building construction and the work of other trades will permit. Some adjustment of routings and installation of conduit, cable tray and devices should be expected. The electrical work shall conform to the requirements shown on all of the drawings. General and Structural drawings shall take precedence over Electrical Drawings. Because of small scale of the electrical drawings, it is not possible to indicate offsets, fittings and accessories which may be required. The Contractor shall investigate the structural and finish

conditions affecting the work and shall arrange his work accordingly, providing such fittings and accessories as may be required to meet such conditions, without additional cost to the Owner and as directed by the Engineer.

H. Each 3-phase circuit shall be run in a separate conduit unless otherwise shown on the Drawings.

I. Unless otherwise approved by the Engineer, conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed.

J. Where circuits are shown as "home runs" all necessary fittings and boxes shall be provided for a complete raceway installation.

K. Verify with the Engineer the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.

L. Any work installed contrary to or without approval by the Engineer shall be subject to change as directed by the Engineer, and no extra compensation will be allowed for making these changes.

M. The locations of equipment, fixtures, outlets, and similar devices shown on the Drawings are approximate only. Exact locations shall be as approved by the Engineer during construction. Obtain in the field all information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.

N. Surface mounted panel boxes, junction boxes, conduit, etc., shall be supported by spacers to provide a clearance between wall and equipment.

O. Circuit layouts are not intended to show the number of fittings, or other installation details. Furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting, and other electrical systems shown. Additional circuits shall be installed wherever needed to conform to the specific requirements of equipment.

P. All connections to the equipment shall be made as required, and in accordance with the approved shop and setting drawings.

Q. Redesign of electrical work, which is required due to the Contractor's use of an alternate item, arrangement of equipment and/or layout other than specified herein, shall be done by the Contractor at the Contractor's expense. Redesign and detailed plans shall be submitted to the Engineer for approval. No additional compensation will be provided for changes in the work, either the Electrical Contractor's or others, caused by such redesign.

R. All floor mounted electrical equipment shall be placed on 4-inch thick concrete housekeeping pads. Edges shall be chamfered.

1.19 SIZE OF EQUIPMENT

A. Investigate each space in the structure through which equipment must pass to reach its final location. If necessary, the manufacturer shall be required to ship his materials in sections sized to permit passing through such restricted areas in the structure.

B. The equipment shall be kept upright at all times. When equipment has to be tilted for ease of passage through restricted areas during transportation, the manufacturer shall be required to suitably brace the equipment, to ensure that the tilting does not impair the functional integrity of the equipment.

1.20 RECORD DRAWINGS

A. As the work progresses, legibly record all field changes on one set of project contract drawings, herein after called the "record drawings".

B. Record drawings shall accurately show the installed condition of the following items:
1. Panel schedule(s).
2. Control wiring diagram(s).
3. Service, feeder, branch circuit conduit and conductor sizes.
4. Lighting fixture, receptacle, and switch outlets, interconnections and homeruns with circuit identification.
5. Plan view, sizes and locations of switchgear, distribution transformers, substations, motor control centers, and panelboards.

1.21 GUARANTEE

The Contractor shall guarantee the materials and workmanship covered by these drawings and specifications for a period of one year from the date of acceptance by the Owner. The Contractor shall repair and/or replace any parts of any system that may prove to be defective at no additional cost to the Owner within the guarantee period. All equipment warranties shall be as specified and included in the Contract Documents.

1.22 PHASING OF THE WORK

The Electrical Contractor shall schedule his work as described in the relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.

PART 2 - PRODUCTS Not used.

PART 3 - EXECUTION Not used.

END OF SECTION 260500

SECTION 260510 - SELECTIVE ELECTRICAL DEMOLITION

PART 1 - GENERAL

1.1 SECTION INCLUDES

Selective electrical demolition shall be provided by the Electrical Contractor as described herein and as shown on the contract drawings. Gross demolition will be provided by the General Contractor. Identify active utilities, and at the appropriate time, disconnect and cap off such utilities and provide experienced personnel on site during General Contractor demolition operations to perform such operations and resolve issues. Remove materials noted for salvage and reuse.

1.2 RELATED SECTIONS

Division 2 - Demolition

PART 2 -PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Materials and equipment for patching and extending work: As specified in individual Sections.

PART 3 -EXECUTION

3.1 EXAMINATION

A. Verify field measurements and circuiting arrangements are as shown on Drawings.

B. Verify that abandoned wiring and equipment serve only abandoned facilities.

C. Demolition Drawings are based on limited field observation and existing record documents. Survey the affected areas before submitting bid proposal. Report discrepancies to the Engineer before disturbing the existing installation.

D. Beginning of demolition means the Contractor accepts existing conditions.

3.2 PREPARATION

A. Disconnect and/or de-energize electrical systems in walls, floors, and ceilings scheduled for removal.

B. Coordinate power outages with the Owner.

C. Provide temporary and/or permanent wiring and connections as shown and/or as required by conditions to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, and when such work is specifically approved by the Owner, use personnel experienced in such operations.

3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Demolish and extend existing electrical work under provisions of relevant sections of the General and Supplemental General Conditions, Division 1 Specifications Sections, and this Section.

B. Identify and mark wiring to remain for the General Contractor.

C. Remove materials designated for salvage and reuse.

D. Remove, relocate, and extend existing installations to accommodate new construction.

E. Remove disconnected and abandoned wiring to source of supply.

F. Remove electrical work associated with equipment scheduled for demolition except those portions indicated to remain or be reused. Remove unused/abandoned exposed conduit and wiring, including abandoned conduit above accessible ceiling finishes, back to point of concealment. Remove unused/abandoned wiring in concealed conduits back to source (or nearest point of usage). Cut conduit flush with walls and floors, and patch surfaces.

G. Remove exposed wireways, outlet boxes, pull boxes, and hangers made obsolete by the alterations, unless specifically designated to remain.

H. Where electrical systems pass through the demolition areas to serve other portions of the premises, they shall remain or be suitably relocated and the system restored to normal operation. Coordinate outages in systems with the Owner. Where duration of proposed outage cannot be allowed by the Owner, provide temporary connections as required to maintain service.

I. Repair adjacent construction and finishes damaged during electrical demolition and extension work.

J. Disconnect and remove electrical devices serving utilization equipment that has been removed.

K. Disconnect and remove abandoned panelboards and distribution equipment.

L. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets which are not removed.

M. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.

N. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.

3.4 DISPOSAL, CLEANING AND REPAIR

In general, it is intended that material and equipment indicated to be removed and disposed of by the Electrical Contractor shall, upon removal, become the Contractor's property and shall be disposed of, off the site, by the Contractor unless otherwise directed by the Owner. A receipt showing acceptable disposal of any legally regulated materials or equipment shall be given to the Owner.

A. Clean and repair existing materials and equipment which remain or are to be reused.

B. All salvageable materials shall be properly stored by the Electrical Contractor until installed in new construction.

3.5 INSTALLATION

Install relocated materials and equipment under the provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

END OF SECTION 260510

SECTION 260519 - BUILDING WIRE AND CABLE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Building wire and cable.

B. Wiring connectors and connections.

1.2 RELATED SECTIONS

A. Section 260533 - Conduit.

B. Section 260534 - Boxes.

C. Section 260553 - Identification.

1.3 REFERENCES

A. ANSI/NFPA 70 - National Electrical Code.

B. NECA Standard of Installation (National Electrical Contractors Association).

1.4 SUBMITTALS

A. Submit under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Product Data: Provide manufacturer's catalog information showing dimensions, ratings, colors, and configurations.

C. Test Reports: Indicate procedures and values obtained.

D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years documented experience.

1.6 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70.

B. Furnish products listed and classified by testing firm acceptable to authority having jurisdiction as suitable for purpose specified and shown.

1.7 PROJECT CONDITIONS

A. All wire and cable shall be installed in conduit. This includes all power wiring; fire alarm, sound and communications wire and cable (unless noted otherwise); HVAC control cable; etc.

B. Verify that field measurements are as shown on Drawings.

C. Conductor sizes are based on 75° C. copper.

D. Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet Project Conditions.

E. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

1.8 COORDINATION

A. Coordinate Work under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

PART 2 - PRODUCTS

2.1 BUILDING WIRE AND CABLE

A. Description: Single conductor insulated building wire.

B. Conductor: Copper. Solid and stranded as specified below. Minimum #12 AWG, maximum 500 KCMil.

C. Insulation/Voltage Rating: 600 volts.

D. Insulation: Dual-rated THHN/THWN or XHHW.

E. Color Coding:

	120/240 volts and 208/120 volts	480/277 volts
Phase A -	Black	Brown
Phase B -	Red	Orange
Phase C -	Blue	Yellow
Neutral -	White	Gray
Ground -	Green	Green

F. 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 WIRING CONNECTORS AND CONNECTIONS

A. Conductors shall be installed continuous from outlet to outlet with no splicing except within outlet or junction boxes, troughs and gutters. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.

B. Use mechanical connectors for copper conductor splices and taps, 8 AWG and larger, except main grounding conductors, which shall be terminated with compression lugs. Tape un-insulated conductors and connector with electrical tape to 150 percent of insulation rating of conductor or use UL-approved insulating covers.

C. Use insulated spring wire connectors with plastic caps for copper conductors, 10 AWG and smaller, splices and taps in junction boxes, outlet boxes and lighting fixtures, Ideal “wirenuts” or 3M Company “Scotchlock”. “Push wire” type connectors are not acceptable.

D. “Sta-Kon” or other permanent type crimp connectors shall not be used for branch circuit connections.

E. Joints in stranded conductors shall be spliced by approved mechanical connectors and gum rubber tape or friction tape. Solderless mechanical connectors for splices and taps, provided with U.L approved insulating covers, may be used instead of mechanical connectors plus tape.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that interior of building has been protected from weather.

B. Verify that mechanical work likely to damage wire has been completed.

C. Verify that raceway installation is complete and supported.

3.2 PREPARATION

A. Completely and thoroughly swab raceway before installing wire.

3.3 WIRING METHODS

A. Concealed Dry Interior Locations: Use only building wire in raceway.

B. Exposed Dry Interior Locations: Use only building wire in raceway.

C. Above Accessible Ceilings: Use only building wire in raceway.

D. Wet or Damp Interior Locations: Use only building wire in raceway.

E. Exterior Locations: Use only building wire in raceway.

F. Underground Installations: Use only building wire in raceway.

G. VFC Output Circuits: Type TC-ER cable with braided shield in raceway.

3.4 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Route wire and cable as required to meet Project Conditions.

C. Install cable in accordance with the NECA "Standard of Installation".

D. Use solid conductor for feeders and branch circuits 10 AWG and smaller, and Class B stranded for larger conductors.

E. Use conductor not smaller than 12 AWG for power and lighting circuits.

F. Use conductor not smaller than 14 AWG for fire alarm and control circuits.

G. Use 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 75 feet (23 m) or branch circuit homeruns longer than 50 feet.

H. Use 10 AWG conductors for 20 ampere, 277 volt branch circuits longer than 200 feet or branch circuit homeruns longer than 125 feet.

I. Pull all conductors into raceway at same time.

J. Use suitable wire pulling lubricant for building wire 4 AWG and larger.

K. Neatly train and lace wiring inside boxes, equipment, and panelboards.

L. Clean conductor surfaces before installing lugs and connectors.

M. Identify wire and cable under provisions of Section 260553.

N. Identify each conductor with its circuit number or other designation indicated on Drawings.

O. Common neutral multiwire receptacle branch circuits are not permitted. Provide separate, individual neutral conductors for receptacle circuits.

3.5 FIELD QUALITY CONTROL

A. Perform field inspection and testing under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Inspect wire for physical damage and proper connection.

C. Measure tightness of bolted connections and compare torque measurements with manufacturer's recommended values.

D. Verify continuity of each branch circuit conductor.

E. Prior to energizing, feeders, sub-feeders and service conductor cables shall be tested for electrical continuity and short circuits.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Grounding electrodes and conductors.

B. Equipment grounding conductors.

C. Grounding well components.

1.2 REFERENCES

A. IEEE 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.

B. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (International Electrical Testing Association).

C. NFPA 70 - National Electrical Code.

1.3 GROUNDING SYSTEM DESCRIPTION

A. All grounding conductors shall be installed in conduit sized in accordance with the NEC. Conduit carrying a grounding conductor shall also be grounded at the earth electrode.

1.4 SUBMITTALS FOR REVIEW

A. Submittals: Procedures for submittals. Submit under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Product Data: Provide for grounding electrodes and connections.

1.5 SUBMITTALS FOR INFORMATION

A. Submittals: Submittals for information. Submit under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Test Reports: Indicates overall resistance to ground and resistance of each electrode.

C. Manufacturer’s Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.

1.6 SUBMITTALS FOR CLOSEOUT

A. Contract Closeout: Procedures for submittals as required under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Project Record Documents: Record actual locations of components and grounding electrodes.

C. Certificate of Compliance: Indicate approval of installation by authority having jurisdiction.

1.7 QUALIFICATIONS

Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience, and with service facilities within 100 miles of Project.

1.8 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. Products: Listed and classified by testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 WIRE

Material: Stranded copper sized per NEC requirements.

PART 3 -EXECUTION

3.1 EXAMINATION

Coordination and Meetings: Verify existing conditions prior to beginning work as required under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

3.2 INSTALLATION

A. Quality Control: Manufacturer's instructions shall be followed as required under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Provide bonding to meet Regulatory Requirements.

C. Provide separate, insulated conductor within each feeder and branch circuit raceway.

D. Equipment Grounding Conductor: The raceway system shall not be relied on for ground continuity. A green grounding conductor, properly sized per the NEC (Table 250-122) shall be run in all raceways. Terminate each end on suitable lug, bus, or bushing. Exceptions are as follows:
   1. Raceways for telecommunications.
   2. Raceways for data.
   3. Raceways for audio conductors.
   4. Services.

E. Equipment grounding continuity shall be maintained through flexible conduit as required in previous sections.

F. Grounding conductors shall be installed as to permit the shortest and most direct path from equipment to ground. All connections to ground conductors shall be accessible for inspection and made with approved solderless connectors, brazed or bolted to the equipment or structure to be grounded. All contact surfaces shall be thoroughly cleaned before connections are made to insure good metal to metal contact.

G. All equipment housings and/or enclosures, and all non-current carrying metallic parts of electrical equipment, raceway systems, etc., shall be effectively and adequately bonded to ground.

H. Boxes with concentric, eccentric or over-sized knockouts shall be provided with bonding bushings and jumpers. The jumper shall be sized per the NEC and lugged to the box.

I. An equipment ground bus shall be installed in each panelboard for terminating equipment grounding conductors.

J. All wiring devices equipped with grounding connections shall be permanently and securely connected to the enclosure in which they are mounted with a copper grounding jumper.

3.3 FIELD QUALITY CONTROL

A. Quality Assurance: Field inspection, testing and adjusting as required under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections..

B. Inspect and test in accordance with NETA ATS, except Section 4, or provide for qualified technicians to perform testing according to the manufacturer’s recommendations.

END OF SECTION 260526

SECTION 260529 - SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Conduit and equipment supports.

B. Anchors and fasteners.

1.2 REFERENCES

A. NECA - National Electrical Contractors Association.

B. ANSI/NFPA 70 - National Electrical Code.

1.3 SUBMITTALS

A. Submit under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Product Data: Provide manufacturer's catalog data for fastening systems.

C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.4 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70.

B. Furnish products listed and classified by testing firm acceptable to authority having jurisdiction as suitable for purpose specified and shown.

PART 2 - PRODUCTS

2.1 PRODUCT REQUIREMENTS

A. Materials and Finishes: Provide adequate corrosion resistance. See Specifications Section 260500, Para. 1.14 for additional hardware corrosion resistance requirements.

B. Provide materials, sizes, and types of anchors, fasteners and supports to carry the loads of equipment and conduit. Consider weight of wire in conduit when selecting products.

C. Anchors and Fasteners:
   1. Concrete Structural Elements: Use expansion anchors.
   2. Steel Structural Elements: Use beam clamps.
   3. Concrete Surfaces: Use self-drilling anchors and expansion anchors.
   4. Hollow Masonry, Plaster, and Gypsum Board Partitions: Use toggle bolts.

5. Solid Masonry Walls: Use expansion anchors.
6. Sheet Metal: Use sheet metal screws or bolts
7. Wood Elements: Use wood screws.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Provide anchors, fasteners, and supports in accordance with NECA "Standard of Installation".

C. Do not fasten supports to pipes, ducts, mechanical equipment, and conduit.

D. Do not use powder-actuated anchors.

E. Obtain permission from Engineer before drilling or cutting structural members.

F. Fabricate supports from structural steel or steel channel. Rigidly weld members or use hexagon head bolts to present neat appearance with adequate strength and rigidity. Use spring lock washers under all nuts.

G. Install surface-mounted cabinets and panelboards with minimum of four anchors.

H. In wet and damp locations use steel channel supports to stand cabinets and panelboards one inch (25 mm) off wall.

I. Conduits installed on the interior of exterior building walls shall be spaced away from the wall surface a minimum of 1/4 inch (65mm) using "clamp-backs" or struts.

J. Use sheet metal channel to bridge studs above and below cabinets and panelboards recessed in hollow partitions.

END OF SECTION 260529

SECTION 260533 – RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Metal conduit.

B. Flexible metal conduit.

C. Liquidtight flexible metal conduit.

D. Electrical metallic tubing.

1.2 RELATED SECTIONS

A. Section 260534 - Boxes.

B. Section 260526 - Grounding and Bonding.

C. Section 260529 - Supporting Devices.

D. Section 260553 - Electrical Identification.

1.3 REFERENCES

A. ANSI C80.1 - Rigid Steel Conduit, Zinc Coated.

B. ANSI C80.3 - Electrical Metallic Tubing, Zinc Coated.

C. ANSI/NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.

D. ANSI/NFPA 70 - National Electrical Code.

E. NECA “Standard of Installation”.

F. NEMA TC2 - Schedule 40 PVC

G. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.

1.4 DESIGN REQUIREMENTS

Conduit Size: ANSI/NFPA 70.

1.5 SUBMITTALS

A. Submit under provisions of relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Product Data: Provide for metallic conduit, flexible metal conduit, liquidtight flexible metal conduit, metallic tubing, nonmetallic conduit, fittings and conduit bodies.

1.6 PROJECT RECORD DOCUMENTS

A. Submit under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Accurately record actual routing of conduits larger than 2 inches (51 mm).

1.7 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70.

B. Furnish products listed and classified by testing firm acceptable to authority having jurisdiction as suitable for purpose specified and shown.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle Products to site under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Accept conduit on site. Inspect for damage.

C. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.

D. Protect PVC conduit from sunlight.

1.9 PROJECT CONDITIONS

A. Verify that field measurements are as shown on Drawings.

B. Verify routing and termination locations of conduit prior to rough-in.

C. Conduit routing is shown on Drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

PART 2 - PRODUCTS

2.1 CONDUIT REQUIREMENTS

A. Size: Conduit shall be sized in accordance with the latest edition of the NEC unless shown otherwise, with minimum conduit size being ½ inch, except homeruns minimum size shall be 3/4". Flexible metal and watertight ("sealtite") conduit in size ½ inch and larger are acceptable for motor, appliance and fixture connections provided green ground wire is installed (see Section 260526) and NEC is followed.

B. All conduit will be provided with insulated throat.

C. Wet and Damp Locations: Use rigid steel conduit.

D. Dry Locations:
   1. Concealed: Use rigid steel conduit, intermediate metal conduit or electrical metallic tubing. EMT may be utilized as permitted by the NEC, with the following restrictions. EMT shall not be installed:
      a. where tubing, couplings, elbows and fittings would be in direct contact with the earth.
      b. underground (in/below slab-on-grade or in earth).
      c. any location outdoors where the tubing, etc., would be subjected to the elements.
      d. where subject to severe corrosive influence.
      e. where subject to severe physical damage.
   2. Exposed: Use rigid steel conduit or intermediate metal conduit.

2.2 METAL CONDUIT

A. Rigid Steel Conduit: ANSI C80.1.

B. Plastic-Coated Rigid Steel Conduit: ANSI C80.1, 40 mil PVC coating.

C. Intermediate Metal Conduit (IMC): Rigid steel.

D. Fittings and Conduit Bodies: ANSI/NEMA FB 1; material to match conduit with all steel fittings.

2.3 FLEXIBLE METAL CONDUIT

A. Description: Interlocked steel construction.

B. Fittings: ANSI/NEMA FB 1, steel.

2.4 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. Description: Interlocked steel construction with PVC jacket.

B. Fittings: ANSI/NEMA FB 1, steel or nonmetallic type.

2.5 ELECTRICAL METALLIC TUBING (EMT)

A. Description: ANSI C80.3; galvanized tubing.

B. Fittings and Conduit Bodies: ANSI/NEMA FB 1; steel or malleable iron, compression type, insulated throat.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Circuiting is shown schematically. Exact routing of branch circuits may be varied to suit building construction; however, the combination of circuits within raceways and panelboard connections shall not be changed from those shown on the drawings.

B. Raceways shall be installed concealed in finished areas. Where construction does not permit concealed raceways and where indicated on the drawings, raceways shall be run exposed. Exposed raceways shall be run parallel to, or at a right angle with the building walls. Route conduit installed above accessible ceilings parallel and perpendicular to walls.

C. Where any run of rigid conduit may change to a run of EMT or vice-versa, each change shall be made in a junction or outlet box with each conduit terminated separately therein. Rigid conduit to EMT (or vice-versa) adapters shall not be permitted.

D. Install conduit in accordance with NECA "Standard of Installation".

E. Arrange conduit to maintain headroom and present neat appearance.

F. Maintain adequate clearance between conduit and piping.

G. Maintain 12 inch (300 mm) clearance between conduit and surfaces with temperatures exceeding 104 degrees F (40 degrees C).

H. Cut conduit square using saw or pipecutter and de-burr cut ends.

I. Bring conduit to shoulder of fittings; fasten securely.

J. Use conduit hubs or sealing locknuts to fasten conduit to sheet metal boxes in damp and wet locations and to cast boxes.

K. Install no more than equivalent of three 90-degree bends between boxes. Use conduit bodies to make sharp changes in direction, as around beams. Use factory elbows, or hydraulic one-shot bender, to fabricate bends in metal conduit larger than 2 inch size.

L. Avoid moisture traps; provide junction box with drain fitting at low points in conduit system.

M. Provide suitable fittings to accommodate expansion and deflection where conduit crosses, control and expansion joints.

N. Provide suitable pull string in each empty conduit except sleeves and nipples.

O. Use suitable caps to protect installed conduit against entrance of dirt and moisture.

P. The raceway system shall not be relied on for grounding continuity. Ground and bond conduit under provisions of Section 260526.

Q. Identify conduit under provisions of Section 260553.

R. The use of "LB's" shall be limited where possible. Where necessary to use "LB's" sized above 2 inch, mogul units shall be installed.

S. Where concentric, eccentric or over-sized knockouts are encountered, a grounding type insulated bushing shall be provided.

T. Fasten conduit supports to building structure and surfaces under provisions of Section 260529.

U. Arrange supports to prevent misalignment during wiring installation.

V. Support conduit using coated steel or malleable iron straps, lay-in adjustable hangers, clevis hangers, and split hangers.

W. Group related conduits; support using conduit rack. Construct rack using steel channel; provide space on each for 25 percent additional conduits.

X. Do not support conduit with wire or perforated pipe straps. Remove wire used for temporary supports.

Y. Do not attach conduit to ceiling support wires.

Z. All metallic raceways entering or leaving panelboards (branch circuits less than 30 amperes in lighting and appliance branch circuit panelboards excepted), switchboards, transfer switches, enclosed circuit breakers, safety switches, transformers, etc. shall be provided with insulated grounding and bonding bushings and each separate piece of raceway shall be individually bonded to the equipment ground bus or metallic enclosure, as applicable, by means of copper conductor sized in accordance with the National Electrical Code.

AA. The term “fittings” includes couplings, connectors, offsets, LBs, etc.

BB. No pressure cast (pot metal) fittings or conduit bodies shall be allowed.

CC. Outlets, junction, taps, etc., on exposed rigid metal conduit shall be cast metal conduit fittings or cast metal boxes of the type and size appropriate for the location. Sheet steel outlet boxes shall not be permitted on exposed raceway runs except at or near a ceiling for interior construction.

DD. EMT couplings and terminations shall be made utilizing steel-plated hexagonal compression connectors. No set screw or indented type fittings shall be utilized.

EE. EMT couplings and terminations shall be “concrete tight” where buried in masonry or concrete. EMT fittings, where installed in damp locations, shall be of the “raintight” type.

FF. Install nonmetallic conduit in accordance with manufacturer’s instructions.

GG. Join nonmetallic conduit using cement as recommended by manufacturer. Wipe nonmetallic conduit dry and clean before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for 20 minutes, minimum.

HH. PVC schedule 40 shall not be used exposed or concealed in gypsum walls, but may be used in CMU walls.

II. IMC and GRC shall terminate with either a double locknut / bushing set, or in a threaded hub.

JJ. Conduit couplings for IMC, GRC and PVC shall be in accordance with the NEC.

KK. The placement of conduit in floor slabs shall be thoroughly coordinated with the General Contractor to avoid conflicts with steel reinforcing bars, reductions in net concrete sections and floor penetrations.

LL. Raceways that penetrate outside walls, ceilings from conditioned space or other similar condition shall be effectively sealed to prevent condensation from infiltrating humid air.

MM. EMT conduit provided below roof deck shall be installed 11/2 inches away from the deck to allow for screws not to penetrate the EMT conduit during reroofing.

NN. Conduits, JBs, Troughs, any enclosure when mounted outside on the walls, shall be off the walls by one inch.

3.2 INTERFACE WITH OTHER PRODUCTS

A. Install conduit to preserve fire resistance rating of partitions and other elements, using materials and methods under the provisions of Division 7.

B. Route conduit through roof openings for piping and ductwork or through suitable roof jack with pitch pocket. Coordinate location with roofing installation specified under Division 7.

END OF SECTION 260533

SECTION 260534 - BOXES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Wall and ceiling outlet boxes.

B. Pull and junction boxes.

1.2 RELATED SECTIONS

A. Drawings and Division 26 Technical Specifications, New Hanover County Schools Request for Proposals, Specifications, Bid Form, General Requirements, and associated attachments apply to this Section.

B. Section 260526 - Grounding and Bonding.

C. Section 260553 - Electrical Identification.

D. Section 262726 - Wiring Devices.

E. Section 260529 – Supporting Devices.

1.3 REFERENCES

A. NECA - Standard of Installation.

B. NEMA FB 1 - Fittings and Supports for Conduit and Cable Assemblies.

C. NEMA OS 1 - Sheet-steel Outlet Boxes, Device Boxes, Covers, and Box Supports.

D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

E. NFPA 70 - National Electrical Code.

1.4 SUBMITTALS FOR REVIEW

A. Product Data: Provide manufacturer’s catalog information showing dimensions and configurations.

1.5 SUBMITTALS FOR CLOSEOUT

A. Record actual locations and mounting heights of outlet, pull, and junction boxes on project record documents.

1.6 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. Provide Products listed and classified by testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 OUTLET BOXES

A. Sheet Metal Outlet Boxes: NEMA OS 1, galvanized steel.

1. Junction and outlet boxes for interior use in dry locations shall be zinc coated or cadmium plated sheet steel, 4" square and 2-1/8" deep, unless otherwise indicated on the contract drawings. Smaller and shallower outlet boxes will be permitted only by special permission of the Engineer where such boxes are necessary due to structural conditions encountered. Where larger junction boxes are required, they shall be fabricated from No. 10, 12, 14 or 16 gauge sheet steel as required by the Underwriters Laboratories, Inc., and galvanized after fabrication. All junction boxes shall have screw fastened covers. Outlet boxes shall be provided with extension plaster rings where required by structural and finish conditions. Sheet steel boxes shall be as manufactured by Appleton, Raco, Steel City or Spring City.

B. Cast Boxes: NEMA FB 1, Type FD, cast feralloy. Provide gasketed cover by box manufacturer. Provide threaded hubs. Cast boxes shall be by Crouse-Hinds, Appleton, O. Z. Gedney or Killark.

2.2 PULL AND JUNCTION BOXES

Sheet Metal Boxes: NEMA OS 1, galvanized steel.

PART 3 - EXECUTION

3.1 EXAMINATION

Verify locations of outlets prior to rough-in.

3.2 INSTALLATION

A. Install boxes in accordance with NECA "Standard of Installation".

B. Install in locations as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections and compliance with regulatory requirements.

C. Set boxes at elevations to accommodate mounting heights indicated. Boxes are shown on Drawings in approximate locations unless dimensioned. Adjust box location up to 10 feet if required to accommodate intended purpose. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only. Install boxes to preserve fire resistance rating of partitions and other elements, using approved materials and methods.

3.3 ADJUSTING

A. Install knockout closures in unused box openings.

3.4 CLEANING

A. Clean interior of boxes to remove dust, debris, and other material.

B. Clean exposed surfaces and restore finish.

END OF SECTION

SECTION 260553 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Nameplates and labels.

B. Wire and cable markers.

C. Conduit markers.

D. Wiring device plates marking.

E. Underground warning tape.

1.2 RELATED SECTIONS

Division 9: Painting.

1.3 REFERENCES

ANSI/NFPA 70 - National Electrical Code.

1.4 SUBMITTALS

A. Submit under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Product Data: Provide catalog data for nameplates, labels, and markers.

C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation and installation of Product.

1.5 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70.

B. Furnish products listed and classified by testing firm acceptable to authority having jurisdiction as suitable for purpose specified and shown.

PART 2 - PRODUCTS

2.1 NAMEPLATES AND LABELS

A. Nameplates: Engraved three-layer laminated plastic as follows:

Furnish and install engraved laminated phenolic nameplates for all electrical equipment supplied

under this contract for identification of system, equipment controlled or served, phase, voltage, ampacity, etc. Nameplates shall be securely attached to equipment with stainless steel screws, and shall identify by name the equipment controlled, attached, etc. Embossed, self adhesive plastic tape is not acceptable for marking equipment. Nameplate material colors shall be:

1. Blue surface with white core for all 120/208 volt equipment.
2. Black surface with white core for 277/480 volt equipment.
3. Bright red surface with white core for all equipment related to fire alarm system.
4. Dark red (burgundy) surface with white core for all equipment related to Security.
5. Green surface with white core for all equipment related to “emergency” systems.
6. Orange surface with white core for all equipment related to telephone systems.
7. Brown surface with white core for all equipment related to data systems.
8. White surface with black core for all equipment related to paging systems.
9. Purple surface with white core for all equipment related to TV systems.

B. Locations:
   1. Each electrical distribution and control equipment enclosure (safety switches, panelboards, transformers, etc.)
   2. Communication cabinets.
   3. Pull and splice boxes.

C. Letter Size: Letters shall be a minimum of 1/2 inch (13 mm) high.

2.2 WIRE MARKERS

A. Description: Split sleeve type wire markers or approved equivalent.

B. Locations: Each conductor at panelboard gutters, pull boxes, outlet and junction boxes, and each load connection.

C. Legend:
   1. Power and Lighting Circuits: Branch circuit or feeder number as indicated on drawings.
   2. Control Circuits: Control wire number as indicated on schematic and interconnection diagrams on drawings.

2.3 CONDUIT, RACEWAY AND BOX MARKING

Paint visible surfaces of exposed junction and outlet boxes and covers of raceway systems above lay-in and other accessible ceilings. Paint all boxes and covers before installation. Paint exposed conduit and raceways at ten foot minimum intervals with a 6 inch wide band in accordance with the color scheme outlined above. Mark conduits at junction boxes above accessible ceilings with the panelboard and circuit numbers of the circuits contained in the raceway using a permanent black marking pen.

2.4 WIRING DEVICE PLATES MARKING

A. Description:
   1. Adhesive backed, laminated plastic receptacle device plate labels identifying the circuit feeding the device. Labels shall be label machine printed, black lettering on a clear background, to indicate panel and circuit number and shall be Casio, Brother, T&B or approved equal.
   2. Print circuit number on flag type plastic cable tie with a permanent marker (Sharpie, etc.) and

attach to conductors in outlet box. Flag shall be readily visible upon removal of device plate.

B. Locations: Each receptacle device plate. Apply centered on the lower portion below the receptacle, parallel to the lower surface.

C. Legend: Typed labels to indicate panel and circuit number feeding the device (i.e., RPA-24).

PART 3 - EXECUTION

3.1 PREPARATION

Degrease and clean surfaces to receive nameplates and labels.

3.2 APPLICATION

A. Install nameplate parallel to equipment lines.

B. Secure nameplate to equipment front using self tapping stainless steel screws, lockwashers and acorn nuts as shown on the Drawings.

C. Secure nameplate to inside surface of door on panelboard that is recessed in finished locations.

D. Install receptacle identification labels at top of each device plate, parallel to upper surface.

E. Identify conduit using field painting under provisions of Division 26.

F. All empty conduit runs and conduit with conductors for future use shall be identified for use and shall indicate where they terminate. Identification shall be by tags with string or wire attached to conduit or outlet.

G. Update all existing panelboard directories where changes are made. Provide new panel schedule cards as required to maintain legibility.

H. Identify underground conduits using one underground warning tape per trench at 6 - 8 inches below finished grade.

I. Install adhesive backed labels and nameplates only when ambient temperature and humidity conditions for adhesive use are within range recommended by manufacturer.

END OF SECTION 260553

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fuses.

B. Spare fuse cabinet.

1.2 REFERENCES

A. NFPA 70 - National Electric Code.

B. NEMA FU 1 - Low Voltage Cartridge Fuses.

1.3 SUBMITTALS

A. Submit under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Product Data: Provide data sheets showing electrical characteristics including time-current curves.

1.4 PROJECT RECORD DOCUMENTS

A. Submit under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Record actual fuse sizes.

1.5 QUALIFICATIONS

Manufacturer: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.6 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. Furnish products listed and classified by testing firm acceptable to authority having jurisdiction as suitable for purpose specified and indicated.

1.7 EXTRA MATERIALS

A. Provide no less than 10% of each fuse size and type installed, with a minimum of at least one set of three of each.

B. Provide one fuse puller.

PART 2 - PRODUCTS

2.1 FUSE REQUIREMENTS

A. Dimensions and Performance: NEMA FU 1, Class as specified or indicated.

B. Voltage: Provide fuses with voltage rating suitable for circuit phase-to-phase voltage.

C. UL Listed.

	Circuit Type	Fuse type
1.	Service Entrance and Feeder Circuits over 600Amp 200K Amp interrupting rating.	Class L
2.	Service Entrance and Feeder Circuits 600Amp or less 200K Amp interrupting rating.	Class RK1 or J
3.	Motor, Motor Controller and Transformer Circuits 200K Amp interrupting rating.	RK5

D. For individual equipment where fault current does not exceed 50KA use Class K5 fuses with 50KA interrupting rating.

E. Fusible safety switches with short-circuit withstand ratings of 100KA or 200KA require Class R or Class J rejection fuse block feature.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fuses in accordance with manufacturer’s instructions.

B. Install fuse with label oriented such that manufacturer, type, and size are easily read.

C. Install spare fuse cabinet in main electrical equipment room or adjacent to the main service equipment.

END OF SECTION 262813

SECTION 262816 - ENCLOSED SWITCHES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fusible switches.

B. Nonfusible switches.

1.2 RELATED SECTIONS

A. Section 260529 – Supporting Devices.

B. Section 260553 – Electrical Identification.

C. Section 262813 – Fuses.

1.3 REFERENCES

A. NECA - Standard of Installation (published by the National Electrical Contractors Association).

B. NEMA FU1 - Low Voltage Cartridge Fuses.

C. NEMA KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

D. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (published by the International Electrical Testing Association).

E. NFPA 70 - National Electrical Code.

1.4 SUBMITTALS FOR REVIEW

A. Submittals: Procedures for submittals. Submit under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Product Data: Provide switch ratings and enclosure dimensions.

1.5 SUBMITTALS FOR CLOSEOUT

A. Contract Closeout: Submittals for project closeout. Submit under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Record actual locations of enclosed switches in project record documents.

1.6 QUALIFICATIONS

Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.7 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. Products: Listed and classified by testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Cutler Hammer.
B. General Electric.
C. Siemens.
D. Square D.
E. Substitutions: As permitted in relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.

2.2 RATINGS

A. Service Conditions:
   1. Temperature: 104°F. (40°C.).
   2. Altitude: N/A.
   3. Terminal Rating: 75°C. minimum.

B. Minimum Integrated Short Circuit Rating: 10,000 amperes rms symmetrical, or as indicated.

2.3 FUSIBLE SWITCH ASSEMBLIES

A. Description: NEMA KS 1, Type HD with externally operable handle interlocked (defeatable) to prevent opening front cover with switch in ON position, enclosed load interrupter knife switch. Mechanisms shall be non-teasible, positive, quick make-quick break type. Handle lockable in ON or OFF position. Switches shall have handles whose positions are easily recognizable in the ON or OFF position.

B. Fuse clips: Designed to accommodate NEMA FU1, Class R fuses.

2.4 NONFUSIBLE SWITCH ASSEMBLIES

Description: NEMA KS 1, Type HD with externally operable handle interlocked (defeatable) to prevent opening front cover with switch in ON position, enclosed load interrupter knife switch. Mechanisms shall be non-teasible, positive, quick make-quick break type. Handle lockable in ON or OFF position. Switches shall have handles whose positions are easily recognizable in the ON or OFF position.

2.5 ENCLOSURES

A. Fabrication: NEMA KS 1.
   1. Interior Dry Locations: Type 1.
   2. Exterior Locations: Type 3R.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with NECA “Standard of Installation”.

B. Switches shall be installed in a manner to be fully compliant with the seismic restraint requirements of the North Carolina State Building Code. Provide mounting devices and hardware, bracing, fittings, etc. as required for seismic restraint. See Section 260500, Paragraph 1.23 for additional requirements.

C. Install fuses in fusible disconnect switches serving Division 26 equipment.

D. Apply adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.

3.2 FIELD QUALITY CONTROL

A. Quality Control: Field inspection, testing and adjusting as required under provisions of the General and Supplemental General Conditions and Division 1 Specifications Sections.

B. Inspect and test in accordance with NETA ATS, except Section 4, or provide for qualified technicians to perform testing according to the manufacturer’s recommendations.

END OF SECTION 262816