PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: This section describes requirements, products, and methods of execution relating to the building automation controls system for the project.

B. Related Sections: Refer to related sections for other technical requirements, products, and methods of execution relating to the controls system for monitoring and control of mechanical systems.

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 226300 - Medical Gas Systems
4. 230593 - Testing, Adjusting and Balancing
5. 232113 - Hydronic Piping and Specialties
6. 232113 - Hydronic Pumps
7. 233100 - Ducts and Accessories
8. 233400 - HVAC Fans
9. 233600 - Air Terminal Units
10. 235216 - Condensing Boilers and Accessories
11. 237416 - Packaged Rooftop Units
12. 238123 - Dedicated Air-Conditioning Units
13. 238200 - Terminal Heating and Cooling Units
14. 253000 - Building Automation System Field Devices
15. 259000 - Sequence of Operations
16. Divisions 26, 27 and 28 - Electrical

1.2 REFERENCES

A. Codes and Standards. Perform work in accordance with applicable national, state and local codes to include:

1. See Section 200000 - Mechanical General Requirements.
2. ANSI-C2, National Electrical Safety Code - NESC.
3. Underwriters Laboratory (UL) or approved equal.
4. Institute of Electrical and Electronics Engineers - IEEE.
5. National Electrical Manufacturers' Association - NEMA.

B. Abbreviations and Acronyms:

1. Building Automation System (BAS).
2. Direct Digital Control (DDC).

C. Definitions:

1. ASHRAE: The American Society of Heating, Refrigerating and Air-Conditioning Engineers.
2. BACnet: A Data Communication Protocol for Building Automation and Control Networks, ANSI/ASHRAE Standard 135-current edition, developed under the auspices of ASHRAE.
3. Bridge: A device that routes messages or isolates message traffic to a particular segment, sub-net, or domain of the same physical communication media.
4. Building Automation System (BAS): Collection of sensors, operators, controllers, and interconnecting wiring that control the operation of the building mechanical and electrical systems as described in these specifications.
5. Field device or field control device: A physical component such as a temperature sensor, pressure sensor, contact, motor operated valve, and motor operated damper. Generally considered to bring only one point to a controller.
6. Gateway: A hardware/software package that allows communication between dissimilar ("foreign") systems and different protocols. Gateways are typically custom built, configured, and used only for transmitting and receiving data between different systems. System programming through gateways is not possible within the scope of this definition.
7. LonTalk: An open protocol for communication developed privately by the Echelon Corporation in Palo Alto, California.
8. Operator workstation: The central personal computer for the user to implement day to day operation of the system.
9. Router: A device for connecting different local-area network segments within a network. Routers that are used between networks with different protocols are limited. Point mapping in this type of router is automatic and requires less than one hour to configure. This device is not capable of storing point map information.
10. TCP/IP (Transmission Control Protocol/Internet Protocol): The communication language or protocol that defines the Internet. TCP/IP can also be used as a communication protocol in private networks.
11. Terminal Unit Controller: A device to control very specific applications such as a VAV box, cabinet unit heater, fan terminal unit and the like. These units may have predefined operating sequences with limited custom programming available. (Also called an "application specific controller").

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. The HVAC Control System will consist of a flat, open architecture based upon BACNet meeting the requirement of ANSI/EIA 709.1 and ASHRAE Standard 135. Provide necessary BACnet-compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.
2. The system shall operate as a low-voltage multiplexed data system. The controls and instrumentation specified herein shall be integrated and installed as a complete package by the Contractor.
3. The completed system shall be integrated such that graphics, reports, and system interfaces from the Operators workstation appears as if there is one system.
4. No BAS system components requiring the use of gateways will be accepted.

5. To provide future flexibility, router domains shall not exceed nominally 75 percent of the maximum number of devices in the domain, unless specified otherwise.

B. Performance Requirements:

1. This section specifies the requirements for the BAS to be installed in conjunction with this project.
2. Controls contractor shall furnish and install an integrated building automation system, incorporating DDC for energy management, equipment monitoring and control, and subsystems as herein specified. Controls contractor will complete the temperature control system as specified herein.
3. Materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. Systems and components shall have been thoroughly tested and proven in actual use for at least two years.
4. Controls contractor shall be responsible for BAS and temperature control wiring for a complete and operable system. Wiring shall be done in accordance with Divisions 26, 27 and 28 of this specification and local and national codes.
5. Control and monitoring for mechanical systems installed under this Contract, including:

    a. Building ventilation systems.
    b. Building heating systems.
    c. Domestic water heater trouble/alarm monitoring.
    d. Dental air and vacuum system trouble/alarm monitoring.

6. The Work under this Section includes furnishing and installing wiring, conduit, connectors, terminal strips, and any other equipment required to interface each sensor or control point to the control system.
7. Provide control system and subsystem network cabling, routers, and other devices required for the systems shown and specified, except as specifically noted or shown on the drawings.
8. Providing sequences of operation described in Section 259000 - Sequence of Operations.
9. Installation of control instrumentation and hardware specified in Section 253000 - Building Automation System Field Devices, necessary for a complete system of controls.
10. Integrating the controls under this Contract with the Owner's HVAC Supervisory System.
11. Commissioning support activities as required in 019100 - Commissioning, including requirements in development of commissioning checklists, phased commissioning, installation examination and performance test activities, training and IO&M requirements. BAS contractor shall provide field and office support of commissioning activities.
12. System functional requirements include, but are not limited to:

    a. BAS system shall provide all normal and off-normal control functionality without reliance upon PC file server or workstation.
    b. Programming information, graphics, databases, and other information required to restore the entire system in the event of equipment failure or malfunction or human error shall be protected with a centralized back-up system.
    c. Systems shall be designed to maximize multiple-vendor flexibility to replace or modify any portion of the system.

13. Software upgrades for PC and control network operating systems, the supervisory system, web browser, programming/binding tools, etc., without limitation shall be provided at no additional charge for a period of one year after Substantial Completion of the BAS.

14. A training program shall be provided to include: Data acquisition and report generation on the Operator's workstation.
15. The cost of providing power from the building electrical system shall be included in the bid. Power sources are subject to submittal requirements, and review and approval.

1.4 PREINSTALLATION MEETINGS

A. Coordinate installation of the building automation system with trades responsible for portions of this and any other related sections of the Project Manual prior to installation of any components.

1.5 SUBMITTALS

A. Refer to Section 200000 - Mechanical General Requirements for general submittal requirements.

B. Product Data:

1. Provide manufacturer's literature that demonstrates compliance with the manufacturing methods, appurtenances and salient features specified.
2. Equipment tagging method specifically listing each device and the identification tag to be applied.
3. Sequence of Operations.
4. Riser Diagrams.
5. Control Diagrams.
6. Panel layouts.
7. Valve and Damper schedules.
8. Point Summary Report.
9. Blank (Reserved for Enhanced Alarm Report).
10. Blank (Reserved for Commented PPCL).
11. Blank (Reserved for Trend Logs).
12. Blank (Reserve for Electronic Plans Room file).

C. Shop Drawings:

1. Riser Diagrams.
2. Control Diagrams.
3. Panel layouts.
4. Valve and Damper schedules.

D. Quality Control Submittals:

1. Pre-functional Installation (PC) and Functional Performance Test (FT) Checklists in accordance with Section 019100 - Commissioning.
2. Incorporate BAS control requirements into the applicable equipment PC/FT checklists.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Contracts: Include information on any maintenance contract with Owner.

B. Operation and Maintenance Data. The O&M Manuals will consist of the following (Progression from Submittal to O&M Manual takes place using the same binders):

1. Sequence of Operations.
2. Riser Diagrams.
3. Control Diagrams.
4. Panel layouts.
5. Valve and Damper schedules.
6. Point Summary Report.
7. Enhanced Alarm Report.
8. Commented PPCL (Program Code).
9. Trend Logs.
10. Product Data including items reused from existing control system as noted.
11. Electronic Plans Room file.

1.7 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturers: Companies specializing in manufacturing the products specified in this section with a minimum of three (3) years documented experience.
2. Installers: Minimum three (3) years' experience in the installation, programming and start-up of building automaton systems.
3. Testing Agencies: Regulatory requirements for products requiring electrical connection – Listed and classified by Underwriters Laboratories Incorporated, or by a testing firm acceptable to the MOA.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:

1. Verify equipment and associated appurtenances are delivered in original factory packaging/crating and are free from damage and corrosion.
2. Replace equipment delivered to job site that does not comply with above requirements at no expense to the Owner.

B. Storage and Handling Requirements:

1. Store products in covered storage area, protected from the elements, outside the general construction area until installed.
2. Handle items carefully to avoid breaking, chipping, denting, scratching, or other damage.
3. Replace damaged items with same item in new condition.

1.9 WARRANTY

A. Manufacturer Warranty:

1. Provide in accordance with Section 200000 - General Mechanical Requirements.

2. Provide maximum 4 hour response time to service/warranty calls from the Owner during the warranty period.

B. Special Warranty:

1. The warranty shall consist of a commitment by controls contractor to provide, at no cost to the Owner, parts and labor as required to repair or replace such parts of the control system that prove inoperative due to defective materials or installation practices.
2. The warranty expressly excludes routine service such as instrument calibration.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Existing facility Building Automation System is Johnson Controls.

1. Building Automation System for this project shall match existing.

B. Management Level Network (MLN). Acceptable manufacturers are limited to the following:

1. Johnson Controls.
2. No Alternate Brand Request; no Substitution Request.

C. Building Level Network (BLN). Acceptable manufacturers are limited to the following:

1. Johnson Controls.
2. No Alternate Brand Request; no Substitution Request.

D. Floor Level Network (FLN). Acceptable manufacturers are limited to the following:

1. Johnson Controls.
2. No Alternate Brand Request; no Substitution Request.

2.2 APPLICATION SPECIFIC CONTROLLER (ASC)

A. General Requirements:

1. Application Specific Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
3. The ASC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.

4. ASC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement.

B. ASC Interface Software:

1. General: ASC shall be configured, not programmed, via PC based interface software. This software shall be a program applet that runs within the network management tool chosen. Intimate knowledge of operation of ASC shall not be required for configuration.
2. ASC shall provide a selection of control applications performable through configuration of the device. Download of new application should not be required for one of these applications.

C. ASC Device Software:

1. General: An ASC shall operate in standalone mode as needed for specified control applications if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.
2. Operating system software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage network communications, and scan inputs and outputs. The operating system shall also contain built in diagnostics.

2.3 APPLICATION GENERIC CONTROLLER (AGC)

A. General Requirements:

1. Application Generic Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
3. The AGC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.
4. AGC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement. Network and power wiring shall allow for ‘pass-thru’ of signal when electronic boards are removed.

B. AGC Interface Software:

1. General: AGC shall be configured, not programmed, via PC based interface software. This software shall be a program applet that runs within the network management tool chosen. Intimate knowledge of operation of AGC shall not be required for configuration.

2. AGC shall provide a selection of control applications performable through configuration of the device. Download of new applications from network management tool shall be possible, but not required.

2.4 CUSTOM APPLICATION CONTROLLER (CAC)

A. General Requirements:

1. Custom Application Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
3. CAC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.
4. CAC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement. The complete CAC including accessory devices such as relay, transducers, power supplies, etc. shall be factory-mounted, wired and housed in a NEMA 1 enclosure or as required by the location and local code requirements.
5. Equip CAC's with diagnostic indicators for the following:

    a. Transmit.
    b. Receive.
    c. Power up test.
    d. Power up fail.
    e. Power up test okay.
    f. Bus error.

B. CAC Software:

1. General: A CAC shall operate in standalone mode as needed for specified control applications if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.
2. Operating system software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage CAC to OI communications, and scan inputs and outputs. The operating system shall also contain built in diagnostics.
3. Input/Output Point Processing Software shall include:

    a. Continuous update of input and output values and conditions. Connected points are to be updated at a minimum of one-second intervals.
    b. Analog to digital conversion, scaling and offset, correction of sensor non-linearity, sensing no response or failed sensors, and conversion of values to 32 bit floating point format. Both the maximum and minimum values sensed for each analog input are to be retained in memory. It shall be possible to input subsets of standard sensor

ranges to the A/D converter and assign gains to match the full-scale 32-bit conversion to achieve high accuracy readout.

c. A reasonability check on analog inputs against the previously read value and discard those values falling outside pre-programmed reasonability limits.
d. Assignment of proper engineering units and status condition identifiers to analog and digital input and outputs.
e. Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and actual alarm) to an input or to assign a set of floating limits (alarm follows a reset schedule or control point) to the input. Each alarm shall be assigned a unique differential to prevent a point from oscillating into and out of alarm. Alarm comparisons shall be made each scan cycle.
f. Debounce of digital inputs to prevent nuisance alarms. Debounce timing shall be adjustable from two seconds to two minutes in one second increments.

4. Alarm lockouts:

a. Alarm lockout software shall be provided to prevent nuisance alarms. on initial start-up of air handler and other mechanical equipment a "timed lockout" period shall be assigned to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period is to be programmable on a per point basis from 0 to 90 minutes in one minute increments.
b. A "hard lockout" shall also be provided to positively lock out alarms when equipment is turned off or when true alarm is dependent on the condition of an associated point. Hard lockout points and lockout initiators are to be operator programmable.
c. Design the power supply to accommodate the power requirements of all components (or nodes) connected, plus 50 percent.

5. Run Time Totalization or Point Trending:

a. Run time shall be accumulated based on the status of a digital input point. It shall be possible to totalize either on time or off time up to 10,000 hours with one-minute resolution. Run time counts shall be resident in non-volatile memory and have CAC resident run time limits assignable through the operator's terminal.
b. Totalized run time or trended data shall be batch downloaded using FTP to the SS on a daily or weekly basis. Trended data shall reside on the SS database server. The automatic update of this data shall be determined by the SS and facility management application requirements.

6. Transition Counting:

a. A transition counter shall be provided to accumulate the number of times a device has been cycled on or off.
b. Counter is to be non-volatile and be capable of accumulating 600,000 switching cycles.
c. Limits shall be assignable to counts to provide maintenance alarm printouts.

7. Custom Direct Digital Control (DDC) Loops:

a. Custom DDC programs are to be provided to meet the control strategies as called for in the sequence of operation sections of these specifications.

b. Each CAC shall have residential in its memory and available to the programs a full library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences:

1). Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self-learning): The adaptive control algorithm shall be used on control loops, as indicated in I/O summary, where the controlled medium flow rate is variable (such as VAV units and variable flow pumping loops). The adaptive control algorithm shall monitor the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of the system dynamics so that on system shutdown and restart, the learning process starts from where it left off and not from ground zero. Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.

2). DDC setpoints, gains and time constants associated with DDC programs shall be available to the operator for display and modification via the SS operator interface.

3). The execution interval of each DDC loop shall be adjustable from 2 to 120 seconds in one-second increments.

4). DDC control programs shall include an assignment of initialization values to outputs to assure that controlled devices assume a fail-safe position on initial system start-up.

2.5 VAV CONTROLLERS

A. Provide manufacturer's thermostat matched to controller. Refer to Section 253000 - Building Automation System Field Devices, for requirements.

B. Coordinate with Section 233600 - Air Terminal Units to have VAV controllers factory mounted on the VAV terminal unit.

C. For applications requiring consistent airflow for space pressure control, provide VAV controllers with an auto-zero module to allow for periodic airflow sensor calibration without interruption of airflow.

2.6 ROUTERS, BRIDGES, REPEATERS AND TRANSCEIVERS

A. Routers, Bridges and Repeaters:

1. Equip each router and bridge with a network transceiver on each network port (inbound and outbound) as dictated by the network type (Type 1 - FTT, Type 2 - TP, Type 3 - PL, Type 4 - LP, Type 5 - RF).
2. The network router shall be designed to route messages from a segment, sub-net, or domain in full duplex communication mode.
3. Routers with TCP/IP capability shall be provided where TCP/IP backbone is used.

4. Routers, bridges and repeaters shall be fully programmable and permit a systems integrator to define message traffic, destination, and other network management functions.
5. The routers, bridges, and repeaters shall be capable of DIN rail or panel mounting and be equipped with status LED lights for Network traffic and power.

B. Transceivers:

1. Type 1 Network Transceiver, Free Topology, Twisted Pair: Provide a transformer isolated, twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:

   a. Differential Manchester encoded signaling for polarity insensitive network wiring.
   b. Transformer isolated for common mode rejection.
   c. 78 Kbps network bit rate up to distances of 2000m.
   d. Free topology supports star, home run, multi drop and loop wiring topologies.
   e. Complies with FCC and VDE requirements.
   f. UL recognized component.

2. Type 2 Network Transceiver, Twisted Pair: Provide a transformer isolated twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:

   a. Differential Manchester encoded signaling for polarity insensitive network wiring.
   b. Transformer isolation for common mode rejection.
   c. 1.25 Mbps network bit rate up to distances of 1000 meters.
   d. Unpotted construction.
   e. Less than 1 mA power consumption with +5VDC input voltage.
   f. FCC and VDE Level B requirements compliance.
   g. UL Listed.

3. Type 3 Network Transceiver, Power Line:

   a. Provide a direct sequence, spread spectrum power line transceiver which is equipped with the following signal processing and error correction capabilities to provide robust and error free communications.

      1). Forward Error Correction (FEC) to enable the system to read and reconstruct corrupted packets without sacrificing throughput. The FEC shall require only six percent overhead for error correction.
      2). Automatic sensitivity adjustment algorithm that dynamically changes the receiver sensitivity based on noise characteristics.
      3). Oversampling correlation filter and adaptive data recovery algorithm to synchronize instantaneously to incoming packets.
      4). Tri-state power amplifier/filter combination to provide a powerful output signal with a minimum number of components.

   b. The transceiver shall be able to operate using the controller power supply and coupling circuit. Provide the following general features as a minimum:

      1). Packaged in a rugged, potted module.
      2). Programmable clock output (1.25, 2.5, 5 or 10 Mhz).

3). 10 Kbps network transmission rate.
4). Packet detect output to drive a status indicator LED.
5). Minus 20 to plus 85 degrees C. operating temperature range.
6). UL Listed.

4. Type 4 Network Transceiver, Link Power: Provide a twisted pair transceiver that utilizes the twisted pair communication media to provide power for Controller(s). The transceiver shall meet the following specifications:

a. Free single-in-line package (SIP) construction.
b. Send both network data and power on a twisted wire pair.
c. Differential Manchester encoded signaling for polarity insensitive network wiring.
d. 78 Kbps network bit rate up to distances of 320 meters.
e. Supports star, home run, multidrop, and loop wiring.
f. Supplies +5VDC @ 100 mA maximum for node power.
g. Compliance with FCC and VDE requirements.
h. UL Listed.

5. Type 5 Network Transceiver, Radio Frequency: Provide a direct sequence, spread spectrum RF transceiver that meets the following specifications:

a. 100 meter open field range.
b. Wireless communications extends network between buildings and to vehicles and portable devices.
c. FCC type certifiable, 48 MHz.
d. Low-cost miniature circuit board, SMT components.
e. Carrier detect output to drive a status indicator LED.
f. Plus 7 to plus 15VDC input voltage.
g. Minus 20 to plus 60 degrees C. operating temperature range.

2.7 OPERATOR WORKSTATION

A. The central personal computer for the user to implement day to day operation of the system. The workstation is generally capable of allowing the operator to accomplish the following functions:

1. Operate in a network environment.
2. Monitor the entire control system.
3. Change set points.
4. Maintain, set, and monitor alarms.
5. Maintain and monitor operating schedules.
6. Control interactively using graphical representations of the system.
7. Manually command points.
8. Trend the behavior of selected points.
9. Archive history.
10. Backup data.
11. Print results.
12. Modify custom programs and sequences of operation.

2.8 PERSONAL COMPUTER OPERATOR WORKSTATION HARDWARE

A. A new graphical operator workstation "client" shall be provided as specified in this section. The new client workstation shall communicate directly with the existing controls database server. Communication shall take place over the Owner's existing Wide Area Network. Programming, graphics and databases created as part of this project shall be incorporated into the existing controls system. Provide a complete, secure backup of the host database at the completion of this project.

B. Provide one graphical operator workstation for command entry, information management, network alarm management and database management functions. The workstation shall communicate seamlessly with the existing Alerton controls system.

1. Provide one workstation of equal or greater capability located as indicated on the contract documents.
2. Workstation shall consist of a personal laptop computer with minimum Windows 10 Pro, 11th Generation Intel Core i7 processor (8 Cores), 16GB RAM, 1 TB solid state hard drive, minimum 16" screen size, video card capable of supporting 1920 × 1080 or above, integrated webcam, USB 3.0 (Type-A and Type-C), WiFi 6, Gigabit network interface card, trackpad, Bluetooth mouse and Kensington combination laptop lock with tamper resistant desk mount anchor point.

2.9 WORKSTATION OPERATOR INTERFACE

A. Basic Interface Description:

1. Operator workstation interface software shall minimize operator training through the use of English language prompting, 30-character English language point identification, on-line help, and industry standard PC application software. Interface software shall simultaneously communicate with up to 4 Building Level Networks and share data between any of the 4 networks. The software shall provide, as a minimum, the following functionality:

   a. Real-time graphical viewing and control of environment.
   b. Scheduling and override of building operations.
   c. Collection and analysis of historical data.
   d. Point database editing, storage and downloading of controller databases.
   e. Alarm reporting, routing, messaging, and acknowledgment.
   f. Display dynamic data trend plot.
   g. Definition and construction of dynamic color graphic displays.
   h. Program editing.
   i. Transfer trend data to third party software.
   j. Scheduling reports.
   k. Operator Activity Log.

2. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection.
3. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. The operator shall be able to work in Microsoft Word,

Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information.

4. Operator specific password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported).
5. Scheduling and Override: Provide a calendar type format for simplification of time-of-day scheduling and overrides of building operations. Schedules reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection or function key.
6. Collection and Analysis of Historical Data: Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

B. Dynamic Color Graphic Displays:

1. Create at least one color graphic display for each piece of mechanical equipment, including air handling units, hot water boiler systems, and room level terminal units. Provide floor plans to facilitate navigation. Point information to be displayed on the graphics shall be provided by the BAS contractor to optimize system performance and analysis and to speed alarm recognition.
2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of submittal AutoCAD drawings and scanned pictures for use in the system.
3. Dynamic temperature values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
4. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
5. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
6. A dynamic display of the site-specific architecture showing status of controllers, PC workstations and networks shall be provided.

C. System Configuration and Definition:

1. Network wide control strategies shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
2. Provide automatic backup and restore of DDC controller databases on the workstation hard disk. In addition, database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and

downloaded to the appropriate DDC Controller. Changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

D. Alarm Management:

1. Alarm Routing shall allow the user to send alarm notification to selected PC locations based on time of day, alarm severity, or point type.
2. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.
3. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.

E. 3 (BLN) and DDC Controller floor level local area networks (FLN). Access to the system shall be totally transparent to the user when accessing data or developing control programs.

F. Management Level Network:

1. PCs shall simultaneously direct connect to the Ethernet and Management Level Network without the use of an interposing device.
2. The Management Level Network shall not impose a maximum constraint on the number of operator workstations.
3. Simultaneous user access to network limited to number of sight licenses issued to user.
4. When appropriate, any DDC controller residing on the peer-to-peer building level network shall connect to Ethernet network without the use of a PC.
5. Any PC on the Ethernet Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet as well as directly connected building level networks. Any PC shall be able to interrogate any controller on the building level network in addition to being able to download program changes to individual controllers.
6. The Management Level Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3.
7. Access to the system database shall be available from any client workstation on the Management Level Network.

G. Peer-to-Peer Building Level Network (BLN):

1. The system shall have the ability to support integration of third party systems (fire alarm, security, lighting, variable speed drives, PLCs, condensers, boilers) via a panel mounted open protocol processor. This processor shall exchange data between the two systems for inter-process control. Exchange points shall have full system functionality as specified herein.
2. Data transfer via Ethernet.

H. Floor Level Network (FLN): This level communication shall support a family of application specific controllers and shall communicate with the peer-to-peer network through DDC Controllers for transmission of global data.

2.10 CONTROL PANELS

A. Terminal Equipment Controllers will be mounted in enclosed control panels with screwed, removable covers.

B. Control devices located in exposed areas subject to outside weather conditions or near circulator pumps (spray due to shaft seal failures) shall be mounted inside weatherproof enclosures. Location of each panel shall be convenient for adjustment service.

C. Nameplates shall be provided beneath each panel face mounted control device describing the function of each device. Nameplates shall have white letters engraved on blue Lamicoid, or approved equal.

D. Control panels shall bear a UL label compatible with the application.

E. Electrical devices within the panel shall be pre-wired to terminal strips, with inter-device wiring within the panel completed prior to installation of the system.

F. BLN level controllers shall be provided with standby/emergency power to provide power quality and minimum 15 minutes operation.

2.11 UNINTERRUPTIBLE POWER SUPPLY

A. Acceptable manufactures are limited to the following:

1. Powerware.
2. Alternate Brand Request or Substitution Request required.

2.12 ACCESS PANELS

A. Access panels provided by Section 083113.

B. Coordinate access panel location with the Owner’s Representative and Section 083113. Provide access to concealed control devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Special Techniques:

1. Mount damper operators and other control devices secured to insulated ductwork on brackets such that the device is external of the insulation. See Section 200529 - Hangers and Supports.
2. Do not install control devices in locations where they are subject to damage or malfunction due to normally encountered ambient temperatures.

3. Identification: Permanently tag controllers, switches, relays, thermostats and actuators for identification using the tagging format shown on the BAS control drawings.
4. Sensors and Switches:

    a. Pump flow or fan flow, etc., shall be sensed using current switch unless indicated otherwise. Calibrate current switch to distinguish between loaded or unloaded motor condition due to belt or coupler breakage.
    b. Protect averaging or capillary tubes where they penetrate duct with rubber grommet and seal with clear silicon. Support with capillary clips and maintain minimum 1 inch tubing bending radius.

5. Wiring:

    a. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings, and related wiring accessories. Install wiring in exposed or inaccessible areas in EMT conduit. Plenum-rated cable may be used in concealed, accessible areas only.
    b. Provide wiring between thermostats and unit heater motors, and control and alarm wiring.
    c. Provide conduit and wiring between the BAS panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring in conduit or plenum-rated cable.
    d. Provide conduit and control wiring for devices specified in this Section.
    e. Provide conduit and signal wiring between motor starters in motor control centers and high and/or low temperature relay contacts and remote relays in BAS panels located in the vicinity of motor control centers.
    f. Provide conduit and wiring between the PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contactors, and BAS panels, as shown on the drawings or as specified.
    g. Wiring shall be compliant with the Divisions 26, 27 and 28 requirements and the NEC.
    h. Provide electrical wall boxes and conduit sleeves for wall-mounted devices. Mount thermostats at 44 inches AFF unless otherwise noted.
    i. Ethernet drop at or near designated BAS control panel(s), and as needed.

B. Interface with Other Work:

1. The Contractor is responsible to furnish and install complete and operational systems. The following breakdown is recommend; carefully coordinate work between subcontractors.

2. Products furnished by BAS contractor for installation by the mechanical contractor:

    a. Control valves.
    b. VAV box controllers.

3. Products furnished and installed by mechanical contractor:

    a. VAV boxes. BAS contractor shall furnish VAV box controls to the VAV box manufacturer for factory installation at the expense of the box manufacturer.
    b. VAV box controller enclosures will be provided by box manufacturer.

c. Gauges, thermometers and thread-o-lets for BAS contractor furnished control sensor wells.
d. Airflow measuring stations.
e. Control and balancing dampers.
f. Smoke and fire/smoke dampers actuators.

4. Electrical contractor (Div. 26) provides:

a. Wiring of power feeds through disconnect starters to electrical motors.
b. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by controls contractor.
c. Duct smoke detectors including installation and wiring.
d. Power wiring of smoke/fire dampers provided by Divisions 20, 21, 22, 23, 25.
e. Stand-alone packaged controls and wiring of stand-alone packaged controls to their remote sensors and devices.

C. System Integration. Products to receive integration under this section:

1. Fire Alarm/Life Safety System:

a. The BAS shall communicate with the fire alarm/life safety system via an alarmable point in the form of a dry contact.
b. The device will be provided and terminated by Divisions 26, 27 and 28. This section will provide wiring to the termination device.

3.2 PROGRAMMING

A. Programming and graphics shall be included to implement the controls sequences specified in Section 259000 - Sequence of Operations, and to implement the systems and features included in Facility Services Divisions 20-28. It shall not be necessary for the Contracting Agency to further program the system.

B. Provide licensed copies of software tools and programming aids used to install, develop and troubleshoot the controls system to the Contracting Agency. Assist the Contracting Agency in registering the software in Contracting Agency's name.

C. Implement the control sequences for the equipment on this project as contained in Section 259000 - Sequence of Operations.

D. Point identifiers shall be chosen for easy identification of the actual equipment being controlled or monitored. They shall include equipment tag identifiers shown on the drawings, and may include additional characters to identify floor, area, etc. Maintain a listing of identifiers used in this project, with their plain English names. Submit the listing for review and information.

3.3 GRAPHICS

A. Graphical Mechanical Displays: Create graphical displays of major mechanical equipment for this project and install graphics on the PC-based workstations. At a minimum, these graphical displays shall include building floor plans derived from architectural AutoCAD representations and graphical representations of the equipment controlled under this contract.

1. Plans:

   a. Provide a central site plan for the entire facility and immediate surroundings. As a minimum indicate the following:

      1). Area designation.
      2). Number of levels on each area.
      3). Adjacent street names.
      4). North arrow.

   b. Provide floor overall floor plans for each level of the facility. As a minimum indicate the following:

      1). Area designation and level.
      2). Mechanical and electrical rooms.
      3). Control panel locations.
      4). North arrow.

   c. Provide individual floor plans for the facility. As a minimum indicate the following:

      1). Walls, doors, and general floor plan arrangement.
      2). Mechanical and electrical rooms.
      3). Temperature sensors.
      4). Temperature control zones.
      5). Control panel locations.
      6). North arrow.
      7). List of major HVAC systems serving the area including but not limited to the following:

         a) Air handling systems.
         b) Exhaust fans.
         c) Toilet exhaust fans.
         d) Heating systems.
         e) Cooling systems.

   d. As a minimum provide the following functional links on for each floor plan:

      1). Provide links back and forth between the plan screens noted above.
      2). On floor plan with temperature sensor, provide dynamic color coding for each sensor as follows:

         a) Blue indicates space temperatures less than 65 degrees F.
         b) Green indicates space temperatures between 66 degrees and 74 degrees F.
         c) Red indicates space temperatures above 75 degrees F.

      3). Provide a link to each VAV terminal unit from the associated temperature sensor.
      4). Provide a link to each major mechanical system serving the temperature sensor.

2. Room Reheat coils:

a. Indicate the following information for each unit:

1). Room Temperature.
2). Coil valve position percent.
3). Fintube valve position percent.

3. Air Handling: Indicate the following information for each AHUs/MAUs, relief/exhaust fans, and toilet exhaust fans:

a. Put control points and adjustable set points on the screen.
b. Define action of dampers and valves (N/O or N/C);
c. Fan schedule override commands.
d. Reset schedules.
e. Outside air CFM and minimum requirement.
f. Duct static set point.

B. Use approved designations for room names, spaces, equipment tags, etc.

3.4 SITE QUALITY CONTROL

A. Document each installation and operational step utilizing the approved PC/FT checklists in accordance with Section 019100 - Commissioning.

B. Programming BAS to provide system operation and monitoring in accordance with Section 259000 - Sequence of Operation and other referenced sections.

C. Trend Logs:

1. Prepare trend logs for all points required to demonstrate BAS calibration, control and stability.
2. Trend logs shall document building operation after applicable PC/FT checklists are completed and building site commissioning is satisfactorily completed.
3. Set points, valve positions, etc. may be temporarily adjusted to artificially induce the intended sequences to occur.

3.5 CLOSEOUT ACTIVITIES

A. Demonstration:

1. Provide demonstrations in accordance with Section 017900 - Demonstrations and Training.
2. Demonstrate the proper operation and control of systems controlled and monitored by the BAS.
3. The demonstration shall include, but not necessarily be limited to, the following:

a. Review of the Trend Logs.
b. Complete and proper operation of control systems including simulations.
c. Access to devices for required maintenance.
d. Review of associated graphics on Host.

B. Training:

1. Provide training in accordance with Section 017900 - Demonstrations and Training.
2. In addition, provide eight (8) hours of on-site instruction by BAS contractor to familiarize operating personnel with the control system. Instructions will include:

   a. A brief description of the controls' sequence of operation.
   b. A discussion and explanation of alarms, switches and gauges.
   c. A summary and explanation of steps to be taken in response to specific alarms or control malfunctions.
   d. Building walk-through to physically locate and examine control devices and demonstrate control setpoint adjustment procedures.
   e. Instructions regarding adjustment procedures shall emphasize methods for continual building "fine-tuning".

END OF SECTION 255000

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: This section describes the building automation system (BAS) control sequences for the heating, ventilating, and air-conditioning (HVAC) systems, electrical systems and plumbing systems provided for this project.

B. Related Sections: Refer to Section 255000 - Building Automation System

1.2 REFERENCES

A. Refer to Section 255000 - Building Automation System.

1.3 SYSTEM DESCRIPTION

A. Refer to Section 255000 - Building Automation System.

1.4 PREINSTALLATION MEETINGS

A. Refer to Section 255000 - Building Automation System.

1.5 SUBMITTALS

A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

B. Product Data:

1. Provide BAS manufacturers' product literature, clearly annotated to indicate performance criteria to include the following:

   a. Building level to floor level network controller riser diagrams. Include building locations and equipment controlled by each controller.
   b. Sequences of operation for HVAC, electrical and plumbing systems.
   c. Process control diagrams to support each sequence of operation. Show field mounted control device locations and circuit routing.
   d. Complete electrical and pneumatic BAS points list.

C. Quality Assurance/Control Submittals:

1. Installation and Functional Performance Test Letter.

   a. Provide a letter certifying that the building automation system hardware is completely installed and sequences of operation have been programmed,

operationally tested, with physically verification, to comply with the sequences of operation as specified. The installer(s), sub-contractor(s) and the Contractor must sign the letter.

b. Include as an attachment, a list of programming deviations from the specified sequences of operation with justification to support each deviation.

c. Include as an attachment, a table of final adjustable setpoint values for each applicable control point.

D. Installation, Operation and Maintenance Data:

1. Refer to Section 200000 – Mechanical General Requirements, for IO&M Manual formatting requirements and number of copies required.
2. Provide approved submittal information, revised to reflect the actual installation as addressed in the attachments provided with the Installation and Functional Performance Test Letter, for inclusion within the project IO&M Manual.

1.6 CLOSEOUT SUBMITTALS

A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

A. Refer to Section 255000 - Building Automation System.

B. Qualifications of Installers/Programmers: Minimum 3 years' experience in the installation and programming of direct digital control systems.

1.9 WARRANTY

A. Refer to Section 255000 - Building Automation System.

PART 2 - PRODUCTS - Not Used

PART 3 - EXECUTION

3.1 MEDICAL GAS ROOM EXHAUST FAN (EF-3) AND ROOM TEMPERATURE CONTROLS

A. Exhaust Fan:

1. Fan operates continuously 24 hours per day and 7 days per week.
2. Monitor fan operating status via current sensor and generate trouble alarm if fans fail to run when commanded.
3. Manually activated emergency shut down switch and manually activated audible and visual room alarm for medical gas storage rooms by Division 28 as noted on drawings. Coordinate with Divisions 26, 27, and 28.

B. Room Temperature Controls and Monitoring:

1. Set room temperature at 60 degrees F (adjustable).
2. Provide room temperature monitoring and alarming capabilities via the BAS system to generate alarm if room temperature drops below 45 degrees F (adjustable).

3.2 GENERAL BUILDING EXHAUST FAN OPERATION (EF-2)

A. Exhaust fan EF-2 provides general building exhaust for toilet rooms, lab, closed dental treatment rooms, sterile processing department, locker rooms, etc. throughout the building. Operate exhaust fan as follows:

1. Open motor operated exhaust fan backdraft damper and start exhaust fan at 6 a.m. (adjustable).
2. Stop exhaust fan and shut motor operated backdraft damper at 9 p.m. (adjustable).
3. Monitor exhaust fan motor and generate a fan specific “EF-2 Trouble” alarm when exhaust fan fails to operate when commanded.

3.3 VENTILATION SYSTEM (RTU-1)

A. General Ventilation System Description:

1. The ventilation systems consist of two centralized roof top air-handling units (RTU-1 and RTU-2) located on the roof. The roof top units serve the following areas:

   a. RTU-1: Basement, Level 1, and a portion of Level 2.
   b. RTU-2: A portion of Level 2 and Level 3.

2. RTU-1 and RTU-2 utilize a variable air volume (VAV) control strategy incorporating variable speed drive motor controllers to modulate supply fan speed. During periods of low system demand, supply fans automatically reduce speed, minimizing fan horsepower and conserving electrical energy.
3. Supply air from RTU-1 and RTU-2 is transferred to their respective variable air volume (VAV) terminal units through a system of medium pressure ductwork. Each VAV terminal unit, equipped with a hydronic reheat coil, controls supply airflow rate (CFM) and temperature to maintain zone setpoint temperature.

4. Return air from RTU-1 and RTU-2 flows back to each roof top unit through above ceiling plenums and two return air shafts. Once inside the RTU, return air is either re-circulated through the building, or is relieved from the RTU through the relief air dampers.

B. Control the system to the following typical sequences:

1. VAV Motor Monitoring.
2. VAV Air-Handling Unit Fan Speed Control.
3. Minimum Motor Run Timer.
4. Air Filter Monitoring.
5. Smoke Detector Shutdown.
6. Fire Alarm System Interface.
7. Duct Static Pressure Monitoring and Shutdown.
8. Low temperature shutdown.
9. Zone VAV Temperature Control with Reheat.
10. Zone Temperature Monitoring.

C. Full Shutdown Mode:

1. Supply fan off.
2. Mixing box outdoor air damper and relief air damper shut.
3. Mixing box return air damper fully open.
4. Heating coil hydronic control valve modulating to maintain 55 degrees F. (adjustable) minimum mixing box air temperature.
5. Cooling coil off.

D. Occupied Mode (6 a.m. to 11 p.m., adjustable):

1. Control to the typical sequences.
2. Heating Coil (HC-1) control: Modulate the heating coil control valve to maintain a 55 degrees F supply air temperature (adjustable) whenever the outside air temperature is 55 degrees F or colder (adjustable) and Mixed Air Temperature is below 55 degrees F. Optimize the Supply Air Temperature (SAT) as follows:

    a. The optimum setpoint is a dynamic floating value of 55 degrees F. or more as required to satisfy the cooling demand of the critical zone.
    b. Definition: The critical zone is defined as that zone which requires the largest percentage of its zone terminal unit cooling capacity to maintain zone setpoint temperature.
    c. Find the critical zone by polling the condition status of each zone terminal unit and the demand for cooling from each zone thermostat. Ignore zone terminal unit serving storage rooms and similar small incidental spaces when searching for the critical zone.
    d. Dynamically optimize the SAT setpoint to the highest temperature possible (above 55 degrees F.) to satisfy the critical zone cooling requirement. Allow SAT to increase until the critical zone is operating with its zone terminal unit control damper at the 95 percent open position and zone setpoint temperature is being maintained within setpoint tolerance.

3. Cooling Coil (CC-1) control: Modulate the DX unit to maintain a 55 degrees F. supply air temperature (adjustable) during the cooling season whenever the outside air temperature is 57 degrees F. or warmer (adjustable) and the cooling system is enabled (through BAS).
4. Building Static Pressure Control: Modulate relief dampers to maintain RTU zone static pressure.

E. Unoccupied Mode (11 p.m. to 6 a.m., adjustable):

1. Air handling unit is initially operating in Occupied Mode.
2. The system operates the same as occupied mode, except:

a. Cooling coil control is disabled.
b. Outside air dampers are shut.

F. DX Cooling System:

1. On call for cooling by the cooling coil:

a. Maintain supply air temperature set point with packaged controls via the interface with the BAS.
b. Modulation of the cooling coil output shall be through the control system, either through an analog signal from the BAS or through an acceptable interface.
c. When cooling is satisfied, disable cooling coil.

G. Building Static Pressure Control:

1. Pressure Sensing:

a. Provide two outdoor ambient static pressure reference heads located above the roof line on opposing corners of the building.
b. Provide an indoor ambient static pressure reference head in the following general location. See drawings for specific sensor location:

1). Level 1 dental reception area.

c. Provide differential pressure analog signals to the BAS between the average of the 2 outdoor ambient static pressure reference heads and each indoor ambient static pressure reference head.

2. Relief Fan Operation:

a. Open lead relief fan damper and start lead relief fan. Increase relief fan speed to maintain negative 0.1” PSID differential pressure setpoint (adjustable) between the fan room and averaged outdoor ambient pressure.
b. If the lead relief fan speed increases to 100 percent and the differential pressure setpoint has not been reached, continue to start additional relief fans in series until setpoint is established. Modulate speed of last fan operating to maintain fan room differential pressure setpoint.
c. Monitor building zone differential pressure. Reset fan room differential pressure to maintain a slightly positive (0.05 inch W.C., adjustable) building pressure.

d. When ventilation system shifts to Unoccupied Mode, stop relief fans, and shut relief fan dampers. Disable Building Static Pressure Control sequence.
e. Rotate lead relief fan daily.

H. Maintenance and Alarm Monitoring:

1. See Typical Sequences.
2. RTU Flow monitoring:

a. Provide BAS monitoring of variable speed drive enable/disable contacts, analog speed controller, and trouble contacts.
b. Generate “VSD Fault” alarm if the VSD fan motor controller goes into fault.
c. Monitor fan motor and generate a fan specific “RTU-X off” critical alarm if RTU-X fails to operate.

3.4 VENTILATION SYSTEMS (RTU-2)

A. Existing sequences to remain.

3.5 NEW AIR TERMINAL UNITS AND ZONE TEMPERATURE CONTROLS

A. Project revises existing air terminal units and zone temperature controls on level 1 and level 2 areas of work. Match existing control sequences and add programming for unoccupied minimum air terminal unit airflow settings for new level 1 dental clinic zones and level 2 optometry clinic zones as noted on drawings.

3.6 NEW DENTAL GAS AND VACUUM SYSTEMS MONITORING

A. Project adds new dental compressed air, vacuum, and medical gas equipment. Match existing sequences for equipment trouble status monitoring via the BAS.

3.7 FIRE ALARM PANEL MONITORING – EXISTING SEQUENCE TO REMAIN, SEQUENCE PROVIDED FOR REFERENCE

A. Monitor the building fire alarm panel alarm (common alarm, common trouble, and common sprinkler alarm) conditions.

3.8 TYPICAL SEQUENCES

A. Setpoints and delays shall be adjustable. Delays shall be incorporated to prevent short cycles to account for system "inertia", equipment and control device operations, and control system sampling frequency for specified sequence of operations.

B. Equipment and system operating conditions used for control shall be field adjusted during testing, adjusting, and balancing, and field verified during commissioning.

C. Typical Circulating Pump Rotation:

1. For lead/standby and lead/lag pump systems, alternate lead pump monthly. Operate pumps with lead pump in "run" and standby (lag) pump in "standby."
2. If lead pump fails to start disable lead pump and start standby (lag) pump.

D. Typical Fan and Pump Constant Speed Motor Monitoring:

1. Monitor motor current and generate an independent maintenance alarm if fan fails when it has been commanded “On” by the BAS. Current type switches are not acceptable.
2. Determine normal and motor inrush currents. Set high and low alarm setpoints based upon normal operating currents. Provide a time delay to reduce nuisance alarms due to motor start inrush currents.
3. Generate a "<Unit tag> low current motor fault" alarm if the motor current falls below low alarm setpoint whenever the device has been commanded on.
4. Generate a "<Unit tag> high current motor fault" if the motor current is above high alarm setpoint whenever the device has been commanded on.
5. Points: See specific control sequence.

E. Typical Fan and Pump Variable Speed Drive (VSD) Motor Monitoring:

1. Monitor Variable Speed Drive (VSD) and alarm if the fan or pump or VSD fails when it has been commanded "On" by the BAS.
2. Set high and low alarm setpoints based upon VSD operating current parameters.
3. Generate a "<Unit tag> low current motor fault" alarm if the motor current falls below low alarm setpoint whenever the device has been commanded on.
4. Generate a "<Unit tag> high current motor fault" if the motor current is above high alarm setpoint whenever the device has been commanded on.
5. Limit speed when Emergency Generator is running. Refer to the Generator sequence of operations.

F. Typical Fan and Pump Variable Speed Drive (VSD) Motor Speed: Motor shall be set to run at minimum of 30 percent speed, unless noted otherwise.

G. Typical Minimum Motor Run Timer: Provide adjustable system run time of 10 minutes (minimum) and adjustable system off time of 5 minutes (minimum).

H. Typical VAV Air-Handling Unit Fan Speed Control:

1. Locate duct static pressure sensors in main supply air duct, approximately 3/4 the distance between the AHU supply outlet and most remote zone variable air volume (VAV) terminal unit branch duct connection. Suggested locations are shown on the drawings (two on level 1).
2. Compare branch duct pressure readings for each air handling system and control supply fan speed, through the variable speed drive (VSD) controller, to maintain the lowest branch pressure at 1.5-inch W.C. (adjustable) setpoint pressure.
3. Program VSD such that the air handling unit goes into Full Shutdown Mode in the event of VSD failure. Require manual position on VSD keypad to restart the system. The supply fan operates at 75 percent speed during manual mode.

I. Typical Safety Shutdowns:

1. "Hardwire" system safety shutdowns to provide safe, reliable operation in the event of Building Automation System (BAS) failure.
2. Where equipment is provided with packaged stand-alone controls, capable of operating the equipment independently from the BAS, provide control logic which shifts the equipment to stand-alone operation in the event of BAS failure.

J. Typical Smoke Detector Shutdown:

1. Provide smoke detector in the main return duct / at return air damper assembly immediately upstream of AHU cabinet for all air handling units larger than 2,000 CFM.
2. Hardwire supply-duct smoke detectors directly to the building's fire alarm panel. Refer to Section 28 31 00 – Addressable Fire Alarm for sequence of operation.
3. Provide fan starter with hardwire relay for smoke detector. Stop fan motor on smoke detection from smoke detector.
4. Provide BAS monitoring of smoke detector status. Generate "<Unit tag> Smoke Alarm" alarm on smoke detection and shut down fan as follows:

    a. Verify supply fan is off. If supply fan is still running, stop fan.
    b. Close outside air dampers and reposition return air damper to 100 percent open.

K. Typical Fire Alarm System Interface:

1. On "General Alarm" from fire alarm panel, the BAS shall:

    a. Verify air handling unit fans are off. If fans are operating, stop fans.
    b. Shut IAQ and economizer cooling dampers. Reposition return air damper to 100 percent open.
    c. Stop relief fans and shut relief fan dampers.
    d. Stop exhaust fans and shut exhaust fan dampers.
    e. Close relief air hoods.

L. Typical Duct Static Pressure Monitoring and Shutdown:

1. Duct Static Pressure Monitoring:

    a. Generate "<Unit tag> Duct Static Pressure High/Low" maintenance alarm if duct pressure falls outside setpoint tolerance, plus or minus 0.05 inches W.C.
    b. Provide three-minute alarm time delay (adjustable) to prevent spurious alarms.

2. If ventilating system duct supply static pressure increases to High Duct Static Pressure alarm point (3.0 inches W.C. adjustable):

    a. Command the applicable ventilating system to Full Shutdown Mode.
    b. Provide "<Unit tag> High Static Pressure" alarm.

3. Provide BAS software reset to reinitiate AHU ventilation system restart sequence.

M. Typical Low Temperature Shutdown:

1. Stop fan and close outside air damper if discharge supply temperature is less than 40 degrees F.

2. Provide “<Unit tag> Low Temperature” alarm to BAS.
3. Provide BAS software reset to initiate the system restart sequence.

N. Typical Air Filter Monitoring:

1. Provide differential pressure sensor across each filter bank. Provide high pressure alarms at set point (adjustable) as indicated in the sequences or as directed.
2. Pre-Filter Banks:

    a. Differential pressure range is 0.28 inches W.C. (clean) to 0.90 inches W.C. (dirty) at 500 feet per minute.
    b. Generate "<Unit tag> High Filter Differential Pressure" alarm at 0.80 inch W.C.

3. Final Filter Banks:

    a. Differential pressure range is 0.38 inches W.C. (clean) to 1.5 inches W.C. (dirty) at 300 feet per minute.
    b. Generate "<Unit tag> High Filter Differential Pressure" alarm at 1.30 inch W.C.

O. Typical Zone VAV Temperature Control with Reheat:

1. Zone Sensors: Provide wall-mounted zone thermostat with input to zone VAV terminal equipment controller.
2. Provide duct-mounted supply-air temperature sensors downstream of each reheat coil.
3. Occupied Mode Operation:

    a. Cooling Mode: Modulate the VAV terminal unit control damper between minimum CFM and maximum cooling CFM to maintain zone normal setpoint temperature plus or minus one degree F. Reheat coil control valves remain shut.
    b. Heating Mode: Modulate the VAV terminal unit control damper between minimum CFM and maximum heating CFM to maintain zone normal setpoint temperature plus or minus one degree F. Modulate VAV reheat coil control valve in parallel with control damper.
    c. Limit the discharge air temperature to 20 deg F greater than the room temperature.

4. Unoccupied Mode Operation:

    a. Heating Mode: When AHU is operating, modulate VAV terminal unit control damper between Minimum CFM and maximum heating CFM to maintain zone setback temperature plus zero, minus three degrees F. Modulate VAV reheat coil control valve in parallel with control damper.
    b. Cooling Mode: Ventilation system remains off regardless of zone temperature.

P. Typical Zone Temperature Monitoring:

1. Generate “<location> Zone Temperature High/Low” maintenance alarm if any zone temperature is not being maintained within setpoint band tolerance.

3.9 MECHANICAL ROOM VENTILATION SYSTEM

A. Existing sequence to remain.

3.10 TELECOMMUNICATIONS & ELECTRICAL ROOMS AIR-CONDITIONING SYSTEMS (AC-1/CU-1, AC-2/CU-2)

A. Operate air conditioning systems utilizing package microprocessor control systems. Monitor general fault alarm through BAS.

3.11 HYDRONIC HEATING SYSTEM OPERATION

A. General System Description:

1. The hydronic heating system consists of two identical condensing hydronic boilers (BLR-1 and BLR-2) each sized for approximately 60 percent of the building's and parking garage's design heating load.
2. Heating loop lead/standby pumps PMP-1/PMP-1A provide variable speed circulation to VAV box reheat coils, cabinet unit heaters, unit heaters, radiant ceiling panels, and fin tube throughout the facility. Each pump is sized to handle 100 percent system zone flow.
3. Water heater loop lead/standby circulation pumps PMP-2/PMP-2A provide heating glycol fluid to the domestic water heaters (WH-1, WH-2). Each pump is sized to handle 100 percent system flow.
4. Boiler circulation pumps PMP-3/PMP-3A provide circulation to each of the boilers.

B. Coordination with Packaged Boiler Controls:

1. Coordinate connection of the BAS to the packaged controller.
2. Provide boiler plant enable/disable control via the BAS. Boiler sequencing is controlled by the Aerco Boiler Control System (ACS).

C. Full Shutdown Mode (Initial conditions):

1. Both boilers off.
2. Heating pumps off (PMP-1/PMP-1A).
3. Water heater loop circulator pumps off (PMP-2/PMP-2A).
4. Boiler circulator pumps off (PMP-3/PMP-3A).

D. Operating Mode:

1. System Enable and Startup:

a. Enable heating system pumps to run.
b. Start lead loop circulator pump (PMP-1 or PMP-1A).
c. After loop flow has been established for 10 minutes, enable boiler operation via boiler controller (ACS).

2. Boiler and Pump Control:

   a. Boiler lead-lag and staging control is provided by the ACS.
   b. Provide lead/standby control for loop circulators (PMP-1/ PMP-1A). Alternate lead pump during the heating season. Operate pumps with lead pump in "run" and standby pump in "standby." If lead pump fails to start as determined by analog current sensor, disable lead pump and start standby pump.

3. Boiler Operation:

   a. Supply temperature is determined by the BAS and sent to the ACS.
   b. Hydronic heating system supply temperature is reset according to the following table.

Hydronic System Temperature Reset Schedule	
Outside Air Temperature	**Heating Loop Water Temperature Setpoint**
60 Degrees F.	120 Degrees F.
10 Degrees F.	160 Degrees F.

   c. Monitor facility heating zones:

      1). If any zone is in 100 percent heating and cannot maintain zone setpoint temperature, reset Hydronic System Supply Temperature Setpoint up 2 degrees every 15 minutes until zone's heating calculation stabilizes at 80 percent.
      2). Record final Hydronic System Supply Temperature Setpoint and outside air temperature. Adjust Hydronic System Supply Temperature Reset Schedule to new outside air temperature and Hydronic System Supply Temperature Setpoint (adaptive learning routine).

   d. Boilers fire under the control of the boiler on-board combustion management system to maintain remote header temperature setpoint.
   e. Sequencing of individual boilers within the boiler plant is controlled by the ACS.
   f. Flow through standby boilers is isolated from the system loop via 2-way motorized isolation valves controlled by boiler manufacturer's control panel.
   g. Connect boiler supply and return header temperature sensors to the ACS.
   h. Connect boiler supply and return header temperature sensors to the BAS.
   i. Connect ACS outside air temperature sensor to the panel for use in the building hydronic heating supply water temperature reset control.
   j. Establish original boiler reset schedule within the ACS. This schedule will be used by the ACS if communication with the BAS is lost. This schedule will not be reset by the BAS adaptive learning routine.

      1). Coordinate with boiler manufacturer’s representative and adjust setpoints and time constants in accordance with manufacturer’s recommendations.
      2). Coordinate with Section 23 5216 and connect the ACS to the BAS through the BAS interface furnished with the ACS.

k. Coordinate with boiler manufacturer's representative and adjust setpoints and time constants in accordance with manufacturer's recommendations.
l. Coordinate with Section 23 5216 and connect the ACS to the BAS through the BAS interface furnished with the ACS.

4. System Shutdown:

a. Initiate Full Shutdown Mode in the following events:

1). Manual "off" mode.
2). Low water cutoff shutdown of any boiler.

E. Variable Speed Hydronic Pump Control (PMP-1 and PMP-1A):

1. Provide and locate separate differential pressure sensors as indicated on the drawings (two sensors).
2. Adjust VSD controller output to modulate pump speed between 30 percent and 100 percent flow to maintain the lowest-reading differential pressure sensor at setpoint pressure. Initial pressure setpoint is 5 PSIG. Setpoint to be adjusted during Testing, Adjusting and Balancing.
3. In the event of VSD failure, enable and run standby pump.

F. Hydronic System Monitoring and Alarm:

1. Boiler safeguard alarms (BLR-1 and BLR-2): Generate a separate "BLR-X Flame Failure" alarm if any boiler is shut down by its flame safeguard control system.
2. Display Status and Alarms obtained through the ACS interface. Translate Fault Codes into English Language description of fault.

a. Header Temperature.
b. Outside Air Temperature.
c. Fire Rate Out.
d. Header Setpoint Temp.
e. Total Boilers Fired.
f. Fault/Message Code.
g. Lead Boiler Number.
h. Boiler 1 Status.
i. Boiler 2 Status.
j. Return Sensor Temperature.
k. Net Boiler 1 Outlet Temp.
l. Net Boiler 2 Outlet Temp.
m. Net Boiler 1 Code (Fault).
n. Net Boiler 2 Code (Fault).

3. Heating loop pump trouble alarms (PMP-1/PMP-1A):

a. Monitor current for each pump through VSD. Refer to Typical VSD sequence.
b. Generate an alarm if pumps fail to operate in their normal sequence, i.e. alarm if:

1). Both pumps are off when system is in operating mode.
2). Lead pump fails to operate and system switches to standby pump.

3). Both pumps are running.

4. Heating water temperature alarm: Generate an alarm if heating water supply temperature is not maintained within 5 degrees F (adjustable; averaged over a 15 minute period).
5. Hydronic system low pressure alarm:

a. Monitor both the heating loop and the glycol heating loop systems pressures with analog sensor pressure sensors.
b. Generate a separate low-pressure alarm if any system pressure falls below 10 PSIG.

G. Domestic Water Heating Loop System (PMP-2/PMP-2A):

1. General System Description:

a. System provides heated glycol to the indirect water heater heating coils.
b. System consists of variable speed pumps (PMP-2/PMP-2A) with each sized for 100 percent of system flow through the water heaters. Lead/standby pumps PMP-2/PMP-2A circulate heated glycol through the indirect water heater heating coils.

2. System Shutdown (Initial conditions):

a. System circulator pumps off (PMP-2/PMP-2A).
b. Refer to Hydronic System Full Shutdown Mode.

3. Operating Mode:

a. Normal system operation:

1). Variable speed glycol circulation pumps (PMP-2/PMP-2A):

a) Enable lead pump when an WH is operating and calls for heat.
b) Adjust ECM controller output to modulate pump speed between 30 percent and 100 percent flow to maintain the water heater setpoint. Initial differential pressure 5 PSIG.
c) In the event of ECM failure, switch to the standby pump.

4. Monitoring and Alarms:

a. Pump trouble alarms (PMP-2/PMP-2A).

1). Monitor current for each pump through the ECM.
2). Generate an alarm if pumps fail to operate in their normal sequence, i.e. alarm if:

a) Both pumps are off when system is in operating mode.
b) Lead pump fails to operate and system switches to standby pump.
c) Both pumps are running.

3.12 SNOWMELT SYSTEM

A. Existing sequence to remain.

3.13 HYDRONIC HEATING SYSTEM DEVICES

A. Air Handler Heating Coils (RTU-1 and RTU-2): See ventilation system control sequences.

B. Zone VAV Terminal Reheat Coils (RTU-1): See ventilation system control sequences.

C. Zone VAV Terminal Reheat Coils (RTU-2): Existing ventilation system control sequences to remain.

D. Hydronic Unit Heaters:

1. At 60 degrees F. (adjustable) and decreasing, start recirculating fan and open two-way hydronic control valve.
2. At 62 degrees F. (adjustable) and increasing, stop recirculating fan and shut two-way hydronic control valve.

E. Radiant Ceiling Panels:

1. At 68 degrees F. (adjustable) and decreasing, open two-way hydronic control valve.
2. At 70 degrees F. (adjustable) and increasing, shut two-way hydronic control valve.

3.14 PLUMBING

A. Domestic Hot Water Circulation Pump (PMP-4):

1. Turn pump on at 6 a.m. (adjustable).
2. Turn pump off at 9 p.m. (adjustable).
3. Monitor status of circulator pump and generate a pump specific alarm if the pump fails to operate in its normal sequence.

B. Domestic Water Heater (WH-1 and WH-2).

1. Utilize packaged water heater controls.
2. Set aquastat to 140 degrees F. (adjustable).

C. Industrial Water Heater and Circulation Pump (WH-3 and PMP-9).

1. Utilize packaged water heater controls.
2. Set aquastat to 125 degrees F. (adjustable).
3. Operate pump based on in-line aquastat, set to energize pump at 118 degrees F. (adjustable) and deenergize pump at 124 degrees F. (adjustable).
4. Monitor status of circulator pump and generate a pump specific alarm if the pump fails to operate in its normal sequence.

END OF SECTION 259000

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Specific requirements, products, and methods of execution relating to the provision of fuel gas systems for the project.

B. Related Sections:

1. 200000 - Mechanical General Requirements
2. 200529 - Mechanical Hangers and Supports
3. 200553 - Mechanical Identification
4. 225216 - Condensing Boilers and accessories

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. NFPA 54 - National Fuel Gas Code.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. This section describes specific requirements, products and methods of execution for interrelated systems necessary for the distribution of natural gas within the building.
2. Provide products including above and below ground piping, connections to gas burning apparatus, and work at the gas source to provide complete fuel gas systems where required. Provide gas equipment pressure regulator vents to outside the building at fuel gas trains.

B. Performance Requirements:

1. Gas service and meter are existing to remain.
2. Verify natural gas service volume and pressure to the building as shown on drawings.

1.4 PRE-INSTALLATION MEETINGS

A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data: Provide manufacturers' product literature for items specified in Part 2 and those products required by the performance standards of this section, clearly annotated to indicate specified salient features and performance criteria.

C. Shop Drawings: Submit dimensioned shop drawings of gas piping size and routing as part of the plumbing shop drawings, with callouts indicating deviations from layout shown.

D. Test and Evaluation Reports:

1. Obtain a certificate of final inspection from the Contracting Agency.
2. Submit a letter of certification with copy of certificate of final inspection, indicating that the gas piping has been completed, tested, and inspected.

E. Quality Control Submittals: Provide a certified test report showing the system has been tested in accordance with Code requirements and is in compliance.

1.6 CLOSEOUT SUBMITTALS:

A. See Section 200000 - Mechanical General Requirements.

B. Record Documentation: Record actual locations of equipment, piping, and components, and areas required for maintenance access.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

A. See Section 200000 - Mechanical General Requirements.

B. Regulatory Requirements: NFPA 54.

1.9 DELIVERY, STORAGE, AND HANDLING

A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 PIPING

A. Above ground, pressure less than 14 inches water column:

1. Schedule 40 black steel pipe.
2. Welded or threaded black malleable iron fittings.
3. Corrugated Stainless Steel Tubing (CSST):

a. CSST complying with ASTM A 240, 125 PSIG maximum operating pressure and 200 degrees F maximum operating temperature.
b. Fittings and appurtenances by same manufacturer as CSST product.
c. Manufacturer: OmegaFlex TracPipe PS-II, or approved equal.

B. Above ground, pressure greater than or equal to 14 inches water column:

1. Welded schedule 40 black steel pipe.
2. Welded schedule 40 steel fittings.

2.2 BALL VALVES

A. Brass or bronze construction, threaded ends, 600 PSIG rating, listed for natural gas service.

2.3 ZONE VALVE BOX

A. Provide 18 gauge steel box with white epoxy finish and brackets to mount box to studs. Size of box shall be specifically designed to house the natural gas isolation valve. The valve box shall have an opaque cover with pull ring for easy removal. The cover shall have view ports to observe the valve and label. Valves shall be oriented so cover cannot be installed with any valve closed. The valves inside and the cover shall be labeled per NFPA 99.

B. Manufacturers: Tri-Tech Medical Z Series, Parker/Porter, or equal.

PART 3 - EXECUTION

3.1 INSTALLERS

A. Installer: Perform work by experienced personnel under the supervision of a qualified installation supervisor.

3.2 PREPARATION

A. Protection of In-Place Conditions: Plug piping connections for protection from construction dirt and debris.

B. Surface Preparation: Prior to installation of stacks, verify that shop drawings are approved and stack locations and routing have been coordinated with other trades.

3.3 INSTALLATION

A. Special Techniques:

1. Install equipment in accordance with manufacturer's instructions and requirements of the codes specified herein.
2. Arrange products to be readily accessible for inspection, testing, and shutting off gas supply.
3. Install pipe and fittings clean and free from cuttings, burrs, and defects in structure of threading, and thoroughly brushed and scale blown.
4. Do not install any piping in concrete, in masonry, or below grade inside the building.
5. Provide connection to gas consuming appliances. Connect gas appliances and fixtures with flexible connectors in accordance with the requirements of the appliance listing and manufacturer's instructions.
6. Provide independent gas pressure relief pipes to outside the building from each fuel gas train. Size and install reliefs in accordance with the written UL listing installation instructions. Gang piping to penetrate exterior building skin at a common location. Terminate relief vents not less than 10 feet from openings to the building and not less than 25 feet from building outside air intakes.

B. Interface with Other Work: Coordinate and sequence installation of gas piping and equipment with trades responsible for portions of this and other related sections of the Project Manual.

3.4 REPAIR/RESTORATION

A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.

B. Substitute replacement parts from other manufacturers are not acceptable.

3.5 RE-INSTALLATION

A. Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

3.6 SITE QUALITY CONTROL

A. Site Test and Inspections:

1. Test gas piping before connection to the gas source. Do not enclose or conceal any untested portion of the gas system.
2. Test piping in accordance with IFGC requirements.

B. Non-Conforming Work: Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

3.7 CLEANING

A. Clean gas piping, fittings, valves, etc., of grease, rust, dust and dirt.

END OF SECTION 231123

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings for:
    a. Hydronic heating piping.
    b. Equipment drains and overflows.
2. Piping accessories.
3. Flexible pipe connectors.
4. Pipe loops, offsets, alignment guides.
5. Hydronic Specialties:
    a. Expansion tanks.
    b. Air vents.
    c. Air separators.
    d. Strainers.
    e. Flow indicators, controls, meters.
    f. Flushing agents.
    g. Water treatment chemicals.
    h. Glycol specialties.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 200700 - Mechanical Insulation
7. 204100 - Mechanical Demolition
8. 230593 - Testing, Adjusting and Balancing
9. 232123 - Hydronic Pumps
10. 233600 - Air Terminal Units
11. 235216 - Condensing Boilers and Accessories
12. 237413 - Packaged Rooftop Units
13. 238132 - Storage Vault HVAC Equipment
14. 238200 - Terminal Heating and Cooling Units
15. 253000 - Building Automation System Field Devices
16. 255000 - Building Automation System
17. 259000 - Sequence of Operations

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. ANSI/ASHRAE/IENA Standard 90.1-2001 Energy Standard for Buildings Except Low-Rise Residential Buildings.
3. ASME Boilers and Pressure Vessel Code (1998), Sections IV & VI.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:
1. This section describes specific requirements, products, and methods of execution for the system of liquid heat transfer throughout the project. The system of heat generation is specified elsewhere.
2. Design expansion compensation system to adequately protect piping and structure from thermal expansion and contraction forces.

B. Performance Requirements:

1. Provide performance and output shown or scheduled on drawings.
2. Provide loops, pipe offsets, and swing joints, or expansion joints where required or indicated.
3. Pipes shall be capable of thermal expansion movement without disengagement of supports or forces on equipment connections.
4. Provide structural work and equipment required to control expansion and contraction of piping. Verify that anchors, guides, and expansion joints provided, adequately protect system.
5. Expansion Calculations:

a. Installation Temperature: 40 degrees F.
b. Hot Water Heating: 210 degrees F.
c. Domestic Hot Water: 140 degrees F.
d. Safety Factor: 30 percent.

1.4 PRE-INSTALLATION MEETINGS

A. See section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data:

1. Submit product literature for items specified in Part 2 and those products required by the performance standards of this section. Literature clearly annotated to indicate specified salient features and performance criteria.
2. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot (meter) and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
3. Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.
4. Submit selection calculations for expansion joints and compensators.
5. Design Data: Submit calculations for performance specified products and systems.

C. Shop Drawings:

1. Submit shop drawings for performance-specified products and systems.
2. Submit shop drawings for piping systems to demonstrate proper layout and coordination.
3. Provide shop drawings to show system layout with location and detail of flexible pipe connectors and expansion joints.
4. Drawings of boiler room, fan rooms, and other areas with high-density piping, shall be shown at 1/4-inch scale or larger.
5. Indicate elevation of piping above finish floor.
6. Indicate dimensions and weights of equipment, and placement of openings and holes.
7. Include reference to ductwork and other equipment where space coordination is necessary to avoid conflicts.
8. Indicate mechanical and electrical service locations and requirements.

D. Manufacturer Reports:

1. Certificates, Manufacturer’s Instructions, and Manufacturer’s Field Reports:

a. Provide a complete manufacturer’s written installation, operation and maintenance manual for each type of installed equipment. Annotate the manual to indicate applicable information for the specific equipment model(s) installed.
b. Included with the manual one copy of the completed start-up and operation checklist. The checklist shall include:

1). Printed names and signatures of the installers.
2). Documentation from Manufacturer’s representative and Contracting Agency that the equipment has been properly installed and is fully operational, thus validating the equipment warranty.

2. Test reports:

a. Provide certificate that cleaning of hydronic systems has been accomplished.

b. Provide certificate listing satisfactory results for the hydrostatic pressure tests.
c. Provide certificate listing satisfactory results for the operational tests.

3. Submit a letter to document that the training was conducted. Include in the letter the date, start/stop times for the training, list of attendees and signature/title of the person(s) providing the training.

E. Quality Control Submittals: Refer to Section 019100 - Commissioning for submittal requirements.

1.6 CLOSEOUT SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

B. Operation and Maintenance (IO&M) Manuals:

1. Refer to Section 200000 - Mechanical General Requirements, for IO&M Manual formatting requirements and number of copies required.
2. Include the following:

a. Copies of approved submittal information.
b. Manufacturer's installation, operating and maintenance/repair instructions, parts listings, and spare parts list for each product. Annotate the manual to indicate applicable information for the specific equipment model(s) installed.
c. Computer software manuals and applicable licenses.
d. Completed start-up and operational test report as required to validate equipment warranty.
e. Start-up and operational test reports for each piece of equipment. Report shall include printed names and signatures of the installers and documentation that the equipment has been properly installed and is fully operational, thus validating the equipment warranty.

C. Record Documentation: Record actual locations of equipment, valves, strainers, air vents, flexible pipe connectors, expansion joints, other components, and locations of access doors required for maintenance access in accordance with Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

A. See Section 200000 - Mechanical General Requirements.

1.9 DELIVERY, STORAGE, AND HANDLING

A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Water Systems:

1. Copper pipe three inches and smaller:

a. Type L copper, wrought copper fittings.
b. Fit joints using 430 silver solder, 95-5 tin-antimony or other approved lead-free solder. Solder type must be compatible with pipe and fittings. Solder containing lead shall not be allowed on the job site.
c. Soldering flux: Water flushable, low corrosivity type meeting the requirements of ASTM B813. Flux shall have label indicating it meets these requirements.
d. Extracted branch joints (T-Drill) may be approved when Contractor can demonstrate satisfactory experience with this method. Joints shall be brazed in accordance with the Copper Development Association Copper Tube Handbook using B-Cup series filler metal.

2. Steel pipe four inches and larger: Welded pipe and fittings.

a. Grade B, seamless, ASTM A53 or A106.
b. Schedule 40 black with ANSI B16 butt weld fittings of type and wall thickness to suit pipe.

3. Galvanized piping is not permitted.

B. Glycol Systems (Copper or Steel Option):

1. Copper pipe three inches and smaller:

a. Type L copper, wrought copper fittings.
b. Fit joints using 430 silver solder, 95-5 tin-antimony or other approved lead-free solder. Solder type must be compatible with pipe and fittings. Solder containing lead shall not be allowed on the job site.
c. Soldering flux: Water flushable, low corrosivity type meeting the requirements of ASTM B813. Flux shall have label indicating it meets these requirements.
d. Extracted branch joints (T-Drill) may be approved when Contractor can demonstrate satisfactory experience with this method. All joints shall be brazed in accordance

with the Copper Development Association Copper Tube Handbook using B-Cup series filler metal.

2. Steel pipe four inches and larger: Welded pipe and fittings. No threaded pipe allowed.

   a. Grade B, seamless, ASTM A53 or A106.
   b. Schedule 40 black with ANSI B16 butt weld fittings of type and wall thickness to suit pipe.

3. Viega ProPress copper press-fit joint-type pipe systems are not permitted.
4. Victaulic mechanical joint-type pipe systems are not permitted.
5. Galvanized piping is not permitted.

C. Copper Press Fitting System:

1. Limited to tubing sizes 4 inch and smaller.
2. Cast or wrought copper fittings, ASME B16.51. Pre-formed grooves with pre-lubricated EPDM O-rings designed to seal fitting to copper tubing water tight with the use of manufacturer's crimping tool. Fittings shall be rated for 250 Degrees F., and 200 psi.
3. IAPMO UPC listing.
4. Manufacturer: Viega ProPress, NIBCO Press System, no substitutions.

D. Equipment drains and overflows: Type L copper pipe, wrought copper fittings.

2.2 VALVES

A. Select valves of the best quality and type suited for the specific service and piping system used. Minimum working pressure rating 125 PSIG saturated steam or 200 PSIG WOG. Packing material or seals shall not contain asbestos.

A. Manufacturers: Crane, Nibco, Hammond, Jenkins, Grinnell, Milwaukee, Stockham.

B. Ball Valves 2 inch and smaller: Two piece type, full port, bronze body and silicone bronze ball or chrome plated brass ball, TFE seats, blowout proof stem, 150 PSIG pressure/temperature rating (steam).

C. Ball Valves 2-1/2 inches through 4 inch: Two piece type, full port, bronze body and silicone bronze ball or chrome plated brass ball, TFE seats, 150 PSIG pressure/temperature rating (steam). May be substituted for gate valves except where otherwise indicated.

B. Gate Valves, two inch and smaller: Bronze body and trim, rising stem, solid wedge. Use only where shown on drawings.

C. Gate valves, six inch and larger: Iron body bronze trim, flanged. Rising stem: OS&Y, or non-rising stem with solid wedge.

D. Globe Valve two inch and smaller: Bronze body, renewable disc suitable for service.

E. Globe or Angle Valve 2-1/2 inch and larger: Iron body, bronze trim, flanged, bronze disc. Bronze valves optional for 2-1/2 inch and three-inch.

F. Swing Check Valves two inch and smaller: Bronze body, horizontal swing, Y-pattern, Buna-N-disc for water, oil and gas. TFE disc for steam.

G. Swing Check Valves 2-1/2 inch and larger: Iron body, horizontal swing, bolted bonnet, renewable bronze seat and disc, flanged or grooved. Bronze valves optional for 2-1/2 inch and three-inch.

H. Drain Valves: Full port ball valve with threaded hose adapter with bronze end cap. Do not use sillcocks or butterfly valves as drain valves.

I. Valves Specified Elsewhere: Provide special valves such as motor-operated valves, relief valves, temperature regulating valves, etc., as specified under the individual system, or as indicated on the drawings.

2.3 UNIONS (STANDARD)

A. Steel Piping (Threaded):

1. Class 150 (150 PSIG steam, 300 PSIG WOG) malleable iron, ground joint, ASME B1.20.1, ASME B16.39. McMaster-Carr.
2. Where indicated: Class 250 malleable iron ground joint, copper or copper alloy seat. McMaster-Carr.

B. Copper Piping (Sweat): Cast bronze, ASTM B584 Alloy C84400, copper to copper. Nibco No. 733.

2.4 DIELECTRIC ISOLATORS (ELECTRICALLY INSULATING)

A. Provide dielectric unions for two inch pipe and smaller.

B. Provide dielectric flanges for 2-1/2 inch pipe and larger.

C. Insulating gaskets shall be suitable for fluid type, temperature and pressure.

D. Galvanized pipe to copper: Brass threaded end and sweat copper end.

E. Black steel to copper: Zinc plated steel threaded end and sweat copper end.

F. Manufacturers: Capitol, Epco, Control Plastics, Watts, or approved equal.

2.5 PRESSURE GAUGES

A. Provide where shown on drawings, specified in Part 3, or as required.

B. Bourdon tube type with 4-1/2-inch dial (minimum) accuracy plus or minus one-percent span, recalibratable. Normal operating pressure near midpoint of range. Industrial quality.

C. Gauge cock on gauges and pulsation damper (snubber). Steam gauges shall have siphon to isolate gauge from steam, except where remotely mounted and connected by looped tubing.

D. Differential pressure gauges shall be piston or diaphragm type with range suitable for application and static pressure capability suitable for system pressure. Orange Research.

2.6 THERMOMETERS

A. Provide where shown on drawings, specified in Part 3, or as required.

B. Liquid in glass type: Industrial quality blue-reading with nine-inch scale length (minimum). Straight angle or adjustable as necessary for visibility. Trerice, Marsh, Weksler, or approved equal.

C. Dial Type: Industrial quality three-inch dial with a 270 degrees (minimum) scale. Straight, angle or remote as necessary for visibility. Trerice, Marsh, Weksler, or approved equal.

D. Digital, self-powered type: Weiss DVU or equal.

E. Normal operating temperature at scale midpoint and sufficient range to cover operating conditions.

F. Provide separable wells of suitable material for piping and mounting hardware for ducts. Set probe in heat transfer paste recommended by thermometer manufacturer.

2.7 PRESSURE AND TEMPERATURE TEST PLUGS

A. Provide where shown on drawings, specified in Part 3 or as required.

B. Standard type for 1/8-inch diameter pressure or temperature probes. Self seal when probe removed and complete with threaded cap. Minimum continuous rating 125 PSIG and 220 degrees F coincident. Sealing element suitable for fluid in pipe.

C. Provide one thermometer and one pressure gauge for each range required by system parameters.

D. Manufacturers: Sisco, Peterson Equipment, or approved equal.

2.8 FLEXIBLE PIPE CONNECTORS

A. General:

1. System Application: Hot water heating or 50 percent propylene glycol solution (heating) or 30 percent propylene glycol solution (cooling).
2. System Maximum Operating Temperature: 210 degrees F.
3. Pressure: Internal.
4. Installation: Straight or Offset as shown.
5. Movement: Constant or Intermittent.
6. Maximum offset: Not to exceed 25 percent of the centerline bend radius.
7. Determine appropriate minimum “live hose length” (flexible portion of assembly) based on the centerline bend radius for each application in accordance with manufacturer’s sizing tables.

B. Copper Pipe Flexible Connectors - Small Diameter (Sweat):

1. Size: 3/4 inch through 2-1/2 inch nominal pipe size (NPS).
2. Pipe Ends: Copper tube sweat.
3. Corrugated Hose: Bronze.
4. Outer Braid: Single braided bronze.
5. Minimum Working Pressure Rating: 120 PSIG at 250 degrees F.
6. Maximum Temperature Rating: 250 degrees F.

C. Copper Pipe Flexible Connectors - Small Diameter (Removable):

1. Size: 3/4 inch through 2-1/2 inch nominal pipe size (NPS).
2. Pipe Ends: Female pipe coupling, Female union, Male Hex Nipple, Male Pipe with Hex Nut.
3. Corrugated Hose: Bronze.
4. Outer Braid: Single braided bronze.
5. Minimum Working Pressure Rating: 120 PSIG at 250 degrees F.
6. Maximum Temperature Rating: 250 degrees F.

D. Steel Pipe Flexible Connectors - Small Diameter (welded):

1. Size: 3/4 inch through 2-1/2 inch nominal pipe size (NPS).
2. Pipe Ends: Weld nipple.
3. Corrugated Hose: Bronze.
4. Outer Braid: Single braided bronze.
5. Minimum Working Pressure Rating: 300 PSIG at 250 degrees F.
6. Maximum Temperature Rating: 250 degrees F.

E. Steel Pipe Flexible Connectors - Small Diameter (Removable):

1. Size: 3/4 inch through 2-1/2 inch nominal pipe size (NPS).
2. Pipe Ends: Schedule 40 steel with male pipe thread (MPT).
3. Corrugated Hose: Bronze.
4. Outer Braid: Single braided bronze.
5. Minimum Working Pressure Rating: 300 PSIG at 250 degrees F.
6. Maximum Temperature Rating: 250 degrees F.

F. Steel Pipe Flexible Connectors - Large Diameter:

1. Size: 3 inch through 10 inch nominal pipe size (NPS).
2. Pipe Ends: 150 LB plate steel flat faced flange.
3. Corrugated Hose: Type 304 stainless steel.
4. Outer Braid: Single braided Type 304 stainless steel.
5. Minimum Working Pressure Rating: 150 PSIG at 250 degrees F.
6. Maximum Temperature Rating: 250 degrees F.

G. Manufacturers: Metraflex, Keflex, or equal.

2.9 ACCESSORIES

A. Pipe Alignment Guides:

1. Two piece welded steel with enamel paint, bolted, with spider to fit standard pipe, frame with four mounting holes.
2. Clearance for minimum one inch thick insulation.
3. Minimum three inches travel.

2.10 EXPANSION TANKS

A. General:

1. Performance as scheduled.
2. Full acceptance flexible heavy duty butyl removable bladder or flexible heavy duty butyl diaphragm sealed into tank, as scheduled.

B. Construction:

1. Designed, tested and stamped in accordance with ASME SEC 8-D standards; supplied with National Board Form U-1.
2. Welded steel shell and base.
3. Forged steel system connections.
4. Steel support stand.

C. Ratings:

1. Working pressure: 125 PSIG.
2. Working Temperature: 240 degrees F.
3. Precharge: As Scheduled.

D. Accessories:

1. Pressure gage.
2. Air charging fitting.
3. Tank drain isolation valve.
4. System connection isolation valve.

E. Model and size: As scheduled.

F. Manufacturers: Taco, Amtrol, Armstrong, Bell & Gossett, or equal.

2.11 AIR VENTS

A. Coin operated vent: Manual low profile vent for use in baseboard and other enclosures where automatic vent will not fit. 150 PSIG working pressure, 212 degrees F. operating temperature. Bell & Gossett No. 4V or approved equal.

B. Float Type:

1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
2. Iron body and cover, float, bronze pilot valve mechanism suitable for system operating temperature and pressure; with isolating valve.
3. Operating pressure 150 PSIG, 250 deg F maximum temperature, intended for use in hot or cold lines. Provide ball type isolation valves for air vents that do not have integral shut off valves.
4. Manufacturers: Spirotherm Spirotop, Honeywell EA791004, or equal.

C. Disc Type:

1. Designed to be replaced without removal from line, with built-in check valve.
2. Limited to baseboard, unit ventilators, cabinet unit heaters, convectors, and elsewhere where air vent must be installed in a cabinet or enclosure, unless other type detailed on drawings.
3. Maximum working pressure: 50 PSIG.
4. Manufacturer: Hoffman No. 500, or equal.

2.12 AIR SEPARATORS

A. Construction:

1. Designed, tested and stamped in accordance with ASME standards.
2. Welded steel shell with flanged connections.
3. Entering velocity not to exceed 4 feet per second.
4. Internal copper wound coalescing eliminator.
5. Top venting chamber with integral full port float actuated brass venting mechanism.
6. Side tap with valve to flush dirt or liquids and quick air bleed.

B. Ratings:

1. Working pressure: 150 PSIG (minimum).
2. Working Temperature: 125 degrees F (minimum).
3. Capable of removing 100 percent of free air, 100 percent of entrained air, and 99.6 percent of dissolved air in the system fluid.
4. Dirt separation of at least 80 percent of all particles larger than 30 micron and larger within 100 passes.

C. Size: As scheduled.

D. Manufacturer: Spirotherm VDX (Basis of Design), B&G CRS, Wessels.

2.13 STRAINERS

A. Size two inch and under:

1. Screwed brass or iron body for 175 PSIG working pressure.
2. Y pattern with 1/32-inch stainless steel perforated screen.

B. Size 2-1/2 inches to four inches:

1. Flanged or grooved iron body for 175 PSIG working pressure.
2. Y pattern with 3/64-inch stainless steel perforated screen.

C. Size five inches and larger:

1. Flanged or grooved iron body for 175 PSIG working pressure.
2. Basket pattern with 1/8-inch stainless steel perforated screen.

D. Manufacturers: Metraflex, Armstrong, Crane, Hayward, Watts Regulator, Hoffman, Sarco.

2.14 AUTOMATIC FLOW LIMITING AND ISOLATION VALVES

A. Supply pipe side: Brass alloy body with stainless steel flow cartridge assembly, integral ball valve, 20 mesh strainer element, two pressure/temperature test valves and drain valve with hose bibb adapter and end cap. Body design allows removal of flow cartridge without disturbing piping connections. Threaded sweat adapter inlet. Union with sweat adapter outlet.

B. Return pipe side: Forged brass body with integral ball valve, pressure/temperature test valve and manual air vent. Union with sweat adapter inlet. Threaded sweat adapter outlet.

C. Calibration: Control flow within five percent of selected rating, over operating pressure range of at least 10 times minimum pressure required for control. Provide three operating pressure ranges with a minimum range requiring less than 3.5 PSID to actuate flow control cartridge.

D. Flow Control Cartridge: Stainless steel one piece cartridge with segmented port design and full travel linear coil spring.

E. Provide supply and return components packaged as a system and labeled in accordance with the equipment schedule tag to match terminal heating unit served.

F. Manufacturer: Griswold Controls, Bell & Gossett, or approved equal.

2.15 BALANCING VALVES

A. Provide calibrated plug or ball valve type balancing valves with self-sealing quick connect pressure taps, scale and locking device. Include schedule with submittal.

B. Manufacturers: Bell & Gossett, Taco, or equal.

2.16 FLUSHING AGENT

A. Synthetic organic dispersant manufacturer: CH2O, Product 6149 or approved equal.

2.17 WATER TREATMENT

A. Hydronic loop treatment manufacturer: CH2O, Product 6439 or approved equal.

2.18 GLYCOL SYSTEMS

A. Provide equipment and products specifically designed and approved for continuous operation with the glycol solution specified.

B. Glycol Solution:

1. Inhibited propylene glycol solution premixed to 50 percent by volume for use with hydronic heating systems.
2. Fluid analysis test kit.
3. Manufacturer: Dow Chemical Company Dowfrost. No substitutes.

C. Automatic Glycol Make-up System:

1. Provide packaged glycol make-up system as scheduled with single point electrical connection.
2. Fill glycol make-up tank one half full with clean solution after testing and final system check out has been completed.

PART 3 - EXECUTION

3.1 INSTALLERS

A. Installer: Perform work by experienced personnel previously engaged in hydronic system construction and under the supervision of a qualified installation supervisor.

3.2 PREPARATION

A. Protection of In-Place Conditions: Cover equipment and plug piping connections to protect components from construction dirt and debris.

B. Surface Preparation:

1. Prior to installation of equipment, verify concrete housekeeping pads are complete and properly sized for equipment mounting.
2. Prior to installation of piping and equipment, verify that shop drawings are approved, and locations and routing have been coordinated with the work of other trades.

3.3 INSTALLATION

A. Special Techniques:

1. Install equipment in accordance with manufacturer's instructions and requirements of the codes specified herein.
2. Provide finished products with protective covers during balance of construction.
3. Provide accessible ball type isolation valves at major piping branches, and on main lines as shown, and at terminal devices. Provide drains and manual vents at main line and branch line valves to facilitate draining and filling piping sections. Provide caps on drain outlets.
4. Access Doors: Provide appropriate size and install such that hydronic system features are readily accessible and maintainable.
5. Install balancing valves and automatic flow limiting valves to be accessible and adjustable.
6. Install piping to maintain headroom, conserve space, and not interfere with use of space.
7. Use of bullhead tee with opposed flow, double inlet configuration not allowed.
8. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
9. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
10. Prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting. Refer to Division 9 - Finishes.
11. Thermal Expansion:

    a. Install piping to allow for normal thermal expansion and contraction without stressing pipe, joints, or connected equipment.
    b. Provide anchors where necessary and as shown.
    c. Provide support and expansion loops, expansion compensators, and alignment guides to suit conditions and as shown on drawings.
    d. Piping shall be guided and restrained as recommended by the manufacturer.

12. Provide test plugs on both inlet and outlet sides of heat transfer elements to allow measurement of both fluid pressure drop and differential temperature.
13. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.
14. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor the other end. Install in horizontal plane unless indicated otherwise.
15. Provide pipe anchors, offsets, loops and expansion compensators as required to control the expansion of pipelines.

16. Flushing:

    a. Where hydronic piping installed under this project is connected to an existing hydronic system, provide branch isolation valves and provision for cleaning and flushing consisting of tees with valve, hose fittings and caps immediately adjacent to the branch isolation valves.
    b. Clean internal surfaces of the completed heating system as follows:

        1). Flush hydronic piping to remove black magnetic iron oxide and mill scale from the system.
        2). Flush system piping with synthetic organic dispersant to remove grease. Circulate solution through system at 150 degrees F or greater for 12 to 24 hours.

3). Repeat process until the system is clean to the satisfaction of the Contracting Agency.
4). Flush system with fresh water as necessary to remove residual cleaning agent.
5). Exercise proper care during flushing and cleaning of systems to make sure no damage is done to equipment, valves, fittings, or Work of other trades. Restore damaged system components or Work of other trades to new or original condition at no additional cost to Owner.

B. Interface with Other Work: Coordinate and sequence installation of hydronic products with trades responsible for portions of this and other related sections of the Project Manual.

3.4 REPAIR/RESTORATION

A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.

B. Substitute replacement parts from other manufacturers are not acceptable.

C. Touch-up finished surfaces with touch-up paint provided by the equipment manufacturer.

3.5 SITE QUALITY CONTROL

A. Non-Conforming Work: Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

B. Manufacturer Services:

1. Verify units are installed and operational in accordance with the manufacturer's written installation instructions.
2. Both the Contractor and Manufacturer's Representative(s) shall sign start-up and operational checklist to confirm proper unit installation and operation.
3. Provide samples of the inhibited propylene glycol solution to the manufacturer for testing using the fluid analysis test kit provided.
4. The manufacturer of the inhibited propylene glycol solution shall provide free testing of the solution 24 hours after system startup and again 90 days later to verify proper fluid performance for both tests.
5. Provide one copy of manufacturer's test reports to the Owner. Adjust fluid concentration and/or correct deficiencies as addressed in the report.

C. Hydronic System Cleaning and Treatment Coordination Meeting:

1. Conduct a meeting prior to flush cleaning and treatment of the hydronic heating system to discuss cleaning agents, treatment chemicals and procedures to be used. Discuss system fill procedures with inhibited propylene glycol solution.
2. Participants shall include the Contractor and Subcontractor directly performing the work and the Owner's Maintenance Staff personnel.
3. Provide one week notice prior to the meeting.

4. Cleaning, filling and treatment of any hydronic system is not permitted until this coordination meeting has been conducted and the Contracting Agency's concerns have been adequately addressed.

D. System fill:

1. After flush cleaning the hydronic heating system, fill the primary system with water and add treatment chemicals to the concentration recommended by the manufacturer. Fill the secondary loop system with inhibited propylene glycol solution as specified.

2. Thoroughly vent the systems to include piping high points and equipment vents (pump casings, air separators, etc.).

E. Site Tests:

1. Hydrostatic Pressure Test:

a. Make sure hydronic heating system is filled with clean operating fluid. Hydrostatically test system to 100 PSIG. System must hold test pressure for a two hour period with no pressure drop to pass test.
b. Inspect system during test and repair leaks.
c. Provide written report indicating that the pressure test has been satisfactorily completed.

2. Operational Test:

a. Inspect system for proper fluid circulation, sufficient clearance for expansion and contraction of piping and proper system pressure control.
b. Note and correct discrepancies and deficiencies.
c. Provide written report indicating that the operational test has been satisfactorily completed.

3. Test results shall be certified in writing as required by General Conditions. Include dates and sections tested, test pressure, test duration, printed names and signatures of person performing the test and Contracting Agency witnessing the test.

F. Inspection: Arrange for inspections and provide written notice to the Contracting Agency when the entire work or logical portions thereof, is ready for inspection.

G. Verify penetrations are installed to maintain assembly integrity.

3.6 SYSTEM STARTUP

A. Start-up and operate hydronic heating systems and equipment in accordance with the manufacturer's written installation and operation manual checklist.

A. Document start-up and operational checks using the checklist and submit in accordance with submittal requirements.

3.7 ADJUSTING

A. Adjust functional components for proper operation in accordance with manufacturer's recommendations, or as otherwise directed.

B. Coordinate and work directly with the Balancing and Testing Agency and the requirements of Section 230593 - Testing, Adjusting and Balancing, to provide systems in proper operating order.

C. Make corrections and adjustments as required by the Testing, Adjusting and Balancing (TAB) Agency in a timely manner.

3.8 CLEANING

A. Waste Management: After construction is completed, clean and wipe down exposed surfaces of pumps, piping and appurtenances.

3.9 CLOSEOUT ACTIVITIES

A. Demonstration: Provide 2 hours of demonstration conducted by authorized factory start-up personnel to the Contracting Agencies authorized maintenance personnel.

B. Training: Provide 4 hours of operational instruction conducted by authorized factory start-up personnel to the Contracting Agencies authorized maintenance personnel.

END OF SECTION 232113

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. In-line circulators.
2. Vertical in-line pumps.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 204100 - Mechanical Demolition
7. 230593 - Testing, Adjusting and Balancing
8. 232113 - Hydronic Piping and Specialties
9. 235216 - Condensing Boilers and Accessories
10. 253000 - Building Automation System Field Devices
11. 254000 - Variable Speed Drives
12. 255000 - Building Automation System
13. 259000 - Sequence of Operations

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. UL 778 - Motor Operated Water Pumps.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. This section describes specific requirements, products and methods of execution for interrelated systems necessary for the pumping of heating fluid, which will be distributed to the locations shown.
2. The method of generation of, and distribution of, this heat is specified elsewhere.

B. Performance Requirements:

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

2. Provide performance and output shown or scheduled on drawings.

1.4 PRE-INSTALLATION MEETINGS

A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data:

1. Provide manufacturers' product literature, clearly annotated to indicate specified salient features and performance criteria.
2. Include the following:

   a. Catalog data sheets for each pump scheduled. Indicate which model is being submitted.
   b. Certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
   c. Dimensional data.
   d. Features and appurtenances being provided.
   e. Electrical characteristics and connection requirements.

C. Shop Drawings:

1. Submit fully dimensioned shop drawings of boiler room showing major equipment and housekeeping pads, with clear callouts indicating deviations from layout shown.
2. Indicate mechanical and electrical service locations and requirements.

D. Quality Assurance/Control Submittals:

1. Design Data and Test Reports: Provide design data and test reports for each pump.
2. Certificates, Manufacturer's Instructions, and Manufacturer's Field Reports:

   a. Provide a complete manufacturer's written installation, operation and maintenance manual for each installed pump. Clearly annotate the manual to indicate applicable information for the specific equipment model(s) installed.
   b. Test pump operation and sequencing in accordance with the manufacturer's written installation and testing instructions and Section 259000 - Sequence of Operations.
   c. Submit a letter of certification indicating that the pump installation and start-up has been completed, that the pumps are properly adjusted and operating within the tolerances as specified by the manufacturer, and that the sequence of operation is fulfilled.
   d. Included with the manual one copy of the completed start-up and operation checklist. The checklist shall include:

      1). Printed names and signatures of the installers.

2). Documentation from Manufacturer's representative and Contracting Agency that the pumps have been properly installed and each is fully operational, thus validating the equipment warranty.

1.6 CLOSEOUT SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

B. Closeout Submittals:

C. Project Record Documents: Record actual locations of pumps and associated valves, and areas required for maintenance access.

D. Operation and Maintenance (IO&M) Manuals:

1. Provide copies of approved submittal information for inclusion within the project IO&M Manual.
2. Include manufacturer's descriptive literature, operating instructions, installation instructions, assembly views, lubrication instructions, maintenance and repair data, parts listings, and spare parts list.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

A. See Section 200000 - Mechanical General Requirements.

B. Regulatory Requirements: Products Requiring Electrical Connection shall be listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.9 DELIVERY, STORAGE AND HANDLING

A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 IN-LINE CIRCULATORS

A. Type: Horizontal shaft, single stage, direct connected, with resiliently mounted motor for in-line mounting.

B. Materials:

1. Pump Volute: Cast iron, with 125 pound ANSI flanged pump connections.
2. Impeller: Stainless Steel.
3. Shaft: Alloy steel copper sleeve.
4. Mechanical Seal Assembly: Carbon brass trim, ceramic seat.

C. Performance:

1. As scheduled.
2. Maximum working temperature: 230 degrees F.
3. Maximum working pressure: 145 PSIG.

D. Electrical Characteristics:

1. As scheduled.
2. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

E. Manufacturers: Taco (Basis of Design), Grundfos UPS Series, Armstrong, Bell and Gossett.

2.2 VERTICAL IN-LINE PUMPS

A. Type: Single stage, single suction, split coupled, vertical in-line pump with inverter duty motor for VSD operation.

B. Materials:

1. Pump Body: Cast iron, with 125 PSIG ANSI flanged connections.
2. Impeller: Stainless Steel.
3. Bearings: Sleeve, Oil Lubricated.
4. Shafts: Stainless steel.
5. Mechanical Seal Assembly.

a. Stationary face: Carbon.
b. Rotating face: Tungsten Carbide.

C. Performance:

1. As scheduled.
2. Maximum working temperature: 230 degrees F.
3. Maximum working pressure: 145 PSIG.

D. Electrical Characteristics:

1. As scheduled.
2. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

E. Manufacturers: Taco (Basis of Design), Grundfos, Armstrong, Bell and Gossett.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protection: Cover pumps and plug piping connections to protect pumps from construction dirt and debris.

B. Preparation: Prior to installation of pumps, verify that electrical power is available and of the same voltage and phase characteristics as the pump being installed.

3.2 INSTALLATION

A. Install pumps, pump supports, suction guides, mechanical seal piping, pressure gauges and other pump appurtenances in accordance with the manufacturer's written installation instructions.

B. Provide access space around pumps for service. Provide no less than the minimum as recommended by manufacturer.

C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings.

D. Provide line sized shut-off valve on pump suction, and line sized soft seat check valve.

E. Provide air cock and drain connection on horizontal pump casings.

F. Provide gauges with connections to suction and discharge.

G. Lubricate pumps before start-up.

3.3 CONSTRUCTION

A. Interface with Other Work:

1. Coordinate and sequence installation of pumps and appurtenances with trades responsible for portions of this and other related sections of the Project Manual.
2. Rework required as a result of failure to follow the manufacturer’s written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

3.4 REPAIR/RESTORATION

A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.

B. Substitute replacement parts from other manufacturers are not acceptable.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

1. After completion of the installation, a qualified representative of the pump manufacturer shall conduct pump start-up and written certification.
2. Start-up and adjust the system to within the tolerances as specified by the equipment manufacturer. Verify pump impellers rotate in the correct direction.
3. Provide two hours operating instruction to authorized Owner's Representative.
4. Test pump operation and sequencing in accordance with submittal requirements.
5. Submit a letter of certification indicating that the pump installation and start-up has been completed.

3.6 ADJUSTING

A. Coordinate and work directly with the Testing, Adjusting and Balancing Agency to provide systems in proper operating order. Make corrections and adjustments as required by the Balancing and Testing Agency in a timely manner.

3.7 CLEANING

A. After construction is completed, clean and wipe down exposed surfaces of pumps, piping and appurtenances.

B. Touch up marred or scratched factory finished surfaces using finish materials furnished by manufacturer.

3.8 DEMONSTRATION & START-UP

A. Start-up and operate hydronic pumps in accordance with the manufacturer's written installation and operation manual checklist.

B. Document start-up and operational checks using the checklist and submit in accordance with submittal requirements.

END OF SECTION 232123

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal Ductwork and Fittings.
2. Flexible Ductwork.
3. Acoustical Linings.
4. Volume Dampers.
5. Smoke and Combination Fire/Smoke Dampers.
6. Flexible Duct Connectors.
7. Access Panels and Doors.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200700 - Mechanical Insulation
6. 230593 - Testing, Adjusting and Balancing
7. 233400 - HVAC Fans
8. 233600 - Air Terminal Units
9. 233700 - Air Outlets and Inlets
10. Division 28 - Electrical

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. ASHRAE Standard 90.1-2010 Energy Standard for Buildings Except Low-Rise Residential Buildings.
3. SMACNA HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005.
4. SMACNA HVAC Air Duct Leakage Test Manual, Second Edition 2012.
5. SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, Fifth Edition 2002.
6. NFPA 90A - Installation of Air-Conditioning and Ventilating Systems.
7. ACR the National Air Duct Cleaners Association (NADCA) Standard for Assessment, Cleaning and Restoration of HVAC Systems, 2013.

1.3 PRE-INSTALLATION MEETINGS

A. See Section 200000 - Mechanical General Requirements.

1.4 SUBMITTALS

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data: Include manufacturer's detailed fire, smoke, and combination fire/smoke damper installation instructions for each specific wall, ceiling, and floor construction type(s) for the project.

C. Shop Drawings:

1. Include the following information in the scaled ventilation system shop drawings:

a. Label duct sizes using the same labeling method as the Contract Documents.
b. Show terminal equipment ductwork connections.
c. Volume, control, backdraft, fire, smoke, and combination fire/smoke damper locations as applicable.
d. Flexible connection locations.
e. Access panels and doors with sizes and swing directions shown.

2. Casings and plenums: Submit detailed shop drawings showing the proposed plenum and casing materials to be used and the construction method.

D. Test and Evaluation Reports:

1. Provide written certification to the Contracting Agency that smoke and combination fire/smoke dampers have been operationally tested and function in accordance with Section 283100 - Addressable Fire Alarm sequences of operation.

E. Installation, Operation and Maintenance (IO&M) Manuals.

1.5 CLOSEOUT SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

B. Record Documentation: Record actual locations of ductwork and areas required for maintenance access in accordance with Section 200000 - Mechanical General Requirements.

1.6 QUALITY ASSURANCE

A. See Section 200000 - Mechanical General Requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

A. See Section 200000 - Mechanical General Requirements.

1.8 WARRANTY

A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 METAL DUCTWORK AND FITTINGS

A. General: Provide metal ductwork and fittings fabricated in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, G90 zinc coated unless otherwise noted.

B. Medium Pressure/Velocity Ductwork:

1. Duct Pressure Class: 6 inches WC.
2. Seal Class: A.
3. Maximum Velocity: 2,200 FPM.

C. Low Pressure/Velocity Ductwork:

1. Duct Pressure Class: 2 inches WC.
2. Seal Class: A.
3. Maximum Velocity: 1,500 FPM.

2.2 FLEXIBLE DUCTWORK

A. Manufacturers:

1. Thermaflex, Model M-KE.
2. Hart & Cooley.
3. JPL.
4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Description: UL listed, Class 1 flexible ductwork in compliance with NFPA 90A and 90B.

C. Performance/Design Criteria:

1. Positive Pressure Rating:

Ten inches WC	(4”-12” ID).
Six inches WC	(14”-16” ID).
Four inches WC	(18”-20” ID).

2. Negative Pressure Rating:

One inch WC	(4”-12” ID).
One half inch WC	(14”-20” ID).

3. Maximum Velocity: 5000 FPM.
4. Operating Temperature Range:

   a. 0 degrees F to 140 degrees F (continuous).
   b. Minus 20 degrees F to 250 degrees F (intermittent).

5. Insulating Value: R-4.2.

D. Materials:

1. Acoustically rated black polyester core permanently bonded to coated spring steel wire helix.
2. Fiberglass insulation.
3. Tear resistant, reinforced metalized vapor barrier.

2.3 ACOUSTICAL LININGS

A. Manufacturers:

1. Knauf.
2. Johns Manville.
3. Owens-Corning.
4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Description:

1. UL listed.
2. NFPA 90A and 90B compliant.
3. One inch thick, 1.5 PCF, flexible, edge-coated, mat-faced glass fiber insulation bonded with thermosetting resin.
4. Does not promote growth of fungi or bacteria.

C. Performance/Design Criteria:

1. Maximum Velocity: 6000 FPM.
2. Operating Temperature Range: Up to 250 degrees F.
3. Maximum Water Vapor Sorption: Three percent by weight.

2.4 VOLUME / BALANCING DAMPERS

A. Manufacturers:

1. Ruskin.
2. Greenheck.
3. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Materials:

1. Refer to SMACNA HVAC Duct Construction Standards - Metal and Flexible for fabricated volume damper construction requirements.
2. Round ducts to 12 inches diameter and rectangular to 18 inches width:

    a. Flat sheet, galvanized steel, single blade damper.
    b. Damper blade two gauges thicker than the duct gauge at the location installed (24 gauge minimum for round, 22 gauge minimum for rectangular).
    c. Manual hand quadrant.

3. Round ducts over 12 inches diameter:

    a. Flat sheet, galvanized steel, single blade damper.
    b. Damper blade two gauges thicker than the duct gauge at the location installed (22 gauge minimum).
    c. Manual hand quadrant with continuous steel rod.

4. Rectangular ducts over 18 inches width:

    a. Flat sheet, galvanized steel, single blade damper.
    b. Damper blade 18 gauge minimum.
    c. Manual hand quadrant with continuous steel rod.

5. Accessible and lockable damper operators.

C. Extractors: Not Permitted.

D. Splitter Dampers: Not Permitted.

2.5 REMOTE VOLUME DAMPER OPERATORS

A. Manufacturers:

1. Duro-dyne.
2. Young Regulator.
3. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Provide flush mounted chrome plated remote operators with tamperproof cover, extension rod, and not more than one 90 degree angle gear drive.

C. Regulator: Duro-dyne Series SRC-380 or Young Regulator 301.

D. Angle Drive: Duro-dyne Model AD-38 or Young Regulator 927.

2.6 SMOKE AND COMBINATION FIRE / SMOKE DAMPERS

A. Manufacturers:

1. Ruskin FSD60 (Basis of Design).

2. Greenheck.
3. Pottorff.
4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Regulatory Requirements:

1. Smoke dampers UL listed and labeled in accordance with UL Standard 555S.
2. Combination fire/smoke dampers also listed in accordance with UL Standard 555.

C. Performance/Design Criteria:

1. Fire rating suitable for the applicable wall construction rating in accordance with IBC.
2. Rated for use in dynamic system with maximum velocity of 4,000 FPM and maximum 8 inches WC static pressure.
3. Elevated temperature rating: Minimum 250 degrees F.
4. Leakage classification: Class I.
5. Supply damper actuators as part of the listed damper assembly. If the damper actuators must be provided separately, actuators must be UL listed for a temperature rating greater than or equal to that of the damper.
6. Provide damper actuators powered by 120 VAC, energized in the normal open position and spring driven closed on loss of power. See Section 283100 - Addressable Fire Alarm for sequences of operation.
7. Provide thermal actuation of combination fire/smoke dampers by a UL listed electric temperature-sensing device (165 degrees F electric fuse) with manual remote reset capability from the fire alarm system.

2.7 FLEXIBLE DUCT CONNECTORS

A. Manufacturers:

1. Duro-dyne Corporation.
2. Vent Fabrics.
3. Ductmate.
4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Performance/Design Criteria: Provide fan connectors with static pressure ratings suitable for each specific application. Minimum pressure ratings must be greater than, or equal to, the fan's shut-off static pressure, as indicated by the submitted fan curve, with a 50 percent safety factor.

C. Materials:

1. Metal edging: 24 gauge galvanized steel.
2. Fabric: UL Listed, polyester blend with vinyl coating. Double folded seams. Four inches width.

2.8 ACCESS PANELS AND DOORS FOR DUCTS AND PLENUMS

A. Manufacturers:

1. Air Balance Inc. model FSA-100 (Basis of Design).
2. Ruskin.
3. Ductmate.
4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Material:

1. Frame and Door: Minimum 24 gauge galvanized steel.
2. Reinforced doors with cross-bracing and/or otherwise stiffened to prevent rattling and vibration.
3. Seals: Rubber gaskets, secured to door or frame.
4. Where ductwork is insulated or lined, provide double-walled access door panels with one inch of internal insulation to match duct or plenum insulating and/or sound attenuating characteristics.
5. Walk Through Doors:

a. Construct in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
b. Provide insulation and inner liner to match plenum or casing.

C. Hinges and Latches:

1. Low velocity system access panels:

a. Sizes 12 inches by 12 inches through 24 inches by 24 inches.
b. Continuous steel hinge mechanically fastened to frame and quarter turn cam latches.

2. Medium velocity system access panels:

a. Sizes 12 inches by 12 inches through 24 inches by 24 inches.
b. Continuous steel hinge mechanically fastened to frame.
c. Provide a minimum of two latches for rolled plate doors.
d. Cement sheet rubber gasket to door.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify location, size and type (i.e. fire resistive construction) of wall, floor and ceiling/roof penetrations.

3.2 PREPARATION

A. Protection on In-Place Conditions: During construction, install temporary closures of sheet metal, cardboard or polyethylene taped over ductwork openings to prevent construction dust and debris from entering duct systems.

3.3 INSTALLATION

A. Metal Ductwork and Fittings:

1. Install, seal and support ductwork and fittings in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible for the duct pressure class and seal class specified. The use of “duct tape” as a duct seal method is prohibited.
2. Provide medium pressure/velocity ductwork at the following locations: VAV ventilation systems from air handler cabinet discharge plenum connection to VAV terminal unit inlet neck connection.
3. Provide low pressure/velocity ductwork at the following locations:

    a. VAV terminal unit discharge connections to air outlet connections.
    b. Outside air intake ductwork.
    c. Exhaust air ductwork.
    d. Constant volume ventilating systems.

4. Proprietary or other joint systems may be substituted for SMACNA details when submitted and approved in writing before starting work.
5. Where ducts penetrate through walls exposed in occupied spaces, provide sheet metal escutcheons at each penetration to provide a clean, finished appearance.
6. Duct penetrations: See Section 200529 - Mechanical Hangers and Supports.
7. Provide standard 45-degree lateral wye takeoffs. When space does not allow 45-degree lateral wye takeoffs, use 90-degree conical tee or low-loss tee connections.
8. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream of equipment.
9. Provide orifice plates or balance dampers at branch connections as required for proper ventilation system balancing. Select balancing device and installation method to limit noise from mechanical vibration or air bypass.
10. Do not use turning vanes in medium velocity duct systems.
11. Support duct mounted equipment equal to or greater than 40 pounds, such as heating coils, independently from ductwork.
12. Support duct mounted equipment less than 40 pounds using standard duct supports and sway bracing located within 12 inches of equipment.
13. Where offsetting ductwork is not possible, ducts may be reduced a maximum of 20 percent to clear obstacles with Contracting Agency’s permission.
14. Where steel ductwork is visible through air outlets or inlets, paint visible interior ductwork flat black.

B. Flexible Ductwork:

1. Install, connect and support flexible ductwork in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
2. Connection to air outlets in suspended grid ceiling systems: Provide a flexible duct length of 6 to 8 feet with one 90-degree bend or large radius 180-degree curve in addition to outlet connection. Support flexible duct at connections to air outlets to maintain minimum recommended bend radius.
3. Seal flexible duct connections to rigid ductwork with draw bands to the pressure class of the rigid duct system.
4. Flexible duct connections between medium pressure ductwork and air terminal units are prohibited.
5. Flexible ductwork is prohibited in inaccessible locations, such as above “hard” ceilings.
6. Flexible ductwork is prohibited at penetrations through walls.

C. Acoustical Lined Ductwork:

1. Provide standard one inch thick acoustically lined ductwork as indicated using the acoustical liner material specified. Attach the lining material to the ductwork in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. Provide thicker acoustical lining where specifically noted.
2. Duct dimensions indicated are net free-area duct dimensions. Add twice the liner thickness to obtain outside duct dimensions.
3. Sleeve acoustical duct penetrations through full height walls perpendicular to wall surface. Provide 1/2-inch minimum gap between sleeve and duct. Fill gap with mineral wool backer and seal each side of penetration with acoustical sealant.

D. Volume Dampers:

1. Provide air volume dampers at each low-pressure duct main and branch take-off for proper air balancing.
2. Locate dampers a minimum of 10 feet from diffusers except where shown otherwise.
3. Volume dampers are not to be installed in medium pressure, variable air volume systems.

E. Control Dampers:

1. Provide opposed blade type dampers for the following applications:

   a. Exhaust fan discharge dampers.
   b. Outside air intake dampers.
   c. Isolation dampers.

2. Provide parallel dampers for the following application: Air handling unit mixing box.

F. Fire, Smoke and Combination Fire/Smoke Dampers:

1. Before starting work, verify the location and types of fire resistive construction as indicated by the Contract Drawings. Typical fire rated separations include:

   a. Area separation walls, vertical only.
   b. Occupancy separation walls, or partitions and floors. Vertical or horizontal.
   c. Fire resistive egress corridors, halls and vestibules.

d. Fire resistive enclosures of hazardous spaces within an occupancy, including rooms for fuel-fired or electric heating equipment.
e. Fire resistive floor/ceiling assemblies associated with any of the above.

2. Verify locations and types of dampers indicated on drawings. If dampers appear to be incorrectly located or missing, obtain clarification from Contracting Agency.
3. Install dampers at locations indicated on the Drawings and in accordance with manufacturer's UL approved installation instructions.
4. Install round dampers plumb and free from racking. Install rectangular dampers square and free from racking.
5. Do not compress or stretch damper sleeve into duct or opening.
6. Handle damper using frame/sleeve. Do not lift damper using blade, actuator, or jackshaft.

G. Flexible Duct Connectors:

1. Install duct connectors in accordance with the manufacturers written installation instructions.
2. Provide a flexible airtight joint between fans and other vibrating equipment and the air distribution ductwork systems.
3. Externally isolated air handling units and fans: Provide flexible connections where ducts attach to unit inlet and outlet(s) of unit.

A. Penetrations:

1. Coordinate mechanical penetrations with architectural and structural construction details prior to installation. Set sleeves in position in concrete formwork. Provide reinforcement around sleeves as required.
2. Provide compatible materials, fasteners, adhesives, sealants, and other products required for proper installation.
3. Penetrations through roof, exterior walls and floors to be weather and water tight.
4. Penetrations through fire rated assemblies to be UL listed.
5. Penetrations through smoke partitions and barriers to resist passage of smoke.
6. Other penetrations to have acoustical seals.

H. Access Panels and Doors:

1. Locate access doors to enable in-duct equipment to be easily inspected, cleaned, maintained and tested and/or reset.
2. Provide access doors at the following locations:

a. Fire, smoke and combination fire/smoke dampers.
b. Motor operated dampers.
c. Each side of duct mounted coils.
d. As necessary for duct cleaning in accordance with NADCA Industry Standard for Mechanical Cleaning of Non-Porous Air Conveyance System Components.
e. As necessary for maintenance access to serviceable instrumentation and control equipment.

3. Coordinate location and size of access doors in walls, partitions and ceilings to correspond with duct access doors, dampers and automatic control devices and instruments.

4. Coordinate with supplier of component air handlers, package units and similar equipment to ensure that access doors and panels will not be obstructed when the equipment is installed.

I. Interface with Other Work:

1. Assist electrical and controls trades in mounting instrumentation devices and safety controls in ductwork and air handling units.
2. Make penetrations through exterior building walls watertight. Detail ductwork connections to prevent condensation or leakage from entering into surrounding building construction. Provide sleeves, special connections and sealant as required to accomplish this performance requirement.

3.4 SITE QUALITY CONTROL

A. Site Tests and Inspections:

1. Smoke and Combination Fire/Smoke Dampers: Test automatic closure and reset of smoke and combination fire/smoke dampers in accordance with Section 283100 - Addressable Fire Alarm sequences of operation.

B. Verify accessibility to ventilation system components for maintenance, adjustment and cleaning.

3.5 ADJUSTING

A. Adjust and balance dampers in accordance with Section 230593 - Testing. Adjusting and Balancing.

3.6 CLEANING

A. Refer to section 230131 - Duct Cleaning.

END OF SECTION 233100

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PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. In-line centrifugal fans.
2. Roof exhaust fans.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 230593 - Testing, Adjusting and Balancing
7. 233100 - Ducts and Accessories
8. 233700 - Air Outlets and Inlets
9. 253000 - Building Automation System Field Devices
10. 254000 - Variable Speed Drives
11. 255000 - Building Automation System
12. 259000 - Sequence of Operations
13. Divisions 26, 27 and 28 - Electrical

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. Air Movement and Control Association (AMCA) 99 - Standards Handbook.
3. ANSI/AMCA 210 (ANSI/ASHRAE Standard 51) - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
4. AMCA Publication 261 Directory of Products Licensed to Bear the AMCA Certified Rating Seal.
5. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
6. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

1.3 SYSTEM DESCRIPTION

A. Performance Requirements: Provide product performance characteristics and output as specified or scheduled on drawings.

1.4 PRE-INSTALLATION MEETINGS

A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data:

1. Provide fan curves with scheduled operating point clearly plotted.
2. Provide sound power levels (in decibels) for each octave band for inlet, discharge, and radiated sound power for the assembled fan unit. Obtain sound level data by one of the following methods:

   a. Actual measurements from tests performed in accordance with AMCA Standards in an AMCA registered test chamber.
   b. Documented calculations that start with AMCA tested fan sound data and are modified in accordance with ASHRAE procedures identified in Chapter 48 of the 2011 ASHRAE HVAC Applications Handbook to accurately predict the sound power levels for the configuration shown.

3. Provide electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

C. Shop Drawings. Include the following information in the scaled ventilation system shop drawings:

1. Location, orientation, and size of fans.
2. Maintenance access and clearance requirements.
3. Fan support methods (i.e. housekeeping pads, roof curbs, etc.).
4. Ductwork connections and sizes.

D. Operation and Maintenance (IO&M) Manuals.

1.6 CLOSEOUT SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

B. Record Documentation: Record actual locations of fans and components and areas required for maintenance access.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

A. See Section 200000 - Mechanical General Requirements.

1.9 DELIVERY, STORAGE AND HANDLING

A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturers:

1. Greenheck.
2. Cook.
3. Acme.
4. Substitution request required.

B. Regulatory Requirements:

1. AMCA Certified Ratings seal for sound and air performance.
2. Products Requiring Electrical Connection - Listed and classified by Underwriters Laboratories Inc., or by a testing firm acceptable to the Authority Having Jurisdiction as suitable for the purpose specified and indicated.

C. Performance/Design Criteria: As scheduled.

D. Manufacturer’s Nameplate: Permanently affixed, embossed metal containing model number and individual serial number for future identification, located on a permanent part of the fan.

2.2 IN-LINE CENTRIFUGAL FANS

A. Duct mounted, direct drive, in-line centrifugal type fans. Rectangular fan housing design constructed of heavy gauge galvanized steel with rectangular duct mounting collars.

B. Removable panel in fan cabinet of sufficient size to permit access for service to internal components without dismantling the cabinet.

C. Centrifugal backward inclined fan wheel, constructed of aluminum and matched wheel and inlet cones for precise running tolerances. Dynamically and statically balanced at the factory.

D. Heavy duty ball bearing type fan motors, carefully matched to the fan load, and furnished at the specified voltage, phase, and enclosure. Motors and drives readily accessible for maintenance.

E. NEMA 1 disconnect switch provided as standard. Factory wiring provided from motor to the handy box.

F. AMCA Certified Ratings. Seal for both sound and air performance.

G. Electronically Commutated Motor (ECM) with manual speed adjustment for balancing.

H. Basis of Design: Greenheck SQ with VariGreen ECM.

2.3 ROOF EXHAUST FAN

A. Description:

1. General: Provide roof curb mounted up-blast type roof exhauster.
2. Regulatory Requirements:

a. UL 762 listed.
b. IMC compliant.
c. AMCA certified ratings seal for sound and air performance.

B. Construction: Heavy gauge aluminum, leak-proof construction.

C. Standard Components:

1. Fan wheel: Backward inclined, non-overloading centrifugal fan wheel.
2. Motor and drive assembly:

a. Provide heavy duty ball bearing type motor with voltage and phase as scheduled.
b. Belt drive with adjustable pulleys for final system balancing. Drives sized for 150 percent of driven horsepower.
c. Heavy gauge galvanized steel drive frame assembly.
d. Precision ground and polished fan shafts mounted in permanently sealed or pillow block ball bearings. Bearings selected for a minimum (L10) life in excess of 100,000 hours (or (L50) life in excess of 500,000 hours) at maximum cataloged operating speed.
e. Motors and drives mounted on vibration isolators and located out of air stream and readily accessible for maintenance. Out of air stream motor cooling intake.

3. Wind band:

a. One piece, heavy duty aluminum construction, continuously welded to aluminum roof cap and drain trough. Aluminum motor cover.
b. Galvanized steel bird screen.
c. Aluminum drain trough.

D. Vibration Isolation:

1. Double studded or pedestal style true vibration isolators.

2. No metal to metal contact.
3. Sized to match the weight of each fan.

E. Electrical:

1. Wiring located out of air stream.
2. Factory installed, NEMA -3R disconnect switch.

F. Accessories:

1. Non-stick fan wheel coating.
2. Hinged roof cap for access to fan wheel and ductwork with rubber curb seal.
3. Breather tube shall be 10 square inches in size for fresh air motor cooling and designed to allow wiring to be run through it.
4. Removable grease repellant compression rubber plug to allow access for cleaning wheel through wind band.
5. Corrosion resistant, lockable curb cap closure device.

G. Coordinate with existing roof curb. Modify curb as needed.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation:

1. Provide roof penetrations and level roof curbs for roof mounted fans.
2. Coordinate penetration locations with structure.

3.2 INSTALLATION

A. General:

1. Install fans in compliance with manufacturer’s written installation instructions.
2. Provide flexible connections at fan duct connections as shown or specified. See Section 233100 - Ducts and Accessories for flexible duct connectors.
3. Support fans independently from ductwork. Provide fan support in accordance with 20 0529 - Mechanical Hangers and Supports.
4. Provide vibration isolation and seismic restraint for fans in accordance with 200548 - Mechanical Vibration and Seismic Control.
5. Ensure that fan access doors and panels are not obstructed when the equipment is installed.
6. Extend lubrication points so each is easily reached for maintenance.

B. Interface with Other Work:

1. Coordinate and sequence installation of fans with trades responsible for portions of this and other related sections of the Project Manual.

2. Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate the installation with related work shall be completed at no additional expense to the Owner.

3.3 REPAIR/RESTORATION

A. Refer to Section 200000 - Mechanical General Requirements for general repair/restoration requirements.

3.4 SITE QUALITY CONTROL

A. Manufacturer Services: Verify fans are installed and operational in accordance with the manufacturer's written installation instructions.

3.5 SYSTEM STARTUP

A. Start-up and operate fans in accordance with the manufacturer's written installation and operation manual check list.

3.6 ADJUSTING

A. Adjust and balance fans in accordance with Section 230593 - Testing, Adjusting and Balancing.

3.7 CLEANING

A. Upon completion of installation and prior to initial start-up, vacuum clean and wipe down external system components and internal shrouded areas.

3.8 CLOSEOUT ACTIVITIES

A. Demonstration: Demonstrate proper system operation in accordance with Section 259000 – Sequence of Operations, utilizing the building automation system.

END OF SECTION 233400

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Single duct variable air volume terminal units.

B. Products Installed But Not Supplied Under This Section: Coordinate installation of damper control actuators and application specific controllers, furnished under Section 255000 - Building Automation System. Control enclosure shall be factory mounted by the air terminal unit manufacturer.

C. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 200700 - Mechanical Insulation
7. 230131 - Duct Cleaning
8. 230593 - Testing, Adjusting and Balancing
9. 232113 - Hydronic Piping and Specialties
10. 233100 - Ducts and Accessories
11. 233700 - Air Outlets and Inlets
12. 255000 - Building Automation System
13. 259000 - Sequence of Operations
14. Divisions 26, 27 and 28 - Electrical

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. SMACNA - HVAC Duct Construction Standards, Metal and Flexible, Third Edition 2005.
3. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
4. ANSI/AHRI 880-2011 - Performance Rating of Air Terminals.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. This section describes specific requirements, products and methods of execution for the single duct, variable air volume, direct digital control terminal units.
2. The method of distribution of air is specified elsewhere.

B. Performance Requirements:

1. Provide product performance characteristics as specified or scheduled on drawings.
2. Operate ventilation system in accordance with Section 259000 - Sequence of Operations.

1.4 PRE-INSTALLATION MEETINGS

A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data.

C. Shop drawings:

1. This Section shop drawings to be submitted under Section 200000 - Mechanical General Requirements.
2. Include the following information on the scaled ventilation system shop drawings:

a. Air terminal unit locations and sizes, including discharge plenum.
b. Equipment tags.
c. Control enclosure orientation and access clearance requirements.
d. Ductwork connections and sizes.
e. Reheat coil and hydronic piping connections and valving as applicable.
f. Coil access door locations.

D. Installation, Operation and Maintenance (IO&M) Manuals.

1.6 CLOSEOUT SUBMITTALS:

A. See Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE:

A. See Section 200000 - Mechanical General Requirements.

B. Certifications: Air terminal units shall be certified under AHRI Standard 880 Certification Program and carry the AHRI seal.

1.9 DELIVERY, STORAGE AND HANDLING

A. See Section 200000 - Mechanical General Requirements for general delivery, storage and handling requirements.

1.10 WARRANTY

A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 SINGLE DUCT VARIABLE AIR VOLUME TERMINAL UNITS

A. Manufacturers:

1. Titus, model DESV (basis of design).
2. Price.
3. Nailor Industries.
4. Substitution request required.

B. Performance/Design Criteria:

1. Capacities: Provide terminal units of the sizes and performance capacities as scheduled.
2. Sound Rating:

a. Sound data certified by AHRI.
b. Sound ratings for basic air terminal units with inlet diameters less than or equal to 16 inches shall not exceed NC-20 at maximum rated flow (CFM) with a differential static pressure drop of 1.0 inch water column.
c. Sound ratings for basic air terminal units with inlet diameters larger than 16 inches shall not exceed NC-30 at maximum rated flow (CFM) with a differential static pressure drop of 1.0 inch water column.
d. Radiated and discharge sound power levels at maximum air flow operating conditions shall be submitted with product information.

3. Casing Leakage: Less than 2 percent of nominal CFM at 1.5 inches WC differential pressure.

C. Control Actuator and Application Specific Controller: NEMA 1 control enclosures/digital control packages furnished by Section 255000 - Building Automation System to the air terminal unit manufacturer for factory mounting on side of casing.

D. Materials:

1. Casing:

a. Minimum 22 gauge galvanized steel.
b. Mechanically sealed and gasketed, leak resistant construction.
c. Beaded inlet for low leakage construction, sized to fit standard round duct.
d. Rectangular discharge opening designed for slip and drive cleat connection to low pressure ductwork or reheat coil.
e. Multi-port, center averaging inlet velocity sensor with sensor tubing. Flow measurement taps provided for connection to application specific controller.
f. Internally line casing with sound liner specified below.

2. Control Damper:

a. Heavy gauge galvanized steel, butterfly type damper.
b. One-piece, 1/2-inch diameter damper shaft with self-lubricating Delrin® or bronze oilite bearings or self-lubricating. Notched shaft end, to indicate damper position.
c. Synthetic damper seal to limit close-off leakage to less than 1% of terminal rated airflow at 3.0 inches water column differential pressure.
d. Mechanical stop to prevent damper over-stroking.

3. Duct Transitions:

a. Provide rectangular reheat coil discharge plenum:

1). Minimum width to match reheat coil width.
2). Minimum height to match reheat coil height or maximum downstream branch duct spin-in connection diameter plus 4 inches, whichever is greater.
3). Minimum length 36 inches or longer to accommodate branch ducts, or as indicated on drawings.

b. Sound line duct transitions and plenums to match terminal unit casing liner.

E. Accessories:

1. Sound Liner:

a. UL Listed and in conformance with NFPA Standard 90A. Liners shall be fungi and bacterial resistant.
b. Liners shall be fiberglass with foil facing such that no fibers are exposed to airstream, as follows:

1). 1” thick aluminum foil faced fiberglass insulation, 4 pound per cubic foot density, cut edges sealed from airstream using mechanically bonded metal barrier strips.

2). Cut liner edges and seal to prevent erosion with discharge edges secured with metal barrier strips for fiberglass or similar insulation.

2. Hydronic Reheat Coils:

a. Performance characteristics as scheduled.
b. Constructed from seamless copper tubing (minimum 0.016-inch wall thickness) with aluminum fins, enclosed in 20 gauge (minimum) galvanized steel casing with slip and drive connections. Provide extended copper sweat connections.

3. Access Doors: Provide access doors upstream and downstream of reheat coils for coil cleaning. Refer to Section 233100 - Ducts and Accessories.

PART 3 - EXECUTION

3.1 INSTALLERS

A. Installer: Perform work by experienced personnel previously engaged in ventilation system construction and under the supervision of a qualified installation supervisor.

3.2 PREPARATION

A. Protection of In-Place Conditions: Cover air terminal unit inlet and discharge openings to protect components from construction dirt and debris.

3.3 INSTALLATION

A. General:

1. Install air terminal units in strict compliance with the manufacturer’s written installation instructions.
2. Do not locate any part or the terminal unit assembly, including reheat coil and associated low pressure sound lined plenums, such that it passes over a partition wall or through a full height wall penetration.
3. Locate terminal units such that the bottom of the complete assembly is 6 to 18 inches above the top of the ceiling grid or hard lid ceiling framing as applicable.
4. Locate terminal unit controller, coil hydronic piping/valves, and coil access doors on same side of unit. Locate on side that maximizes accessibility (i.e. above accessible ceiling tiles, away from full height walls and main duct runs).
5. Support air terminal units independent of duct system. Provide sway bracing within 12 inches of support attachment.
6. Connect air terminal unit inlets to ductwork using straight sections of unrestricted rigid duct of the same inlet diameter as terminal unit inlet. Provide a minimum straight duct length of 4 duct diameters at each terminal unit inlet. Medium pressure flexible duct connections to terminal units is not allowed except where specifically shown.

7. Close-coupling of a terminal inlet to the side of a main supply duct is not acceptable without written permission from the Contracting Agency. When this method is approved, provide an inlet flow straightening device.
8. Install low pressure ductwork branches vertically centered along the sides of the low pressure sounded lined plenum. A minimum of two (2) inches of sheet metal is required between the spin-in (or similar connection) and top and bottom external edge of the metal plenum.
9. Provide insulated access doors upstream and downstream of reheat coil for coil cleaning.
10. Secure control enclosure cover in place as intended by the manufacturer.
11. Verify mechanical connections, electrical and control wiring and sensor tubing are properly secured.

B. Interface with Other Work:

1. Coordinate and sequence the installation of air terminal units with trades responsible for portions of this and other related sections of the Project Manual.
2. Coordinate ceiling and/or wall access panel locations to provide convenient maintenance and cleaning access for each air terminal unit.
3. Coordinate air terminal unit locations with ceiling grids, lighting troffers, air outlets and return grilles to maximize accessibility and minimize interference.
4. Rework required as a result of failure to follow the manufacturer's written installation instructions, properly coordinate the installation with related work, or provide adequate access (as determined by the Contracting Agency) shall be completed at no additional cost to the Owner.

3.4 REPAIR/RESTORATION

A. Refer to Section 200000 - Mechanical General Requirements for general repair/restoration requirements.

3.5 SYSTEM START-UP

A. With the applicable central ventilation system air balancing completed and the ventilation system operating under automatic control utilizing the BAS, cycle each air terminal unit control damper between minimum and maximum scheduled air flow settings to demonstrate proper operation and capacity in accordance with 259000 - Sequence of Operations for verification by the Contracting Agency.

B. Verify reheat coil and auxiliary heating unit (as applicable) hydronic control valves properly cycle with terminal unit control damper, in accordance with Section 259000 - Sequence of Operations.

3.6 ADJUSTING

A. Adjust velocity sensor bias adjustment as necessary to provide accurate air flow measurement.

B. For units with reheat coil supply temperature sensors, verify maximum supply temperature is limited to 20 degrees F above zone temperature setpoint.

3.7 CLEANING

A. Upon completion of installation and prior to initial operation, vacuum clean and wipe down air terminal units and control enclosures.

B. Remove any debris from control enclosure.

C. Inspect and clean reheat coils. Re-straighten coil fins if necessary.

END OF SECTION 233600

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air Diffusers and Registers.
2. Return/Exhaust Grilles.

B. Related Sections:

1. 200000 - Mechanical General Requirements
2. 200529 - Mechanical Hangers and Supports
3. 230593 - Testing, Adjusting and Balancing
4. 233100 - Ducts and Accessories

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. SMACNA HVAC Duct Construction Standards - Metal and Flexible Third Edition 2005.
3. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
4. ARI Standard 890-2001 - Air Diffusers and Air Diffuser Assemblies.
5. MOA Handout A.04 - Suspended Ceilings Industry Standard Construction, May 1, 2008.

1.3 SYSTEM DESCRIPTION

A. Performance Requirements: Provide product performance characteristics as specified or scheduled on drawings.

1.4 PRE-INSTALLATION MEETINGS

A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS:

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data: Air outlets and inlets performance data at operating conditions.

C. Shop Drawings:

1. This Section shop drawings to be submitted under Section 200000 - Mechanical General Requirements.
2. Include the following information on scaled ventilation system shop drawings:

    a. Air diffuser, register and grille locations, duct connection sizes and throw directions.

D. Installation, Operation and Maintenance (IO&M) Manuals.

1.6 CLOSEOUT SUBMITTALS:

A. See Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE:

A. See Section 200000 - Mechanical General Requirements.

1.9 DELIVERY, STORAGE AND HANDLING

A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 AIR DIFFUSERS AND REGISTERS

A. Manufacturers:

1. Titus (Basis of Design).
2. Price.
3. Nailor Industries Inc.
4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Performance/Design Criteria: As scheduled.

C. Finishes: Unless noted otherwise, standard white baked enamel or powder coated finish suitable for field application of custom finish color as required.

D. Accessories:

1. Equalizing grids.
2. Earthquake tabs.

E. Correlate diffuser style, dimension, and fit with ceiling. Provide diffusers with modules of the proper size to match the suspended ceiling layout or with appropriate factory provided frame for surface mounting.

2.2 RETURN/EXHAUST GRILLES

A. Manufacturers:

1. Titus (Basis of Design).
2. Price.
3. Nailor Industries Inc.
4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Performance/Design Criteria: As scheduled.

C. Finishes: Unless noted otherwise, standard white baked enamel or powder coated finish suitable for field application of custom finish color as required.

D. Accessories: Earthquake tabs.

E. Correlate grille style, dimension, and fit with ceiling. Provide grilles with modules of the proper size to match the suspended ceiling layout or with appropriate factory provided frame for surface mounting.

PART 3 - EXECUTION

3.1 PREPARATION

A. Removal: Remove existing air diffusers, registers and grilles designated for relocation and reuse after repair and cleaning.

3.2 INSTALLATION

A. General:

1. Install products in compliance with the manufacturer’s written installation instructions.
2. Connect air outlets, registers, grilles, and louvers to ventilation duct systems in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

B. Air Diffusers, Registers and Grilles:

1. Install air diffusers, registers and return/exhaust grilles at the locations shown.

2. Orient and adjust diffusers to provide the throw directions indicated.
3. Provide appropriate borders for the ceiling, wall, or floor construction type.

3.3 REPAIR/RESTORATION

A. Refer to Section 200000 - Mechanical General Requirements for general repair/restoration requirements.

B. Where air outlets and inlets are indicated for reuse, clean and repair existing air outlets and inlets to function as originally intended prior to reinstallation. Air outlets and inlets which require major repair may be replaced at the Contractor's option.

3.4 CLEANING

A. Clean exposed surfaces of air outlets and inlets, with water and mild soap or detergent not harmful to finish, in order to remove fingerprints and dirt.

END OF SECTION 233700

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Boiler venting system.

B. Related sections:

1. 200000 - Mechanical General Requirements
2. 200529 - Mechanical Hangars and Supports
3. 200548 - Mechanical Vibration and Seismic Control
4. 235216 - Condensing Boilers and Accessories

1.2 REFERENCES

A. Codes and Standards: See Section 200000 - Mechanical General Requirements.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements: This section describes specific requirements, products, and methods of execution for boiler venting systems.

B. Performance Requirements: Provide product performance characteristics as specified or scheduled on drawings.

1.4 PRE-INSTALLATION MEETINGS

A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data:

1. Provide manufacturers' product literature.

2. Annotate to indicate specified salient features and performance criteria for each product specified.

C. Calculations:

1. Provide calculations from the stack manufacturer based on the submitted stack shop drawings and submitted and approved boiler draft requirements to demonstrate adequate draft available under the following operating conditions:

a. Boiler high and low firing rates for winter conditions of -19 degrees F.
b. Boiler high and low firing rates for summer conditions of 75 degrees F.

2. For multiple boilers with a common boiler stack, identify number of operating boilers and the boiler flue connection position in the manifold.

D. Shop Drawings:

1. Submit fully dimensioned shop drawings of boiler room(s) showing the following:

a. Major equipment and housekeeping pads, with clear callouts indicating deviations from layout shown:

1). Submitted boiler shall be dimensionally equal to scheduled product within 6 inches in each dimension. Maintain clearances shown on drawings. Submit fully dimensioned shop drawings of boiler room(s) at drawing scale of 1/4-inch equals 1 foot 0 inches or larger, showing entire boiler room, equipment and deviations. Provide boiler room modifications required due to dimensional and technical deviation at no additional cost to the Owner. Submit shop drawings of proposed equipment layout and base or pad for each piece of equipment.
2). If equipment to be provided exceeds the weight of the specified equipment by more than 20 percent, or if the location is to be altered, submit shop drawings and calculations of proposed revised structural design, noting location of pertinent loads, stamped by a registered professional engineer.

b. Service area boundaries as required by manufacturer’s installation.
c. Boiler piping and vent stack locations with dimensions. Coordinate stack roof penetrations with roof structure.
d. Indicate mechanical and electrical service locations and requirements.

1.6 CLOSEOUT SUBMITTALS:

A. See Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

A. See Section 200000 - Mechanical General Requirements.

1.9 DELIVERY, STORAGE, AND HANDLING

A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 BOILER VENTING SYSTEMS

A. Manufacturers:

1. Schebler.
2. Heat-Fab.
3. Approved equal.

B. Description:

1. Provide complete, engineered venting system for flue gas exhaust for each boiler to include straight duct, fittings, connections, adapters, thimbles, terminations and support brackets.
2. Provide supports and seismic restraints in accordance with the manufacturer's UL listing, Section 200529 - Mechanical Hangers and Supports, and Section 200548 - Mechanical Vibration and Seismic Control.

C. Performance/Design Criteria: UL 1738 listed for use with Category IV appliances (operating temperatures up to 600 Degrees F, positive pressure, condensing flue gas service).

D. Materials:

1. Inner wall shall be AL29-4C stainless steel.
2. Outer wall shall be type 304 stainless steel.

E. Assembly/Fabrication:

1. Double walled venting system with 1 inch air space between walls.
2. Vent sections shall be sealed with banded flanges and silicone joint sealant for temperatures up to 600 degrees F with a UL tested pressure rating of 4.0 inches WC.
3. Inner liner seams shall be fully welded. Riveted, tack or spot welded seams are not permitted.

4. Supports and seismic restraints in accordance with the manufacturer's UL listing.

PART 3 - EXECUTION

3.1 INSTALLERS

A. Installer: Perform work by experienced personnel under the supervision of a qualified installation supervisor.

3.2 PREPARATION

A. Surface Preparation: Prior to installation of stacks, verify that shop drawings are approved and stack locations and routing have been coordinated with other trades.

3.3 INSTALLATION

A. Special Techniques:

1. Install equipment in accordance with manufacturer's instructions and requirements of the codes specified herein.
2. Install with clearances from building elements in accordance with chimney listing and IMC.
3. Install components that were furnished loose with equipment for field installation.
4. Touch up marred or scratched factory finished surfaces using finish materials furnished by manufacturer.

B. Interface with Other Work: Coordinate and sequence installation of boiler and water heater and stacks with trades responsible for portions of this and other related sections of the Project Manual.

3.4 REPAIR/RESTORATION

A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.

B. Substitute replacement parts from other manufacturers are not acceptable.

3.5 SITE QUALITY CONTROL

A. Non-Conforming Work: Rework required as a result of failure to follow the manufacturer's written installation instructions or to pr operly coordinate with related Work shall be completed at no additional expense to the Owner.

3.6 CLEANING

A. Waste Management: After construction is completed, clean and wipe down exposed surfaces of boiler stacks.

END OF SECTION 235100

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PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Packaged condensing gas fired boilers and appurtenances.
2. Packaged boiler management system.

B. Related sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 230593 - Testing, Adjusting and Balancing
7. 231123 - Fuel Gas Piping and Specialties
8. 232113 - Hydronic Piping and Specialties
9. 232123 - Hydronic Pumps
10. 235100 - Breechings, Chimneys and Stacks
11. 255000 - Building Automation System
12. 259000 - Sequence of Operations
13. Divisions 26, 27 and 28 - Electrical

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. NFPA 54 - National Fuel Gas Code.
3. ASME Boilers and Pressure Vessel Code (1998), Sections IV & VI.
4. ASME CSD-1 - Controls and Safety Devices for Automatically Fired Boilers.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. This section describes specific requirements, products and methods of execution for the generation of heat, which will be distributed to the locations shown.
2. The method of distribution of this heat is specified elsewhere.

B. Performance Requirements:

1. Provide product performance characteristics as specified or scheduled on drawings.
2. Operate central heating system in accordance with Section 259000 - Sequence of Operations.

1.4 PRE-INSTALLATION MEETINGS

A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data:

1. Provide manufacturers' product literature, clearly annotated to indicate specified salient features and performance criteria to include:

a. Product model and selected optional equipment, appurtenances and special features.
b. Boiler physical and performance characteristics as scheduled.
c. Total equipment weight (filled with water). Boilers weighing 20 percent more than the scheduled equipment will be disapproved unless it is determined by the Owner's Representative that the structure as designed is capable of bearing the additional load with an adequate safety margin.
d. Dimensional data.
e. Anchoring method.

2. Regulatory Requirements: Provide automatic boiler controls listed in the IMC and ASME CSD-1, latest edition, together with most current addenda and interpretations.

C. Shop Drawings:

1. Submit fully dimensioned shop drawings of boiler room(s) showing the following:

a. Major equipment and housekeeping pads, with clear callouts indicating deviations from layout shown:

1). Submitted boiler shall be dimensionally equal to scheduled product within 6 inches in each dimension. Maintain clearances shown on drawings. Submit fully dimensioned shop drawings of boiler room(s) at drawing scale of 1/4-inch equals 1 foot 0 inches or larger, showing entire boiler room, equipment and deviations. Provide boiler room modifications required due to

dimensional and technical deviation at no additional cost to the Owner. Submit shop drawings of proposed equipment layout and base or pad for each piece of equipment.

2). If equipment to be provided exceeds the weight of the specified equipment by more than 20 percent, or if the location is to be altered, submit shop drawings and calculations of proposed revised structural design, noting location of pertinent loads, stamped by a registered professional engineer.

b. Service area boundaries as required by manufacturer's installation.
c. Boiler piping and vent stack locations with dimensions. Coordinate stack roof penetrations with roof structure.
d. Indicate mechanical and electrical service locations and requirements.
e. Boiler management system location.

D. Quality Control Submittals: Refer to Section 019100 - Commissioning for submittal requirements.

E. Manufacturer Reports:

1. Provide start-up and operational test reports for each boiler. Refer to Article on Site Quality Control.
2. Provide start-up report for boiler control system with selected presets annotated.
3. Submit a letter to document that the training was conducted. Include in the letter the date, start/stop times for the training, list of attendees and signature/title of the person(s) providing the training.

1.6 CLOSEOUT SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

A. See Section 200000 - Mechanical General Requirements.

1.9 DELIVERY, STORAGE, AND HANDLING

A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

A. See Section 200000 - Mechanical General Requirements.

B. Provide prorated 10-year warranty on pressure vessel/heat exchanger against failure due to condensate corrosion, thermal stress, mechanical defects or workmanship.

C. Provide 2-year warranty on control circuit boards.

PART 2 - PRODUCTS

2.1 CONDENSING GAS FIRED BOILERS

A. Manufacturer:

1. Aerco Benchmark series.
2. Approved equal.

A. Description:

3. Gas fired, condensing fire tube design with modulating power burner and positive pressure discharge.
4. UL Listed, CSD-1 approved, ASME coded and stamped.
5. IRI gas train.

B. Performance/Design Criteria: Manufacturer must publish known partial load efficiencies, and the thermal efficiency must increase as the firing rate decreases.

B. Assembly/Fabrication:

1. Size and clearances:

a. Minimum 28 inches wide, 44.5 inches long and 79 inches high.
b. Listed for 0 wall clearance.
c. Max weight 1533 pounds dry.

2. Air/Fuel Supply/Burner:

d. Turndown capacity: 20 to 1 without loss of combustion efficiency or staging of gas valves.
e. Burner shall produce less than 16 PPM of NOx corrected.
f. Burner shall be metal fiber mesh covering a stainless steel body, with spark ignition and flame rectification.
g. All material exposed to combustion shall be stainless steel.
h. Modulating air/fuel valve with single linkage that does not require field adjustment. VFD pre-mix blower for optimum air/gas mixture.
i. Gas train safety shut-off valve with proof of closure switch.
j. Minimum 4.2 inch W.C. gas input at rated capacity.

3. Pressure Vessel/Heat Exchanger:

k. Boiler capable of sustained operation with return water temperature down to 40 Degree F without failure due to thermal shock or fireside condensation.
l. ASME steel construction for working pressure: 160 PSIG.
m. Pressure vessel of SA53 carbon steel, 1/4 inch wall and upper head.
n. Heat exchanger of 316L stainless steel fire tube and 3/8 inch tube sheets, one-pass combusting gas flow.
o. 3-inch steel flange water connection.
p. Maximum water pressure drop through boiler: 4.9 PSIG at 130 GPM.
q. Working temperature: 200 degrees F.
r. ASME approved relief valve: 50 PSIG.

4. Exhaust Flue and Condensate Drain:

s. Corrosion resistant stainless with 6-inch diameter steel flue connection.
t. Gravity condensate drain with collecting reservoir.

5. Packaged Boiler Controls:

u. UL approved.
v. Control panel consisting of multiple circuit boards for separate control functions that area individually field replaceable. Boards provide display functions, low water cutoff, power supply, ignition control, a connector board, and a control function board.
w. The control panel hardware shall support both RS-232 and RS-485 remote communications.
x. The controls shall annunciate boiler & sensor status and include extensive self-diagnostic capabilities that incorporate a minimum of 8 separate status messages and 34 separate fault messages.
y. Integrated control panel with operating sequence, system fault and outlet temperature display, operating mode selector switch.
z. Self-governing features to take over controlled as set up by user in the event of over temperature, improper control signal, or loss of signal.
aa. Combustion safeguard/flame control and monitoring system with spark ignition and rectification type flame sensor.
bb. Electric low water cutoff with test and manual reset functions.
cc. Each boiler shall utilize an electric single seated combination safety shutoff valve/regulator with proof of closure switch in its gas train and incorporate dual over-temperature protection with manual reset in accordance with ASME Section IV and CSD-1.
dd. Self-diagnostic capabilities.
ee. Adjustable high and low setpoint limits.
ff. Temperature control modes:

1). Internal setpoint.
2). Indoor/outdoor Reset.
3). 4mA to 20mA Temperature Setpoint.
4). Network Temperature Setpoint.
5). 4 mA to 20 mA Direct Drive.
6). Network Direct Drive.