SECTION 230102

SYSTEMS CLEANING AND FLUSHING

PART 1 GENERAL - NOT APPLICABLE.

PART 2 PRODUCTS - NOT APPLICABLE.

PART 3 EXECUTION

3.01 OBJECTIVES

A. The objective of this procedure is to provide the acceptance criteria for the cleaning of plant mechanical fluid systems. This procedure applies to permanent plant piping systems listed in Appendix A.

3.02 ACCEPTANCE CRITERIA

A. The acceptance of a cleaned path or system during cleaning/flushing shall be in accordance with the criteria below. Acceptance will be verified using the flush media color method unless otherwise specified. Media color to be determined by Miles representative.

B. Visible cleanliness or wipe cloths as applicable to mechanical cleaning shall show no grindings, filings, oil stains or particulate matter.

C. When flushing material becomes unsuitable for further use, system to be completely drained from one tank. Re-floor system from loading inlet and continue.

D. Class "A" Cleanliness: Two consecutive acceptable samples of two minute duration (minimum). Particulate size will be less than or equal to 1/32 inch in any dimension, except that fine slivers (less than 1/32 in. thick) are permissible up to 1/16 inch long. Filter cloth and effluent shall be clear.

E. Class "B" Cleanliness
   1. There shall be no particles larger than 1/16 inch by 1/8 inch except that particles normally contained in the process fluid are acceptable in size and quantity. In air, gas or water flushed systems, there shall be no evidence of organic contamination of the flush medium or screen, greater than that which is normally contained in the process fluid.
   2. Visible cleanliness on hand cleaned carbon steel surfaces is acceptable with tightly adherent mill scale. Approved paint or preservative coatings on carbon steel surfaces that will not peel or flake when exposed to cold water flushing or air blowing are acceptable.

3.03 NOTES AND PRECAUTIONS

A. Observe all normal precautions associated with operating equipment.

B. Cleaning and flushing of systems will be performed using permanent plant equipment where practical.

C. Under conditions of high sample flow velocities, it is permissible to layer several flush cloths to prevent tearing.

D. Flush media shall be determined by FOAMECH.

E. Cleaning and Flushing program definitions are contained in Appendix E.

F. Deadlegs and branch lines shall be cleaned by any of the approved methods (mechanical, flush) after the main header has been verified clean.

3.04 PREREQUISITES

A. Verify system integrity prior to fill and vent of system to be flushed.

B. Verify sufficient piping supports installed on temporary (if applicable) and permanent piping.

C. Verify communications are established as required.

D. Pre-flush Inspections are complete and documented in accordance with Appendix C of this procedure.

3.05 PROCEDURE

A. Prepare Cleaning Program documentation to complete the cleaning program. Highlight each flush section on P&ID with proper valve line-up per valve line-up sheets.

B. P&ID's or flushing diagrams, with an FD designator prefix in the diagram identification block, containing the following:
   1. Cleanliness level.
   2. Cleaning method.
   3. Pre-flush inspection points (required for all sample points).

C. General Notes:
   1. Any additional prerequisites, comments or remarks that apply to the cleaning operation and may or may not be included on the cleaning P&ID.
   2. Marked up flow paths and sample points.
   3. Post-flush Inspections Points (required for all sample points).

D. Implement the approved cleaning program observing applicable notes and precautions contained within cleaning P&ID. All cleaning program revisions must be approved on the cleaning P&ID by the FOAMECH cleaning and flushing coordinator.

E. When system cleanliness meets the requirements of this procedure, document system cleanliness in accordance with the approved cleaning program.

F. Perform Post-flush inspections.
   1. Post-flush inspections may be performed following total system cleaning at the discretion of the Start-up Engineer. However, the Clean System Verification form shall not be signed until Post-flush Inspections within the applicable flow path are performed. If PFI's are not complete, the Clean System Verification form shall be initialed and dated in the appropriate block by the Start-up Engineer, pending cleaning verification by PFI.
   2. Any additional cleaning requirements as a result of Post-flush inspections or from system re-contamination following maintenance shall be determined by the FOAMECH Engineer.

G. Post-flush inspections shall be documented on Cleaned System Rework form (Appendix D).

3.06 RESTORATION

A. Upon completion of cleaning activities, remove all temporary equipment (piping, valves, diverters, etc.) if applicable and restore system integrity at the direction of the FOAMECH Engineer.

B. For Grade A Systems, hang Final Clean Boundary Tags (Appendix D) on clean boundary values consistent with clean flush paths on the cleaning program P&ID. The Start-up Engineer may move the tags as cleaning operations progresses.

C. Lay-up cleaned systems in accordance with the approved P&ID. Maintenance of the lay-up condition will be controlled through the Owner's program.

D. Maintain system cleanliness in accordance with Appendix D.

E. For the final flushing of the system, TDI shall be the flushing material. The temperature in the room shall be maintained at 72 degrees Fahrenheit or higher. Fresh air stations must also be accessible for use.

3.07 DATA SHEETS

A. The completed cleaning program shall be submitted to the FOAMECH Cleaning and Flushing Coordinator for processing.

APPENDIX C
PRE-FLUSH INSPECTION REPORT

SYSTEM _____

PRE-FLUSH INSPECTION POINT (PIP) NUMBER _____

DATE _____

DESCRIPTION OF INTERNAL CLEANLINESS (As Found)

PRE-FLUSH CLEANING ACTION TAKEN (If Any)

NOTE: If any Pre-flush cleaning action is required, evaluation by a Group Supervisor must be obtained to determine if additional Pre-flush inspections are required.

PRE-FLUSH CLEAN EVALUATION (If Required)

_____
Group Supervisor

All foreign material observed is removable by velocity flushing.

_____
FOAMECH Start-up Representative

APPENDIX D

MAINTENANCE OF CLEANLINESS AND REWORK ON GRADE A

AND SAFETY RELATED SYSTEMS

After system flushing operations have been completed, the following activities shall be performed on Grade A and safety related cleaned systems.

A. In the event that rework is necessary on systems previously cleaned, the following shall be performed.
   1. If the rework is to be performed after RFT by maintenance, the rework requestor shall attach a Cleaned System Rework Form (included in this Appendix) to the Work Request. Prior to forwarding to the Flush Engineer, he shall complete the following sections of the Cleaned System Rework Form.
      a. System.
      b. Cleanliness Level (per Appendix F).
      c. Location.
      d. Scope of Rework.
      e. Rework No (Work Request or Work Document No.)
      f. Date Rework to Start.
      g. Precautions Necessary to Maintain Cleanliness.
      h. Surveillance to be Performed By.
   2. If the rework is to be performed after RFT via CWR the following applies:

APPENDIX D
CLEANED SYSTEM REWORK FORM

SYSTEM: _____ REWORK NO: _____

CLEANLINESS LEVEL: _____ DATE REWORK TO START: _____

LOCATION: _____

SCOPE OF REWORK: _____

PRECAUTIONS NECESSARY TO MAINTAIN CLEANLINESS: _____

SURVEILLANCE TO BE PERFORMED BY: _____

INSPECTION PERFORMED AND WITNESSED BY/DATE: _____

PRIOR TO ENTRY: _____

PRIOR TO FIT-UP: _____

FINAL CLOSURE: _____

SYSTEM REWORK IS COMPLETE AND CLEANLINESS LEVEL HAS BEEN MAINTAINED THROUGHOUT ALL ACTIVITIES.

_____ _____
(NAME) (DATE)

SYSTEM REWORK IS COMPLETE AND CLEANLINESS LEVEL HAS BEEN RESTORED BY ADDITIONAL CLEANING.

_____ _____
(NAME) (DATE)

END OF SECTION

SECTION 230170

EQUIPMENT SOUND POWER LEVELS

PART 1 GENERAL

1.01 WORK INCLUDED

A. The provisions of this section to be met in addition to the requirements of the individual equipment sections.

PART 2 PRODUCTS

2.01 MAXIMUM SOUND POWER LEVELS

A. The maximum sound power level for equipment indicated to be as listed below.

MAXIMUM SOUND POWER LEVELS								
	Sound Power Level (dB) Re: 10^{-12} watts							
	63	125	250	500	1K	2K	4K	8K
AC-1	91	93	94	89	88	83	75	72
RAF-1	89	91	92	87	86	81	75	70
AC-3	91	93	94	89	88	83	75	72
RAF-3	90	92	93	88	87	82	74	71
AC-4	93	95	96	91	90	85	77	74
RAF-4	90	92	93	88	87	82	74	71

PART 3 EXECUTION

3.01 INSTALLATION

A. The equipment to be tested in accordance with latest edition of AMCA 300-67, AHRI 430-66, or ASHRAE 36-72, at the operating conditions identified on the schedule including any operating accessories. The manufacturer to submit for approval, certified data as evidence of conformity with this provision. In addition, the following information to be clearly identified for each item.
   1. Cfm, static pressure, rpm, wheel diameter an number of blades, horsepower peak and actual static efficiency.
   2. Alternatively, data resulting from a manufacturer's independent test may be submitted as evidence to support the claim of conformity with the Sound Power Level requirements. Such data will be acceptable at the discretion of the Designer, but only when presented together with a complete description of the test method. The description of the test shall include but not be limited to the following:
      a. Size, shape and acoustical character of test room.
      b. Location of reference sound source and measurement.
      c. Description of rotating vanes.
      d. Swinging or stationary microphone techniques.

END OF SECTION

SECTION 230500

COMMON WORK RESULTS FOR HVAC SYSTEMS

PART 1 GENERAL

1.01 WORK INCLUDED

A. Provide all labor, materials, tools, and services for a complete installation of equipment and systems contained in contract documents.

B. Principal features of work included are:
   1. Heating, ventilating, and air-conditioning system.
   2. Control system including low voltage control wiring and conduit.
   3. Demolition of existing equipment, ductwork, and piping.
   4. Seismic bracing and anchorage for equipment, ductwork, and piping.

1.02 RELATED WORK

A. Electrical power and interlock wiring and conduit.

B. Field painting of equipment, ductwork, and piping.

1.03 INNOVATION MEMORANDUMS

A. The owner has obtained purchase agreements for select equipment and materials. These purchase agreements are documented as Innovation Memorandums and are to be included as part of this project.
   1. Innovation Memorandum No. 7: All piping, valves, pipe fittings and related products to be purchased from Ferguson Enterprises. Refer to Section 232113.
   2. Innovation Memorandum No. 9: All VAV boxes to be purchased from JCI. Refer to Section 233600.
   3. Innovation Memorandum No. 11: All chillers to be purchased from York/JCI. Refer to Section 236423.
   4. Innovation Memorandum No. 12: All air handling units to be purchased from York/JCI. Refer to Section 237313.
   5. Innovation Memorandum No. 13: All building automation systems to be purchased from York/JCI. Refer to Section 230923.

1.04 GENERAL

A. The contract documents form a guide for a complete system. Provide all items necessary to provide a complete system but not specifically mentioned, such as hangers, transitions, offsets, and drains.

B. Layouts indicated on drawings are diagrammatical only. Coordinate exact location of equipment, ductwork, and piping to eliminate conflict with other divisions. Designer reserves right to make reasonable changes in location of equipment, ductwork, and piping prior to construction. Coordination drawings shall be submitted prior to any equipment/systems being installed to ensure that installation conflicts between trades are minimized.

C. Should Contractor find during progress of work that in his judgment existing conditions make desirable a modification, report such item promptly to Designer for instructions. Do not make deviations from contract documents without review of Designer.

D. Supervise all work with a competent mechanic specifically qualified in mechanical discipline.

1.05 PERMITS

A. Secure and pay for permits, licenses, and inspections for work under this division.

1.06 CODES

A. Comply with all pertinent local, state, and national codes. Refer to Division 01.

1.07 STANDARDS

A. Comply with all pertinent standards. This list is provided as a convenience to Contractor and is not to be considered all inclusive.
   1. Sheet Metal and Air-Conditioning Contractors National Association (SMACNA).
   2. American Gas Association (AGA).
   3. Air Moving and Conditioning Association (AMCA).
   4. Air-Conditioning, Heating and Refrigeration Institute (AHRI).
   5. American Society of Mechanical Engineers (ASME).

1.08 SUBMITTALS

A. Submit for review complete brochures and shop drawings for materials and equipment proposed in accordance with Division 01.
   1. Brochures: Submit complete descriptions, illustrations and specification data for materials and equipment proposed. Clearly indicate proposed items when other items are shown on same sheet. Submit samples on request and/or set up for inspection. Samples will be returned to Contractor.
   2. Submittals shall be submitted in line by line format. Each submittal shall be provided with a cover letter and supporting documentation indicating how the submittal meets each line of the referenced specification section. All discrepancies between the construction documents and the submitted product shall be clearly identified for engineer evaluation.
   3. If a product other than the basis of design is rejected by the engineer for any reason, the Contractor shall provide the basis of design product at no additional cost to the Owner.
   4. Shop Drawings:
      a. Control systems.
      b. Complete equipment, ductwork, and piping systems.
      c. Kitchen hood and grease exhaust ductwork systems.

B. Seismic Certification: Refer to Seismic Specification Section 230547 for all project requirements.

1.09 PROJECT MAINTENANCE MANUALS

A. Prior to final acceptance of project, provide Owner with bound maintenance manuals in accordance with Division 01.

1.10 PROJECT TECHNICAL INSTRUCTION

A. Prior to final inspection of project, provide technical instruction to Owner as follows:
   1. Field Instruction: Provide explanation of how systems and equipment are to operate during each season and during emergencies.
   2. Field Demonstration: Demonstrate operation and routine maintenance for systems and equipment.
   3. Video: Provide digital video of all field instruction and demonstration to Owner at completion.

1.11 PROTECTION

A. Protect all materials and equipment in accordance with Division 01.

B. The contractor must take appropriate precautions, during construction, to prevent unnecessary dust and debris from getting into air and water handling systems by covering equipment, controls and open-ended ducts and pipes as the installation progresses.

1.12 CONSTRUCTION RECORD DOCUMENT

A. Provide construction record documents in accordance with Division 01. Keep at the project one set of drawings and daily record changes at the time they are made. Give drawings to Owner at project completion.

1.13 EXISTING SERVICES

A. Maintain existing services in operation during construction. Coordinate and schedule all service interruptions with Owner.

1.14 OWNER NOTIFICATION

A. Notify Owner two weeks prior to activation of central chilled water and steam service to project.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Provide materials and equipment of domestic manufacture bearing the U.L. label when such label is available.

PART 3 EXECUTION

3.01 COORDINATION

A. Coordinate work in accordance with Division 01. Coordinate locations of equipment, ductwork, and piping to eliminate conflict with other divisions.

B. Carefully examine contract documents to be thoroughly familiar with items which require plumbing or mechanical connections and coordination.

C. Provide proper chases and openings. Place sleeves and supports prior to pouring concrete or installation of masonry.

3.02 CUTTING AND PATCHING

A. Repair or replace routine damage caused by cutting in performance of contract.

B. Correct unnecessary damage caused due to installation of mechanical work.

C. Perform repairs with materials that match existing in accordance with the appropriate section of these specifications.

D. Duct floor penetrations and plenum floor penetrations in mechanical rooms shall have a minimum 2” curb.

E. Floor sleeves in wet areas and mechanical rooms shall extend a minimum of 2” above the floor to prevent water entrance to the sleeve. Vertical pipe supports shall be extended to the floor rather than support from the sleeve.

3.03 FLASHING, COUNTERFLASHING, AND SEALING

A. Flash, counterflash, and seal ductwork and piping at penetrations of roofs and outside walls.

3.04 CONNECTION TO EQUIPMENT

A. Rough-in and connect to sterilizers, lab equipment, kitchen equipment, and Owner furnished equipment and provide a shutoff valve and union at each connection. Provide steam strainer and steam trap for steam equipment. Operating valves and/or controls for this equipment will be provided as an integral part of the equipment. Do not rough-in until shop drawings showing rough-in locations have been reviewed by Designer.

3.05 IDENTIFICATION

A. Identify exposed or accessible piping with stenciling contents indicating pipe contents and direction of flow on piping not more than 20 feet apart, at valves, at access panels, and at least once above each space.

B. Contractors option to identify exposed or accessible piping with snap-on or strap-on type markers. Color code markers in accordance with ANSI. Indicate pipe contents and direction of flow on marker. Install markers on piping not more than 20 feet apart, at valves, at access panels, and at least once above each space.

C. Valve tags are required for all emergency shutoff valves and all manual valves 1” and larger. These shall be engraved brass tags hung from valves with minimum 1” high lettering. Submit valve tag directory in close-out documents. Mark ceiling grid with colored marker indicating valve locations above the ceiling. Emergency shutoff valves shall include all valves 2” and larger for the following services: domestic hot and cold water, chilled water, heating hot water, steam and steam condensate and natural gas.

D. Paint piping exposed in equipment rooms in accordance with the following schedule. Paint to be Sherwin Williams Metaltex or approved substitute.

HCA Piping Color Table (Existing Facilities)	
Piping	Color Description
Chilled Water	Pale Green
Hot Water	Pink
Condenser Water	Blue Green
Steam	Dark Orange
Steam Condensate	Light Orange

E. Include design operating pressures in psig for steam and compressed air services.

F. Control compressed air and buried lines need not be marked.

G. Identify all mechanical equipment with engraved brass, aluminum, or stainless steel nameplates or tags. Use equipment names and numbers appearing in schedules on drawings. Fasten nameplates to equipment using screws. Glue or adhesive is not acceptable. Fasten tags to equipment using brass, aluminum or stainless steel chains.

H. Air terminal units (CAV/VAV) concealed above ceilings shall be marked by a marker clipped or adhered to the grid. Include box ID number on marker.

I. Frame and mount control diagrams and sequences in each equipment room. Use non-fading black and white prints encased in aluminum frame with plexiglass cover.

3.06 CLEANING

A. Thoroughly clean ductwork and equipment casings before fans and filters are operated.

B. Repair damaged factory finishes covering all bare places and scratches.

C. Cleaning HVAC Systems Water Piping:
   1. Do not install devices in which foreign matter could become lodged, such as control valves, until cleaning and flushing are completed. Position valves to bypass chiller, boiler and heat exchanger. Connect supply and return runouts together at each coil location. Make connection of supply and return runouts with short lengths of high pressure rubber hose and brass fittings. One fitting shall be swivel type to eliminate turning fitting in hose.
   2. Fill system at city water make-up connection with all air vents open. After filling, close vents.
   3. Start main pump with pressure reducing valve makeup open. Check vents in sequence to bleed off any trapped air in order to assure circulation through all components of system. Verify pumps are properly aligned and bolted down before start-up to prevent damage to seals or couplings. Circulate water for at least two hours and then drain completely to flush out foreign matter.
   4. Remove, clean, and replace all strainer baskets. Clean all dirt legs. If indications are found of excessive dirt, repeat the above flushing.
   5. Fill the system with fresh water, adding precleaning chemicals designed to remove depositions such as pipe dope, oils, rust, mill scale, and other extraneous materials. Provide dosages of precleaner chemicals recommended by water treatment supplier. Alternate operation of primary and standby pumps, and circulate the cleaning solution for 24 hours. Then turn off the pump and completely drain the system.
   6. Remove, clean, and replace all strainer baskets. Clean all dirt legs. Replace suction diffuser start-up strainer with conventional strainer. Refill the system with clean water, venting all high points and equipment of air and gases. Bring water systems to operating temperature. Recheck all vent points during this process and remove all air.
   7. After the system has been completely cleaned, test system by litmus paper or other dependable method and leave system on slightly alkaline side (ph 7.5 to 8.5). If system is still on acid side (ph 7.0 or lower), add water conditioner.

D. Cleaning Steam Supply and Steam Condensate Return Systems: Thoroughly clean using 5 psig steam allowing condensate to be wasted to drains for 8 hours.

3.07 TESTING

A. Test all installed equipment and systems and demonstrate proper operation. Correct and retest work found defective when tested.

B. Thoroughly check piping system for leaks. Do not add any leak-stop compounds to the system. Make repairs to piping system with new materials. Peening, doping, or caulking of joints or holes is not acceptable.

C. Conduct air or smoke test if in opinion of Designer reasonable cause exists to suspect leakage or low quality workmanship.

D. Test compressed air piping with Nitrogen at 100 psi for two hours without leaks.

E. Test HVAC systems water piping and steam supply and steam condensate return piping at a water pressure of 125 psig for two hours without leaks.

F. Vibration Tests:
   1. Test vibration isolation system in accordance with methods and procedures described in the Testing, Adjusting, and Balancing Chapter in the latest edition of ASHRAE Applications Handbook.
   2. Verify all vibration isolation systems are free floating and not short circuited by any connection between equipment and building structure.
   3. Operate mechanical systems and verify visually and audibly that there is no excessive vibration or noise generated by the system.

END OF SECTION

SECTION 230513

ELECTRIC MOTORS

PART 1 GENERAL

1.01 WORK INCLUDED

A. Provide and install electric motors for mechanical and plumbing equipment.

1.02 SUBMITTALS

A. Submittal data is NOT required for products under this section as separate items. It is assumed they will be reviewed with appropriate equipment submittal.

PART 2 PRODUCTS

2.01 MOTORS

A. Electric motors shall be new NEMA Standard, sized and designed to operate at full load and full speed continuously without causing noise, vibration, and temperature rise in excess of their rating.

B. Motors on belt driven equipment shall have slide rails with adjusting screws for belt tension adjustment. Motors exposed to the weather shall be weather protected.

C. Premium efficiency electric motors shall be provided for all motors 3 horsepower and greater. Any motor used with a variable speed motor controller shall be premium efficiency type and VFD compatible.

D. Premium efficiency motors shall have efficiency and losses determined in accordance with the latest revisions of IEEE Standard 112. Polyphase squirrel-cage motors rated 1 through 125 horsepower shall be tested by dynamometer method B. The efficiency shall be determined using segregated losses in which stray load loss is obtained from a linear regression analysis to reduce the effect of random errors in the test measurements. Guaranteed minimum full load efficiency shall be as follows:

MINIMUM NOMINAL FULL-LOAD EFFICIENCY (%)		
	Open Motors	Enclosed Motors
Number of Poles	4	4
Synchronous Speed (RPM)	1750	1750
Motor Horsepower		
3	89.5	89.5
5	89.5	89.5
7.5	91.0	91.7
10	91.7	91.7
15	93.0	92.4
20	93.0	93.0
25	93.6	93.6
30	94.1	93.6
40 – 75	94.1	94.1
100 above	95.4	95.4
Refer to Latest Edition of ASHRAE 90.1 for other motor rpm and efficiencies.		

E. Motor sound power levels shall not be greater than recommended in NEMA M61-12.49.

F. Motors shall be provided with drive shafts long enough to extend completely through belt sheaves.

G. Motor characteristics shall be as follows:
1. 120V/1/60 Hz: Capacitor start, open drip-proof type, ball bearing, rated 40 degrees C. continuous rise.

2. 460V/3/60 Hz: NEMA Design B, normal starting torque, single speed, squirrel cage type, open drip-proof, rated 40 degrees C. continuous rise, with ball bearings rated for B-10 life of 100,000 hours and fitted with grease fittings and relief ports. Provide motors with aluminum end brackets with steel inserts in bearing cavities.

H. Provide grounding rings on all motors equipped with a VFD.

PART 3 EXECUTION

3.01 INSTALLATION

A. Arrange and set motors.

B. Line up motors on direct drive equipment using dial type gauges.

C. Electrical Contractor to make connections and test motor for proper rotation/phasing.

3.02 ADJUSTMENTS

A. All motors together with driven equipment shall be statically and dynamically balanced by equipment supplier, start-up representative, or this contractor using approved balancing equipment. Fan vibration should be limited to manufacturers' recommendations, but should not exceed 2 mils in any case.

END OF SECTION

SECTION 230533

HEAT TRACING FOR HYDRONIC PIPING

PART 1 GENERAL

1.01 WORK INCLUDED

A. Furnish and install a complete U.L. listed system of heaters, components, and controls to prevent pipelines indicated on drawings from freezing.

PART 2 PRODUCTS

2.01 EQUIPMENT REQUIREMENTS

A. Provide self-regulating type heat tracing consisting of two (2) 16 AWG nickel coated-copper bus wires embedded in parallel in a radiation-crosslinked polymer core that varies its power output to respond to temperature all along its length, allowing the heater to be crossed over itself without overheating, to be used directly on plastic pipe, and to be cut to length in the field. The heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket. The heater shall be equivalent to Raychem XL-Trace, Chromalox Rapid-Trace, or approved equal.

B. To prevent overheating, the heater shall have a self-regulating index of at least 90 percent. The self-regulation factor is defined as the percentage reduction, without thermostatic control, of the heater output going from 50 degree F. pipe temperature operation to 140 degree F. pipe temperature operation.

C. The heater shall operate on a line voltage of 277 volts without the use of transformers.

D. The heater shall be sized according to the following table. The required heater output rating is in watts per foot of pipe length at 40 degrees F.

Pipe Size	**Heater Minimum Watts Per Foot**
3 inch and less	5
4 to 6	8
8	10
10 to 16	16
18 and larger	20

E. Power connection, end seal, splice, and tee kit components shall be provided for installation in the field.

F. The system shall be controlled by a strap-on bulb-sensing thermostat set at 40 degrees F. either directly or through an appropriate contactor.

G. Ground fault circuit breaker shall be provided as required by Section 427-22 of the National Electric Code.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install heater in strict accordance with manufacturers' published installation instructions and Article 427 of the National Electric Code.

B. Apply the heater spirally on the pipe after piping has been successfully pressure tested. Secure the heater to piping with cable ties or fiberglass tape. Heat tracing shall be applied to pipe before applying insulation. See Section 230710 for insulation requirements.

C. Apply "electric traced" signs to the outside of the thermal insulation at least once every 50 feet.

3.02 TESTS

A. After installation and before and after installing the thermal insulation, subject heater to testing using a 5000 VDC megger. Minimum insulation resistance should be 20 megohms regardless of length.

B. The installer shall test both heating cable bus wires to verify the connection of any splices or tees.

END OF SECTION

SECTION 230547

VIBRATION AND SEISMIC CONTROL FOR HVAC EQUIPMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. Provide engineered seismic restraint systems for suspended and base mounted Mechanical Piping HVAC Duct Mechanical Equipment utilities compliant with the 2015 International Building Code (IBC) with local building code amendments.

B. All equipment manufacturer's shall submit, as part of the equipment submittal, compliance certifications. Contractor to be responsible for equipment anchorage details.

C. At seismic restraint installation locations, provide vertical support systems engineered to accommodate dead load plus seismic force reactions.

1.02 RELATED SPECIFICATION SECTIONS

A. Mechanical Piping

B. HVAC Duct

C. Mechanical Equipment

1.03 REFERENCES

A. Publications, codes and standards listed below form a part of this specification to the extent referenced.
   1. 2018 International Building Code (IBC)
      a. Chapter 16 - Structural Design
      b. Chapter 17 – Structural Tests And Special Inspections
   2. ASCE 7-16**,** Chapter 13, Minimum Design Loads For Buildings and Other Structures, American Society of Civil Engineers (ASCE).
   3. ACI 318, Building Code Requirements for Structural Concrete, American Concrete Institute (ACI).

1.04 COMPONENT IMPORTANCE FACTOR

A. In order to identify systems requiring seismic restraint and to define those from which restraints may be excluded, utility components are assigned an ASCE 7 Importance Factor (Ip) on the basis of the following:

B. Ip = 1.5
   1. Seismic Use Group III Occupancy Category IV, essential facilities required for post-earthquake recovery – all "Designated Seismic Systems" per IBC Chapter 17 required for the continued operation of the facility.
   2. Life-safety component which is required to function after a seismic event including fire protection sprinkler systems.
   3. Components that contain hazardous or flammable materials.

C. Ip = 1.0: All other components.

1.05 SUBMITTALS

A. Equipment Certification.
   1. Equipment manufacturer to provide certificate of compliance for 2015 IBC proxing on line capability for the project use group and seismic design category. Provide certifications for the following equipment: variable frequency motor, vibration isolators, controllers, air conditioning single zone units on emergency power, equipment support curbs, chillers, cooling towers, indoor air handlers, rooftop air handlers, exhaust fans, control panels, above ground tanks. Equipment manufacturer certification to be based on shake table or three dimensional shock testing or experience data as required by ASCE/SEI 7-16.

2. The following equipment is considered rugged and does not require a certificate of compliance: pumps, valves, and motors.

B. Contractor to identify and convey each overhead deck condition to which seismic attachments will be made. Information to include type and density of concrete, concrete thickness, size and gage of metal deck and any point load limitations or restrictions.

C. Provide Seismic Design Force calculations per ASCE 7-16, Formulas 13.3-1 thru 13.3-3 stamped by a registered design professional qualified civil or structural engineer licensed to practice in the State where project is located. For multi-story projects, provide calculated Seismic Design Force for each floor.

D. Submit seismic restraint layouts stamped by a registered design professional qualified civil or structural engineer licensed to practice in the State where project is located. Seismic restraint layouts to show:
1. All vertical support and seismic brace locations.
2. All anchorage connections to structure. Anchor brand, type, quantity and size.
3. Vertical support and brace reaction point load at all connections to structure. For review by engineer of record in checking suitability of the building structure to accommodate imposed loads.
4. Plan set sheets showing appropriate installation details reflecting actual job site conditions.

E. Include cover sheet with Seismic Restraint Bracing Legend delineating:
1. Maximum Allowable Size or Utility Weight (Lbs/Lf).
2. Minimum Vertical Support Rod Diameter.
3. Support Rod Total Vertical Load.
4. Maximum Allowable Transverse Brace Spacing.
5. Transverse Brace Reaction.
6. Maximum Allowable Longitudinal Brace Spacing.
7. Longitudinal Brace Reaction.
8. Minimum Required Seismic Restraint Brace Arm Assembly.
9. Minimum Required Seismic Restraint Anchorage to Overhead Structure.
10. Installation Detail Drawing References.

1.06 QUALITY ASSURANCE

A. Registered design professional who completed seismic submittal to check suitability of structure to accommodate applied seismic loads.

B. Registered design professional who completed seismic submittal is to provide a “Statement of Special Inspections” in conformance with 2018 IBC IBC, Chapter 17.

C. Each contractor responsible for the construction of a “Designated Seismic System” shall submit to the building official and owner prior to the commencement of work on the system or component a written “statement of responsibility” per IBC Chapter 17.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Seismic restraint hardware and engineering by International Seismic Application Technology (ISAT), Mason Industries, Tolco, or approved equal.

B. Vertical support and seismic restraint anchorages to utilize Cast-In Place Deck Inserts, or Post Installed Anchors. All deck inserts or post installed anchors to have a valid ICC ESR evaluation report (or equal) substantiating the insert or anchor capacity.

C. Vertical support and seismic restraint connections to structural steel are to utilize fixed Beam Clamp connections or Welded or bolted connections.

PART 3 EXECUTION

3.01 INSTALLATION

A. Roof mounted equipment: All roof mounted equipment is to be positively attached to roof support curb or isolators by bolting or welding. All support curbs to resist compressive, shear, tension, and rotational loads (including seismic loads) and translate these loads to building structure. The design of all support curbs shall be performed by an engineer licensed in the project state. Curb design to minimize rotational loads to structure and be positively attached to building structure by bolting or welding.

B. For conditions not covered within pre-engineered drawings, the required engineering is to be performed by a registered Engineer.

C. Manufacturer shall provide field installation training prior to commencement of install.

D. Field relocation of any seismic installation points away from that shown on the furnished shop drawing layouts shall be coordinated with registered design professional who completed seismic submittal.

E. Consult Registered design professional who completed seismic submittal when field conditions prohibit compliance with the supplied installation details.

F. In order to satisfy ASCE 7 minimum yield strength requirements, the allowable brace spacing for non-ductile systems (eg. cast iron, plastic and glass pipe) shall be no more than half that for ductile systems.

3.02 EQUIPMENT CONNECTIONS

A. Where seismic bracing is allowed to be omitted due to size or proximity to overhead deck, all terminations to fixed equipment, panels, etc. or to other portions of the system requiring seismic restraint are to utilize flexible connectors.

B. Where seismic bracing is allowed by code to be omitted due to size or proximity to overhead deck, contractor shall be responsible for assuring that damaging impact or vertical support failure cannot occur.

3.03 SPECIAL INSPECTION

A. Special Inspection Requirements: All Designated Seismic Systems are subject to Special Inspection per IBC Chapter 17.

B. Special inspection for mechanical components shall be provided as follows:
   1. For all Designated Seismic Systems within seismic design categories D, E or F.
   2. Periodic special inspection during the installation for flammable, combustible or highly toxic piping systems and their associated mechanical units in Seismic Design Categories C, D, E or F.
   3. Periodic special inspection during the installation of HVAC ductwork that will contain hazardous materials in Seismic Design Categories C, D, E or F.
   4. Periodic special inspection during the installation of vibration isolation systems where the construction documents indicate a maximum clearance (air gap) between the equipment support frame and restraint less than or equal to 1/4 inch.

C. Install identification tags at all seismic brace locations. Tags to include the following information:
   1. Specific seismic forces (g-force) the location was designed to resist.
   2. Maximum brace reaction at connection to structure.
   3. For single hung items, the maximum pipe/conduit size the brace location was designed to accommodate.
   4. For trapeze supported items, the maximum weight (lbs/lf) the brace location was designed to accommodate.
   5. For suspended equipment, the maximum unit operating weight (lbs) the brace location was designed to accommodate.
   6. Location identifier cross matched to that on plan set layout.
   7. Company name of installing contractor.

D. Upon completion of construction a Quality Assurance Representative of registered design professional who completed seismic submittal shall review the installation of the seismic-force-resisting system and provide documentation indicating general conformance to seismic restraint layout drawing.

END OF SECTION

SECTION 230548

VIBRATION ISOLATION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Isolate equipment as shown on drawings and specified herein with factory-fabricated vibration isolators in accordance with recommendations in the latest edition of ASHRAE Applications Handbook. Provide isolators of proper sizes and weight loading to meet the requirements.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Mason Industries, Kinetics Noise Control, Vibration Eliminator Co., Vibration Mountings & Control, Inc., Korfund Co., Amber Booth, Vibro-Acoustics, or Hyspan. Provide isolators by a single manufacturer.

2.02 FLOOR MOUNTED SPRING ISOLATORS

A. Provide Kinetics Model FDL restrained spring isolator for:
   1. Chillers (minimum 2" deflection).

2.03 FIBERGLASS OR NEOPRENE PADS

A. Provide Kinetics Model KIP for:
   1. Chilled water pumps.
   2. Hot water pumps.

2.04 SPRING AND RUBBER ISOLATION HANGERS

A. Provide Kinetics Model SFH or SRH for:
   1. First three (3) piping hangers on each side of air handling units, pumps, and chillers (minimum 1.5" deflection).

2.05 CONCRETE INERTIA BASES

A. Provide Kinetics Model CIB inertia bases with Kinetics Model FDS spring isolators for:
   1. Chilled water, and hot water pumps. Base to incorporate complete pump and suction diffuser/inlet and outlet piping support (minimum 2" deflection).

2.06 FLEXIBLE PIPE CONNECTORS

A. Provide Metraflex or approved substitute twin-sphere flexible rubber pipe connectors with female unions or floating flanges on piping connections to equipment subject to vibration.

B. Provide connectors rated for 150 PSI working pressure.

C. Provide flexible pipe connectors for the following:
   1. Water connections to chillers.
   2. Water connections to pumps.
   3. Water connections to air handling units.

2.07 SPRING VIBRATION ISOLATION ROOF CURBS

A. Support all rooftop air handling units with spring vibration isolation roof curbs, Kinetics Model KSCR, Mason Model RSC or approved substitute. The isolation curbs shall be complete assemblies designed to resiliently support the equipment at the proper elevation and shall provide a fully enclosed, air- and weathertight system.

B. The isolation curb shall consist of an upper support frame on which the equipment rests and a lower support assembly which is attached to the roof structure separated by freestanding unhoused laterally stable steel springs.

C. The lower support assembly shall incorporate means of attachment to the building as well as a continuous 2" x 2" wood nailer for attachment of the roofing material. The lower support assembly shall also contain provisions for supporting rigid insulation board.

D. Select spring isolators to provide minimum 2" operating static deflection. Space spring isolators a maximum of 96" O.C. Provide a neoprene pad under springs.

E. Design springs with lateral stiffness greater than one times the rated vertical stiffness and minimum 50 percent overload capacity.

F. Include an adjustment bolt to permit leveling of the equipment after installation. Each spring isolator shall be fully accessible for adjustment without interfering with the integrity of the roof.

G. Provide isolation curb with vertical and lateral restraints as required in order to withstand the project specific wind loads as indicated on the structural drawings. Provide signed and sealed installation details for attachment to structure as part of the equipment submittal to document compliance.

H. The isolation curb shall be air and weathertight using an elastomeric boot which is attached to the upper support frame, extends down past the wood nailer of the lower support assembly, and is counterflashed over the roof materials. Provide sloped to drain cap below any portions of the unit that are not weather tight.

I. Provide isolation curb with cross bracing on the upper and lower assemblies as required to assure stability.

2.08 SPRING VIBRATION ISOLATION ROOF CURB RAILS

A. Support all roof mounted HVAC units with spring vibration isolation roof curb rails, Kinetics Model KSR, Mason Model CMAB or approved substitute. The isolation curb rails shall be complete assemblies and provide a fully enclosed, air and weathertight system. Coordinate locations with all trades to prevent interruption of roof drainage layout and function.

B. Isolation curb rails shall consist of extruded aluminum or roll-formed steel top and bottom members connected with spring isolators. Provide continuous air and water seal for the entire rail perimeter. Select and space spring isolators according to weight distribution of the supported equipment.

C. Provide means for attachment to the roof curb and the supported equipment. Provide additional stiffening members as required to assure stability. Provide vertical and lateral restraints as required in order to withstand the project specific wind loads as indicated on the structural drawings. Provide signed and sealed installation details for attachment to structure as part of the equipment submittal to document compliance.

D. Select spring isolators to provide minimum 1" operating static deflection. Spring components shall be freestanding, unhoused, laterally stable steel springs. Design springs with lateral stiffness greater than 0.8 times the rated vertical stiffness and minimum 50 percent overload capacity.

2.09 OUTDOOR APPLICATIONS:

A. All isolators located outside exposed to weather shall be corrosion resistant construction with hot dip galvanizing or PVC coating.

2.10 SEISMIC RESTRAINTS AND ISOLATORS

A. Provide Kinetics Model FLSS seismic control restrained spring isolators for:
   1. Chillers (minimum 2" deflection).

B. Assemble springs into a welded steel housing assembly engineered to limit movement of supported equipment during an earthquake without degrading the vibration isolation of the spring during normal equipment operating conditions. Vibration isolators shall incorporate a steel angle and plate motion limit assembly and steel spring isolator engineered as a system to accept a force in any direction equal to a minimum of 1.0 times the rated load capacity of the spring isolator without yield or failure and shall limit movement of the point of level bolt connection to supported equipment to less than ½" in any direction relative to any fixed point on the isolator assembly, while subjected to the rated force

specified. Weld the motion limit assembly to a steel base plate having a ribbed neoprene pad and drill holes for bolting to the supporting structures. Position a drilled and tapped load plate and leveling bolt assembly on the base plate.

C. Provide Kinetics Model KSS seismic snubber for all concrete inertia bases and equipment bases. Design snubbers to resist 1.0 g loads or to meet current building codes whichever is greater. The steel members of the snubbers shall be designed to yield but not fail under design conditions. Calculations by a registered Professional Engineer or certified test reports shall be submitted which verify the capacity of each snubber. Snubbers shall be welded steel and shall be attached to the building structure in a manner consistent with anticipated loads. Snubbers shall meet current building codes. Snubbers shall be placed around concrete inertia bases and equipment bases to limit lateral or vertical movement at each snubber to ½". A minimum of four snubbers shall be installed around each piece of resiliently supported piece of equipment. Snubbers shall include resilient pads to cushion any impact and shall be installed so as to be out of contact during equipment operation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install vibration isolation in accordance with the isolator and equipment manufacturer's published installation instructions.

B. Size vibration isolation in accordance with weight distribution, pull or the imposed torque of actual equipment provided.

C. Set anchor bolts when concrete is placed. Install vibration isolation roof curb vibration isolation roof curb rails in accordance with manufacturers' published installation instructions to provide an air and watertight seal.

3.02 SEISMIC RESTRAINTS AND ISOLATORS

A. Provide seismic restraints and isolators for Seismic Design Category C, Occupancy Category IV. Provide static seismic calculations with submittals.

END OF SECTION

SECTION 230549

BASIC MATERIALS AND METHODS FOR HVAC

PART 1 GENERAL

1.01 WORK INCLUDED

A. Work required under this section of the specifications consists of basic materials and methods applicable to work under Division 23.

PART 2 PRODUCTS

2.01 FLEXIBLE PIPE CONNECTIONS

A. Provide double sphere, neoprene flexible pipe connectors with flanged or union connections as manufactured by Metraflex or approved substitute in the following locations:
   1. Piping connections to pumps.
   2. Piping connections to air handling units.
   3. Piping connections to chillers.

2.02 V-BELT DRIVES

A. Provide all fan drives with V-belts rated for 150% of nameplate motor horsepower. Provide adjustable pitch motor sheaves for motor sizes through 20 hp. For motor sizes 25 hp and larger provide fixed pitch motor sheaves after balancing to within plus 5% of design air quantity. Select motor sheaves so centerline does not extend past end of motor shaft and such that motor bearing grease fitting and relief port is not obstructed.

B. Provide belt guards for all belt driven equipment. Provide expanded metal cover with access to driven shaft for tachometer.

2.03 FOUNDATIONS AND PADS

A. Provide foundations, pads, and bases required for equipment. Concrete to be in accordance with concrete division of specifications.

B. Coordinate proper sizes and locations of foundations, pads, bases, louvers, anchors, supports, and other items to be built into structure. Housekeeping pads for all air handling units to be tall enough to allow for proper p-trap installation.

2.04 FASTENINGS TO STRUCTURES

A. Provide structural fastening devices for equipment, materials, piping and ductwork. Devices to be concrete inserts, expansion shields and lag bolts, and through bolts-washers-nuts. All bolted devices to use jamb nuts. Inserts to be continuous type as manufactured by Unistrut or approved substitute. Install per manufacturer's published installation instructions in lengths to suit specific application, complete with spring nuts, end caps, and plastic coated filler to prevent concrete seepage.

B. Use of power drive "shot-pins" is permitted only for ducts 20" in width and smaller and single pipes 1" and smaller.

2.05 ACCESS PANELS

A. Wall and ceiling access panels to be provided by Division 01. Coordinate locations so panels will provide proper access to equipment served. Minimum size: 24" x 24".

2.06 ROOF CURBS

A. Provide prefabricated metal roof curbs at all roof ductwork and piping penetrations and for support of all roof-mounted equipment, fans and ductwork. Construct curbs according to National Roof Contractor's Association guidelines. Prefabricated metal roof curbs shall be manufactured by ThyCurb, Custom Curb, or approved substitute.

B. Construct curbs with minimum 18 gauge galvanized steel (14 gauge for curbs with any side longer than 4'-0" and for all curbs supporting equipment) with fully mitered and welded corners, raised 3" integral cant for roof deck insulation, integral base plate, internal reinforcing with 1" x 1" x 1/8" steel angle for curbs with any side longer than 3'-0", factory installed 1-1/2" thick, 3-pound density fiberglass insulation and factory installed pressure treated wood nailer. Minimum height of curb shall be 12" above finished roof surface. (Consult architectural plans for roof type and thickness.) Curbs for kitchen hood exhaust fan shall be height necessary to provide 40" minimum height from finished roof surface to fan discharge. Construct curbs to match slope of roof and provide a level top surface for mounting of mechanical equipment.

C. Curb types shall be as follows:
   1. Fan and duct penetration curbs with standard curb construction as described above - ThyCurb Model TC.
   2. Equipment and ductwork support curbs with minimum 18 gauge galvanized steel shell, base plate and counterflashing, wood nailer, and internal bulkhead reinforcement - ThyCurb Model TEMS.
   3. Pipe penetration curbs with standard curb construction as described above and insulated metal piping cover - ThyCurb Model TC with Model TP-2 piping cover.

D. Install curbs in strict accordance with manufacturer's published installation instructions and as detailed on the drawings. Coordinate proper curb size, construction, and base prior to fabrication.

2.07 ROOF PIPE SUPPORTS

A. Support horizontal piping across roof with Miro Industries Roof Pillow Block Pipestands or ThyCurb or Custom Curb Pipe Support Curbs.

PART 3 EXECUTION - NOT APPLICABLE

END OF SECTION

SECTION 230593

TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.01 WORK INCLUDED

A. Perform test and balance work by a Test and Balance Agency which is engaged solely in full time test and balance work, is a member of the Associated Air Balance Control (AABC) or approved equal, and is selected and employed by the General Contractor.

B. Perform test and balance in accordance with AABC Standards.

C. Contract to the Test and Balance Agency shall be issued by the General Contractor. Coordination with the agency at the job site shall be the responsibility of the contractor in order to ensure proper scheduling and operation of the systems. All correspondence (reports, letters and communications) between any parties shall have copies sent directly to the designer and contractor.

D. The TAB agency shall review construction plans and specifications. If any discrepancies are noted which would hinder balancing, notify the designer with copy to the contractor. Make inspections of the job during construction for proper installation of the system(s) and of balancing aids in the system(s). Any discrepancies noted shall be brought to the attention of the contractor and designer. The number of inspections vary with the size and complexity of the job and shall be adequate for the purpose intended. Report ALL job visits in writing -MANDATORY.

E. The TAB agency shall work in close coordination with the contractor in calibrating all airflow and water flow stations and all duct and pipe mounted differential pressure sensor / transmitters. The tests shall be documented and included in the final TAB report.

F. The Owner has hired an independent Cx agent to commission the mechanical and controls systems serving this facility. The TAB agency should refer to Specification 019113 General Commissioning Requirements, in order to be apprised of, and become familiar with his responsibilities and accountabilities throughout the Cx process.

1.02 RESPONSIBILITIES OF PROJECT CONTRACTOR

A. The contractor shall:
   1. Provide approved Test and Balance Agency with copy of plans and specifications upon issue of construction documents.
   2. Have the building and HVAC systems in operational readiness for TAB work to begin.
   3. Correct prompt deficiencies of materials and workmanship identified as delaying completion of TAB work.
   4. Be responsible for any added costs to the owner resulting from his failure to have the building and HVAC systems ready or from his failure to correct deficiencies promptly.

B. Complete operational readiness of the building requires that construction status of the building shall permit closing of doors, windows, ceilings installed, etc., to obtain projected operating conditions.

C. Complete operational readiness of the air conditioning systems requires that the following be accomplished:
   1. Air Distribution Systems:
      a. Verify installation conforms to design. All supply, return and exhaust ducts terminated and pressure tested for leakage as required by specifications.
      b. All volume, control, fire and smoke dampers properly located and functional. All dampers shall be fully open. MVD gradients and spin damper handles should be exposed through insulation. Dampers serving requirements of minimum and maximum outside, return and relief air shall provide tight closure and full opening, smooth and free operation.
      c. All supply, return, exhaust and transfer grilles, registers, diffusers, terminal boxes and filters installed.
      d. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be sealed to eliminate bypass or leakage of air.

e. All fans operating at full load and verified for freedom from vibration, proper fan rotation and belt tension; heater elements in motor starters to be of proper size and rating. Check motor amperage and verify that it is under nameplate rating.

2. Water Circulating Systems:
   a. Check and verify pump alignment and rotation. Verify location of thermometers, gages, and PT test plugs.
   b. Open all valves to full open position. Close bypass stop valves. Set mixing valves to full flow through system components. Remove and clean all strainers. Verify specified pipe cleaning has taken place. Repeat operation until circulating water is clean.
   c. Record pump motor amperage on each phase and voltage after reaching rated speed. Readings shall not exceed nameplate rating. Verify heater elements in motor starters to be of proper size and rating.
   d. All water circulating systems shall be full and free of air; expansion tanks set for proper water level; all air vents installed at high points of systems and operating freely. System static pressure to be set minimum 5 psig above highest system elevation.
   e. Check and set operating temperatures of heat exchangers to design requirements.
   f. Verify that piping to coils is complete and set for counter flow. Verify location of thermometers, gauges, PT test plugs, and flow balancing/measuring valves.
3. Automatic Controls:
   a. Verify that all control components are installed and functional in accordance with project requirements, including all electrical interlocks, damper sequences, temperature resets, and safeties.
   b. Verify that pressure controllers are calibrated and control variable speed motor controllers as required to maintain a stable pressure.
   c. All controlling instruments calibrated and set for designed operating conditions.
4. Notification of System Readiness: After completion of the work above, the contractor shall notify the TAB firm and designer certifying that the work has been accomplished and that the building and HVAC systems are in readiness for testing, adjusting, and balancing.

D. As part of this project contract, the contractor shall make any changes in the sheaves, belts and dampers required for correct balance as required by the TAB firm.

E. The contractor shall provide and coordinate services of qualified, responsible contractors, suppliers and personnel as required to correct, repair, or replace any and all deficient items or conditions found during the testing, adjusting and balancing period.

F. In order that all systems may be properly tested, balanced, and adjusted, the contractor shall operate systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB.

G. Project schedules shall provide sufficient time to permit the completion of TAB services prior to owner occupancy.

H. The plans and specifications have indicated valves, dampers and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions, and it will be the responsibility of the contractor to install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the contractor shall provide access as requested by the TAB firm. Also, any malfunction encountered by TAB personnel shall be reported to the contractor and designer and corrected by the contractor immediately so the balancing work can proceed.

I. The TAB fieldwork shall not begin on any system / equipment item until signed prefunctional, startup checklists, pertaining to applicable equipment, have been submitted by the installing contractor to the Cx team.

1.03 QUALIFICATIONS OF THE TAB CONTRACTOR

A. The firm shall submit six (6) completed projects of like size and scope. Provide references for each project.

B. The test and balance firm shall submit a resume for the individual proposed to directly supervise the project. The supervisory personnel for the test and balance firm shall be certified test and balance engineers. All project managers and technicians shall be permanent, full-time employees of the agency.

C. The test and balance firm shall submit a list of its calibrated instrumentation to perform the work.

1.04 DOCUMENTS

A. The contractor shall furnish to the TAB firm the following:
   1. One set of mechanical specifications.
   2. Three sets of mechanical drawings.
   3. All pertinent addenda and change orders.
   4. One set of control submittal drawings.
   5. Approved submittal data on equipment installed, and related changes as required to accomplish the TAB test procedures outlined below.

PART 2 PRODUCTS - NOT APPLICABLE

PART 3 EXECUTION

3.01 RESPONSIBILITIES OF THE TAB FIRM

A. The TAB personnel shall check, adjust, and balance the components of the HVAC system which will result in minimum noise, specified temperature, and air flow conditions in the conditioned spaces of the building while the equipment of the system is operating economically. This is intended to be accomplished after the system components are installed and operating as provided for in the contract documents.

3.02 LIAISON AND EARLY INSPECTION

A. The personnel on the job shall act as liaison between the owner, designer and contractor. They shall inspect the installation of piping systems, ductwork systems, control systems, and other component parts of the HVAC systems during the construction stage to verify proper arrangement and adequate provisions for the testing and balancing.

B. During the balancing process, as abnormalities and malfunctions of equipment or components are discovered by the TAB personnel, the contractor shall be advised in writing so that the condition can be corrected by the contractor. The TAB firm shall suggest solutions to noted problems. Data from malfunctioning equipment shall not be recorded in the final TAB report.

3.03 THE TAB REPORT

A. TAB activities shall culminate in a report to be provided in triplicate to the designer. The intent of the final report is to provide a reference of actual operating conditions for the owner's operating personnel.

B. All measurements and recorded readings (of air, water, electricity, sound, etc.) that appear in the reports must be done on-site by permanently employed technicians or engineers of the firm.

C. All comment sheets (punch lists) shall be signed by the contractor to acknowledge receipt. Any outstanding items at the time of completion shall be included in the report.

D. The report shall be certified and approved by the firm's test and balance engineer. The report shall be recorded on standard forms.

3.04 ACTUAL TESTING AND BALANCING PROCEDURES

A. Airside:
   1. Supply Fan:
      a. Fans checked for rotation, amperage, static pressure, etc.
      b. Terminal boxes set to maximum cfm and adjust supply fan to within 0% to +5% of design cfm.
      c. Main supply duct pitot tube traverse and adjustment of fan speed to produce design cfm while maintaining minimum system static pressure for proper terminal box operation.
      d. The report shall record the VFD speed for the supply fan.
   2. Return Fans:
      a. Fans checked for rotation, amperage, static pressure, etc.
      b. With supply system in the maximum mode, traverse and adjust return fan to within +/- 5% of design cfm.
      c. The report shall record the VFD speed for the return fan.
   3. Outside Air:

a. Fans checked for rotation, amperage, static pressure, etc.
b. With supply system in the maximum mode, traverse and adjust minimum outside air damper and/or fan to design cfm.

4. Exhaust Fan:
   a. Fans checked for rotation, amperage, static pressure, etc.
   b. With supply system in the maximum mode, traverse and adjust exhaust fan to within +/- 5% of design cfm.
5. Diffusers, Registers, and Grilles:
   a. Balance each supply air outlet to within 0% to 10% of design cfm.
   b. Balance each return air outlet to within +/- 5% of design cfm.
   c. Balance each exhaust air outlet to within 0% to -10% of design cfm.
   d. Check and/or adjust pressure relationships so that each positive pressure and each negative pressure area is at least 10% positive or negative as appropriate.
6. After completion, take total air-handling system static profile and record all final statics, amperages, rpm, cfm, etc.

B. Waterside:
1. Chilled Water:
   a. Check system for cleanliness.
   b. With all chilled water valves calling for full cooling, test, set and record each pump head and flow.
   c. Test, set, and record pressure drop and flow through each chiller to within 0% to 5% of design.
   d. Test, set and record pressure drop and flow through each flow balancing station.
   e. Test, set and record pressure drop and flow through each cooling coil to within 0% to 5% of design.
   f. Verify that piping system is vented.
   g. Verify removal of pump start up strainer and replacement with operating strainer.
2. Hot Water:
   a. Check system for cleanliness.
   b. With all hot water coils (including terminal box reheat coils) calling for full heating, test, set and record pump head and flow.
   c. Test, set and record pressure drop and flow through each [convertor][boiler] to within 0% to 5% of design.
   d. Test, set and record pressure drop and flow through each flow balancing station.
   e. Test, set and record pressure drop and flow through each heating coil to within 0% to 5% of design.
   f. Verify that piping system is vented.
   g. Verify removal of pump start-up strainer and replacement with operating strainer.
3. Domestic Hot Water Recirculation System:
   a. Balance recirculation pumps ±5% of design gpm flow.
   b. Set balancing valves to gpm settings as noted on plumbing drawings.

C. Controls:
1. AHU Controls:
   a. Check temperature controls for proper calibration and setpoint.
   b. Check economizer controls for proper damper operation and control calibration.
   c. Check supply/return volumetric synchronization system under maximum and minimum conditions for proper operation.
   d. Check static pressure control under maximum and minimum conditions for proper operation.
   e. Record the following: The supply duct static pressure reading, VFD Hz, and fan rpm when the AHU supply fan is meeting the design airflow of all terminal units simultaneously. Also record the supply static pressure set point established and transmitted to the controls subcontractor.
2. Chiller Controls:
   a. Verify chiller controller is set at design chilled water temperature.
   b. Verify central chiller control panel properly stages chillers.
3. Thermostats and Controllers:
   a. Check for proper control of valves, dampers, terminal boxes, exhaust fans, etc.
   b. Set at design set point.

D. Capacity and Performance Test:
1. Cooling Coils:
   a. Test, set and record pressure drop and flow through each coil.

b. Measure entering and leaving dry and wet bulb air temperatures with glass stem, mercury thermometers accurate to 1/2 degrees F.
c. Measure entering and leaving water temperature with glass stem, mercury thermometer if thermometer wells are provided. If P.T. plugs are provided, use a bi-metal thermometer which reads in 1 degree F. increments and use the same thermometer for both supply and return water temperature measurements.
d. Record final temperatures, BTU/HR. and GPM.
e. Convert actual test conditions to design conditions to insure design coil capacities at design temperatures.

2. Heating Coils (Air Handling Unit and Preheat Only):
   a. Test, set and record pressure drop and flow through each coil.
   b. Measure entering and leaving dry and wet bulb air temperatures with glass stem, mercury thermometers accurate to 1/2 degrees F.
   c. Measure entering and leaving water temperature with glass stem, mercury thermometer if thermometer wells are provided. If P.T. plugs are provided, use a bi-metal thermometer which reads in 1 degree F. increments and use the same thermometer for both supply and return water temperature measurements.
   d. Record final temperatures, BTU/HR. and GPM.
   e. Convert actual test conditions to design conditions to insure design coil capacities at design temperatures.
3. Terminal Box Heating Coils: Test, set and record flow through hot water branch main balancing valves or individual terminal box heating coil. HCA standard is that heating coils on VAV boxes are not provided with individual balancing valves. The contractor shall review the drawings to determine the number of balancing valves on the project.
4. Chillers:
   a. Record full load entering and leaving chilled water temperatures with glass stem, mercury thermometers accurate to 1/2 degree F.
   b. Record GPM at time of test.
   c. Record amperage and voltage.
   d. Perform log-test for a minimum of one hour taking readings at least every ten minutes.
   e. Average all readings and compute test capacity in BTU/HR. and in tons.
   f. Average all readings and compute actual kw/ton of chiller.
5. Thermostat Calibration:
   a. Measure and record dry and wet bulb temperatures at each thermostat.
   b. Report any thermostat which is not controlling with +/-1-1/2 degree F.
6. Control Temperature Readouts:
   a. Test actual temperature next to sensor (if possible) and compare to readout.
   b. Report any sensor which is not within +/-1/1-2 degrees F.

E. Noise Level: The TAB Contractor shall measure the HVAC background noise level in all the spaces as follows: HVAC system produced noise shall not exceed the following levels: patient rooms, nurses stations, offices, conference rooms, LDRs, nursery, exam rooms, therapy rooms, diagnostic rooms, waiting rooms, and treatment rooms shall not exceed a NC 37; operating rooms, C-section rooms, lobbies, cafeteria, toilets, laboratories, and utility rooms shall not exceed a NC 42. NICU is NC 34.

F. The General Contractor and the Mechanical Contractor shall be responsible for reviewing the NC curve for spaces which exceed the required levels and make appropriate adjustments to the system to bring the NC level into range. The final TAB report shall document all spaces with appropriate NC levels.

3.05 REPORTS

A. Problems Encountered: Any items not installed, improperly installed or not functioning properly shall be reported to the contractor.

B. Final Report:
   1. Any unresolved problems shall be reported in a general remarks section in front of the test and balance report.
   2. Any unusual operations or pertinent remarks which may aid the maintenance personnel or ease the reading of the report shall be made in the general remarks section of the report.
   3. All operating data and final tests shall be reported in the final report. This data shall include, but not necessarily be limited to the scope of work outlined above.

4. TAB contractor shall compile an Excel spreadsheet for all terminal boxes, listing each box by its unique identification number, the inlet flow area established by the box manufacturer, the manufacturer's gain factor for the box, final TAB calibrated gain factor for the box if field calibrated, and the ratio of the calibrated gain factor to the manufacturer's gain factor.

3.06 CALLBACK

A. Test and Balance Agency shall retest any unresolved problems noted in the final report. The revised results shall be forwarded after completion of test.

B. At the discretion of the designer before final acceptance of the TAB report, the report data shall be verified one time on the job site by selection of random check points in the presence of the designer. Representatives of the testing firm shall be present and provide the necessary equipment for test data verifications.

C. The firm shall be responsible for testing, adjusting, balancing, and reporting on the performance of all fans, dampers, air distribution devices, pumps and heat exchangers, the flow through all coils, pumps and heat exchangers, and the power consumption of all motors. The contractors and the suppliers of the equipment installed shall cooperate with the balancing agency to provide all necessary data on the design and proper application of the system components and shall furnish all labor and material required to eliminate any deficiency.

D. Make one (1) inspection within ninety (90) days after occupancy of the building to insure that satisfactory conditions are being maintained.

3.07 OPPOSED SEASON TESTING

A. This service allows for testing of equipment that, due to extreme weather conditions, cannot be accurately tested at the time of the initial balance. If a project is balanced during the summer, the opposed season testing is performed during the winter months and vice-versa.

B. During the opposed season testing, any necessary modifications to the initial adjustment required to produce optimum operation of the system components shall be made to produce the proper seasonal conditions in each conditioned space. At the time of opposite season testing, the designer and owner shall be given timely notification before any readings or adjustments are made so that he may participate.

END OF SECTION

SECTION 230710

INSULATION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Contractor shall provide all necessary labor, materials, tools, and equipment to perform work required on the drawings and specified herein.

B. Certain equipment and/or systems to be factory insulated by manufacturer. Factory insulation materials to be as specified in applicable sections of the specifications.

C. All pipe fittings, valves, and strainers in insulated pipe systems to be insulated.

D. Thermal resistance "R" values used herein are expressed in units of "Hour, Degrees F., Sq. Ft./BTU per Inch of Thickness" on a flat surface at a mean temperature of 75 degrees F.

E. Note that where electric cable wrap is called for, insulation is to be applied over cable.

F. "Contractor's Option" referred to in Materials below indicates optional materials which may be used as equals.

1.02 DEFINITIONS

A. "Exposed" equipment, ducts, and piping are areas which will be visible without removing ceilings or opening access panels.

B. Outdoors is considered exposed to the weather.

C. Underground is buried, whereas in a trench below grade is considered concealed.

1.03 CERTIFICATION/QUALITY ASSURANCE

A. Products shall meet applicable national, state, and local building codes and be U.L. (or other recognized testing lab) listed for intended service.

B. All insulations, jackets, adhesives, coatings, sealers, and tapes shall have a flame spread rating of 25 or less and smoke development rating of 50 or less when tested in accordance with ASTM E-84, NFPA 225, U.L. 723, and further must meet the requirements of NFPA 90-A and applicable building, plumbing, and mechanical codes.

C. All insulation materials shall be delivered and stored in manufacturers' containers and kept free from dirt, water, chemical, and mechanical damage. Under no circumstances shall insulation applied to exterior ductwork be allowed to get wet prior to final material covering.

D. Insulation shall be applied in a workmanlike manner by experienced, qualified tradesmen.

E. Insulation shall not be applied until all pressure testing has been completed, inspected, and released for insulation application.

F. Surfaces shall be clean and dry.

G. Insulation joints shall be butted firmly together and all jackets and tapes shall be smoothly and securely installed.

H. Insulation for duct, pipe, and equipment for above grade exposed to weather outside building shall be certified as being self-extinguishing for 1" thickness in less than 53 seconds when tested in accordance with ASTM D-1692.

1.04 APPLICABLE CODES AND STANDARDS

A. ASTM E-84.

B. U.L. 723.

C. NFPA 90-A.

D. ASHRAE 90.1

E. International Energy Conservation Code.

PART 2 PRODUCTS

2.01 MATERIALS FOR PIPE AND EQUIPMENT

A. Materials for Pipe and Equipment: Provide factory pre-molded or shop or site mitered segment type insulation for pipe, pipe fittings, and valves. Fitting insulation to be of same thickness and material as adjoining pipe insulation. All insulation and related materials such as tape and mastic to meet applicable building code requirements for fire and smoke development.
   1. Cellular Glass (Foamglass): Pittsburgh Corning "Foamglass." Product must be guaranteed by manufacturer to have a continuous operational temperature limit of 250 degrees F. and a minimum "R" value of 3.7 per inch (K=0.27) at 75 degrees F mean temperature. Vapor-barrier mastic for application to below ambient pipe insulation shall be fungus resistant per ASTM D 5590 with 0 growth rating; Water based; Permeance per ASTM E 96, Procedure B, 0.013 perm or less at 43-mil dry film thickness suitable for indoor and jacketed outdoor use. Products: Foster 30-80 AF. Color: White. For all butt joints, a pliable insulation joint sealant shall be used. Products: Foster 95-50 or Childers CP-76. Use foamglass for the following services:
      a. Chilled water piping and low-temp chilled water piping: Below 1-1/2” - 1-1/2" thick; 1-1/2" and greater - 2" thick.
      b. Where hanger saddles are installed instead of other piping insulation (fiberglass, flexible tubular) to prevent crushing of insulation at hangers.
   2. Flexible Tubular: Provide 25/50 rated, closed-cell, flexible tubular rubber type pipe insulation. Product to have continuous operational temperature limit of 200 degrees F. and a minimum "R" value of 3.7 per inch (K=0.27) at 75 degrees F mean temperature. Product to be Armstrong AP Armaflex or approved equal pipe insulation. Use flexible tubular for the following services:
      a. Moisture condensate drains: 1" thick.
      b. Horizontal runs of waste lines carrying cold condensate from air conditioning equipment: 1" thick.
      c. Provide multiple layers as required to obtain minimum thickness.
   3. Flexible Sheet: Provide 25/50 rated, closed-cell, flexible sheet rubber type insulation, having a minimum "R" value of 3.7 per inch (K=0.27) at 75 degrees F mean temperature and continuous operational temperature limit of 200 degrees F. Product to be Armstrong "Armaflex II" or approved equal. Use flexible sheet insulation for the following services:
      a. Chiller cooler, suction piping, and any chilled water pipe connections, housings, and other portions of the chiller which might sweat: 1" thick.
      b. Chilled water pump casings and flanges: 1" thick.
      c. Chilled water piping valves, strainers, and hydronic specialties: 1" thick.
   4. Fiberglass: Provide factory-formed, factory-jacketed fiberglass piping insulation. Product to be Manville "Micro-Lok 650" with "Type AP-T" jacketing or equivalent product manufactured by CertainTeed, Knauf, or Owens-Corning. Product to have continuous operational temperature limit of 850 degrees F and a minimum "R" value of 3.5 per inch thickness (K=0.28) at 75 degrees F mean temperature. Jacket to be fiberglass reinforced kraft paper with aluminum foil and pressure sensitive closure system. Vapor-barrier mastic for application to **below** ambient pipe insulation shall be fungus resistant per ASTM D 5590 with 0 growth rating; Water based; Permeance per ASTM E 96, Procedure B, 0.013 perm or less at 43-mil dry film thickness suitable for indoor and jacketed outdoor use. Products: Foster 30-80 AF. Color: White. A breather mastic for application to above ambient pipe insulation (fittings, tees, valves, etc) shall be water based Foster 46-50 mastic or Childers CP-10 / CP-11. Use fiberglass piping insulation for the following services:
      a. Heating hot water piping: below 1-5/8" – 1-1/2" thick; 1-5/8" and greater - 2" thick.
      b. Gravity condensate (steam) piping: below 1-1/2" – 2-1/2" thick; 1-1/2" and greater - 3" thick.
      c. Pumped condensate (steam) piping: below 1-1/2" - 2-1/2” thick; – 1-1/2" and greater – 3" thick.
      d. Steam piping to 15 psi: below 1-1/2" - 2-1/2" thick; 1-1/2” and greater - 3" thick.
      e. Steam piping to 60 psi: below 1-1/2” – 4” thick, 1-1/2” and greater – 4-1/2” thick.
      f. Steam piping to 125 psi: below 1-1/2" – 4” thick; 1-1/2" and greater 4-1/2” thick.

g. Steam converter: 4-1/2" thick.
h. Vents from condensate receiver tank, flash tank, and pressure reducing station relief valve where exposed in building: 1" thick.

2.02 MATERIALS FOR DUCTS

A. Blanket Type Duct Insulation: Provide minimum 3/4 pound per cubic foot density, flexible blanket fiberglass duct insulation with FSKL aluminum foil vapor barrier facing and 2" tab. Insulation shall have minimum 'R' value of 3.4 per inch (K=0.29) at 75 degrees F mean temperature. Product to be Manville "Microlite" or equivalent standard duct wrap by CertainTeed, Knauf, or Owens-Corning. Use blanket type duct insulation for the following:
1. Unlined heating and/or cooling supply and return air ductwork concealed from view: 2" thick.
2. Unlined outside air ductwork concealed from view: 2" thick.

B. Board Type Duct Insulation: Provide minimum 3 pound per cubic foot density, semi-rigid fiberglass duct insulation with FSKL aluminum foil vapor barrier facing. Insulation shall have a minimum 'R' value of 3.8 per inch (K=0.26) at 75 degrees F mean temperature. Product to be Manville "800 series Spin-Glas" or equivalent by CertainTeed, Knauf, or Owens-Corning. Use board type duct insulation for the following services:
1. Unlined exposed heating and/or cooling supply air ducts: 1-1/2" thick.
2. Unlined exposed outside air ducts: 1-1/2" thick.
3. Unlined exposed return ducts: 1-1/2" thick.
4. Unlined exposed supply, return and outside air ducts within equipment rooms or located in unconditioned space: 1-1/2" thick.
5. Apparatus casing: 1-1/2" thick.
6. Unlined supply air and return air ducts outside exposed to weather: 2" thick.
7. Unlined air-handling plenums within equipment rooms: 1-1/2" thick.

2.03 MATERIALS FOR FITTINGS, VALVES, AND SPECIAL COVERINGS

A. Provide coverings and finishes for specific items hereinafter specified.
1. Use pre-molded insulation fabricated by the manufacturer of insulation material or shop or site mitered segment type insulation for: All pipe fittings, elbows, tees, valves, and couplings. Fittings on fiberglass pipe insulation shall be mitered insulation for piping up to 2" diameter and molded fittings for pipe 2-1/2" diameter and larger.
2. PVC fitting covers over blanket fiberglass are NOT acceptable.
3. Contractor to provide factory pre-molded one-piece PVC insulated fitting covers, precut fiberglass insulation inserts, and necessary installation materials for all pipe fittings. Materials to be equal to Manville Zeston white, U.V. resistant, 25/50 rated, 20 mil thickness insulated PVC fitting covers and insulation inserts.
4. PVC fitting covers over blanket fiberglass are not acceptable for steam, gravity steam condensate, and steam boiler/deaerator piping services.
5. Insulation is not required for steam traps, steam, hot condensate, and hot water system strainers, relief valves, and steam pressure reducing valves. Insulate piping to within 3" of uninsulated items.

B. For heat exchangers, air separators, large pipes, etc., in systems operating over 60 degrees F., when exposed-to-view inside building or in equipment rooms, cover insulation with a smoothing coat of Keane Powerhouse cement, one layer of white colored glass mesh embedded and finished with Foster 46-50 mastic or Childers CP-10 / CP-11 mastic.

C. For pipe fittings, valves, strainers, air separators, and other irregular surfaces, in systems operating below 60 degrees F., when exposed to view inside building or in equipment rooms, cover insulation with white colored glass mesh embedded in white, fungus resistant vapor barrier coating Foster 30-80 AF. Coating shall meet ASTM D 5590 with 0 growth rating.

D. Fabricate and install readily removable insulation caps to facilitate service and maintenance accessibility to all strainers including suction diffusers in systems operating below 60 degrees F.

E. For any service when above grade exposed-to-the-weather outside building, cover straight pipe insulation with 0.016" thick aluminum jacket equivalent to ITW or RPR and cover valves and fittings with .024" thick aluminum factory formed covers equivalent to Childers Ell-Jacs.

F. For any service when above grade exposed-to-the-weather outside building, cover pipe insulation with 20 mil thick white, U.V. resistant, 25/50 rated PVC jacketing equivalent to Manville Zeston PVC jacketing and fitting covers. All joints to be made with solvent welding adhesive equivalent to Manville Perma-Weld to create a permanent chemical bond between the PVC members.

G. For flexible tubular pipe and fitting insulation when exposed-to-view inside building or exposed to the weather, finish with two coats of paint, custom color blended to match surrounding surfaces.

H. For externally insulated sheet metal ducts when above grade exposed-to-the-weather outside building, cover board duct insulation with Alumaguard 60 self-adhering weather and vapor barrier membrane by Polyguard or equal by FlexClad having proven ability to withstand a wide range of temperatures without cracking or crazing and that is highly resistant to damage by bumping and abrasion. Product color to be white unless otherwise noted. Apply in accordance with manufacturers' published instructions.

I. When specifically approved by designer, when it is impossible to completely insulate pipe, fittings, or valves with specified insulation, Armstrong Armaflex insulation tape may be used to prevent condensate drip on small piping. Use of cork insulation tape is prohibited.

PART 3 EXECUTION

3.01 GENERAL

A. No insulation shall be cut where a hanger is located. If hangers have been installed by pipefitter tradesmen which violates this strict requirement, notify Designer immediately.

B. Piping and ductwork systems shall be tested and found free of all leaks prior to installation of insulation covering.

C. All surfaces shall be clean and dry when covering is applied. Covering to be dry when installed and during application of any finish, unless such finish specifically requires a wetted surface for application.

D. All adhesives, cements, and mastics shall be compatible with materials applied and shall not attack materials in either wet or dry state.

E. Install insulation using professional insulators who have adequate experience and ability.

F. Exposed-to-view insulation shall have a well tailored appearance.

G. See Section 232113 and 232213 for sleeves and insulation requirements.

H. Stop all duct coverings, including jacket and insulation, at fire and smoke dampered penetrations of partitions. "Fan-Out" or extend jacketed insulation at least 2" beyond angle frames of dampers and secure insulation to partition. Maintain vapor barrier. Where insulated duct access door is not used, install covering over damper access panel so as to be readily removable and identifiable.

I. Treat insulated pipe and duct surfaces in equipment rooms and where exposed to normal view, so surfaces may be painted with water base latex paint. Use of mastics, adhesives, or jacketing which cause "bleeding" is prohibited.

3.02 INSTALLATION OF DUCT COVERING

A. Apply jacketed blanket type fiberglass covering to ducts pulled snug but not so tight as to compress corners more than 1/4". Use insulation having 2" tab, or cut insulation long enough to allow for "peel off" of insulation from jacket to effect a minimum overlap of 2". Secure 2" jacket laps using equivalent of Foster 85-75 or CP-82 adhesive and staple lap with flare type staples on 2" centers. Cover standing seams, stiffeners, and braces with same insulation blanket, using 2" jacket lap and staple lap as hereinbefore outlined. Cover and seal all staples with Foster 30/80 AF, fire resistant vapor barrier coating reinforced with glass cloth.

B. For duct 24" or wider, mechanically fasten insulation to duct bottom, using weld pins or nylon "stick-clip" base plates having self-locking coated metal or nylon discs. Locate fasteners on not over 12" centers laterally and longitudinally. Seal pins as above.

C. For ducts more than 20” deep, mechanically fasten insulation to duct sides, using one row of pins, plates, or discs located on not over 12" centers longitudinally and equidistant laterally between duct top and bottom. For ducts over 24" deep, apply fasteners as before only using minimum of two rows.

D. Apply jacketed board type fiberglass covering to ducts using weld pins or nylon "stick-clip" base plates having self-locking coated metal or nylon discs. Locate fasteners on not over 12" centers laterally and longitudinally. If insulation is grooved to fit around corners, in order to eliminate as many joints as possible, pin as required to hold insulation tight to duct, especially on bottom of duct. Seal pins and joints with Foster 30-80 AF reinforced with glass mesh.

E. Cover all joints, rips, tears, punctures, disc heads, staples, or breaks in vapor barrier jacket with 4" wide woven glass fabric tape embedded in Foster 30-80 AF fire resistant vapor barrier coating. PRESSURE SENSITIVE TAPE NOT ALLOWED.

F. Ductwork manual volume damper (MVD) handles, airflow station pressure ports, access door handles, duct-mounted instrumentation, etc., shall be left exposed and/or accessible above the insulation vapor barrier.

3.03 INSTALLATION OF PIPE AND EQUIPMENT COVERING

A. Where fiberglass or flexible tubular insulation is used on piping sized 2" and larger, insert a section of foamglass insulation at hanger or support points between pipe and metal shield for full length of shield to prevent crushing of insulation. Insulation thickness to be same as adjoining insulation. Where insulation passes through pipe hangers and across trapeze supports, 12" long metal saddles shall be used. On cold pipe, vapor barrier should be carried through the hanger and sealed.

B. Foamglass insulation shall be strictly applied as follows:
   1. The inside full surface of the insulation and both the circumferential and longitudinal joints shall be buttered with fire-resistive pliable joint sealant. Voids and cracks shall be filled with sealant. Sealant shall be Foster 95-50, Childers CP-76 or equal. Insulation shall be secured with 1/2" wide aluminum bands on 12" centers.
   2. The circumferential joints shall be staggered.
   3. Block type insulation shall be adhered by stick-clips or bands, in addition to the sealant, as required to provide support for the insulation.
   4. Finish in concealed locations shall be the bare insulation.
   5. Finish in equipment rooms and elsewhere where exposed-to-view shall be white 8 oz. canvas and Foster 30-36 or Childers CP-50A MV1 lagging adhesive/coating, paintable jacket.

C. Apply flexible tubular insulation to pipe and fittings using the slip-on method with all joints tightly fitted and sealed with Armstrong 520, Foster 85-75, Childres CP-82 adhesive or approved equal. Seal butt joints, miter joints and torn or damaged insulation with adhesive.

D. Prior to application of flexible sheet insulation, thoroughly clean all metal surfaces, making sure that all dirt, scale, loose paint, plaster, and oil have been removed and that surfaces are dry. If surface has been primed, test a 2 square foot section using adhesive equivalent to Armstrong No. 520, Foster 85-75, Childers CP-82 in order to determine whether solvent in adhesive will loosen or lift the primer. If primer is loosened, then remove it. When testing proves acceptable, adhere insulation with smooth side out, using thin but adequate coating of same adhesive. Follow manufacturers’ instructions. Coat all butt edges of each sheet. Stagger all joints. Insulate all standing seams or flanges with same thickness of insulation material as that used on main surface.

E. Apply PVC insulated fitting covers and precut insulation inserts as follows:
   1. Installation for hot systems:
      a. Place the precut fiberglass insert around the fitting, positioning the points of the insert on the inside radius of the elbow.
      b. Butt the ends of the fiberglass insert against the ends of the pipe covering. Tuck and fold the insulation so that it covers all bare surfaces. Keep the fiberglass fluffed up to the thickness of the adjacent pipe insulation to assure maximum thermal efficiency.
      c. Insert two stainless steel serrated tacks approximately 1/4" from one of the lap edges of the fitting cover. Then snap the cover in place over the fiberglass insulation.
      d. After the fitting cover is in position, push the tacks into the overlapping throat seam. Apply color-matched, pressure-sensitive tape to the butt joints.

e. For steam and steam condensate systems, two layers of precut fiberglass inserts shall be applied to fittings. Secure first layer by wrapping with fiberglass yarn.

2. Installation for cold systems:
   a. Position, tuck, and fold the fiberglass insulation insert as described above in steps (a) and (b) for hot systems.
   b. Apply a vapor barrier mastic around the edges of the adjoining pipe insulation. Apply the mastic along the inside of the fitting cover throat overlap seam.
   c. Place the fitting cover over the insulation, lapping the mastic-covered edge over the other side of the throat seam.
   d. Apply color-matched, pressure-sensitive tape over the circumferential joints. The tape should extend over the adjacent pipe insulation and overlap itself by at least 2" on the downward side of the lap.

F. All hot water and chilled water pump casings shall be insulated with readily removable insulation sections that allow easy access to all pump components, pressure gauges, P/T ports, etc., requiring testing or maintenance access.

G. All interconnecting piping on chilled water line pressure gauges and differential pressure stations shall be insulated to prevent sweating.

H. Piping insulation on in-line mounted P/T ports, circuit setting pressure ports, calibrated balancing valve pressure ports, etc., shall be made easily removable so that access to the ports can be readily obtained without destroying the insulation.

END OF SECTION

SECTION 230923

DIRECT DIGITAL CONTROL/BUILDING AUTOMATION SYSTEM (DDC/BAS)

PART 1 GENERAL

1.01 DESCRIPTION

A. Direct Digital Control/Building Automation Systems (DDC/BAS) shall be Johnson Controls. For pricing contact:
   1. Johnson Controls, Inc.
      Contact: Kevin P. Tolbert
      507 E. Michigan St, M-30
      Milwaukee, WI 53202
      email: BE-HCA@jci.com
      478-952-8740

B. All new points are to be mapped back to and integrated with existing JCI front end. Provide software upgrade to accept new controllers and graphics updates if required to integrate project.

C. The work specified under this section of the specifications includes furnishing, installing, programming, and placing into operation the DDC/BAS systems.

D. The BAS/DDC shall use BACNet/IP protocol capable of communicating over an Ethernet system. It shall be capable of residing on the HCA Enterprise WAN/LAN by having an assigned IP address. BAS/DDC systems are required to permit a remote user with password access, monitor points and issue basic commands over the HCA WAN/LAN using a PC type terminal without the need for proprietary BAS/DDC software. The system front end shall reside on a server not a PC.

E. The DDC/BAS systems shall be furnished and installed under this section of the specifications and shall consist of microprocessor based digital system controllers. The systems shall be complete in every respect, including all auxiliary and accessory items as required, and shall be thoroughly coordinated so as to provide a compatible and completely workable system.

F. Provide a complete control system including electrical interlocks, wiring, conduit, relays, switches, control transformers, and other devices as required to accomplish automatic control of the mechanical systems. Refer to drawings for details.

G. All systems shall be guaranteed against defects of any nature and to operate properly for a period of not less than 12 months after final acceptance of the job by the Owner. During this period, the BAS manufacturer shall service and adjust the systems as required for proper operation, replacing components as required.

H. The contractor shall work in close cooperation with the TAB agency in calibrating all airflow and water flow stations and all duct and pipe mounted differential pressure sensor/transmitters.

I. Commissioning of the mechanical and control systems is part of this project. The Cx procedures shall include Prefunctional Performance Testing and final Functional Performance Test. The contractor should refer to Specification Sections 01 9113, in order to be apprised of, and become familiar with his responsibilities and accountabilities throughout the Cx process.

J. The controls contractor shall furnish the test and balance contractor with appropriate DDC system software available to assist in the TAB process. The contractor shall work in close cooperation with the TAB agency in calibrating all airflow and water flow stations and all duct and pipe mounted differential pressure sensor/transmitters. The controls contractor shall provide a technician for 8 hours to assist/train the TAB technician in the coordination/interface of the BAS with TAB activities.

1.02 SUBMITTALS

A. Submit complete shop drawings, equipment and component brochures, list of control valve CV and pressure drops, list of control dampers, written sequences of operations, diagrams indicating panels, gauges, components, spring ranges, and setpoints, and complete composite wiring diagrams indicating all equipment interlocks for entire control system.

B. At the time of submission to architect/engineer, the contractor shall submit an information only copy of the complete BAS/DDC submittal to HCA Engineering FacilitiGroup, 6100 Tower Circle, Suite 400, Franklin, TN 37067.

PART 2 PRODUCTS

2.01 GENERAL PRODUCT DESCRIPTION

A. The building automation system shall consist of the following:
   1. Stand-alone DDC panels.
   2. Stand-alone application specific controllers (ASCs).
   3. DDC panel-mounted operator terminal.

B. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, stand-alone DDC panels, and operator devices.

C. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

D. Stand-alone DDC panels shall be able to access any data from or send control commands and alarm reports directly to any other DDC panel or combination of panels on the network without dependence upon a central processing device. Stand-alone DDC panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

2.02 NETWORKING/COMMUNICATIONS

A. The design of the BAS shall network operator workstations and stand-alone DDC panels.

B. Local Area Network:
   1. Workstation/DDC Panel Support: Operator workstations and DDC panels shall directly reside on a local area network such that communications may be executed directly between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.
   2. Dynamic Data Access: All operator devices shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network.
   3. General Network Design: Network design shall include the following provisions:
      a. High speed data transfer rates. The minimum transfer rate shall be 100 Mb (Mb/s).
      b. Commonly available, multiple source, networking components and protocols shall be used to allow the BAS to coexist with other networking applications. MAP, ETHERNET, IBM Token Ring and ARCNET are acceptable technologies.
      c. Use of an industry standard IEEE protocol.
      d. Synchronization of the realtime clocks in all DDC panels shall be provided.
      e. Permit at least four simultaneous users to access the system over the LAN, based on password level. Users shall have access to monitor parameters, change set points, set up trends, or start/stop controlled equipment. A remote user shall have this capability without having the system data base loaded on his/her remote computer.
      f. Text/Email feature shall be provided with capability to telephone/email selected facility maintenance personnel to notify them of critical BAS alarms.
   4. Connection to Facility's LAN: The BAS shall be connected to the facility's Ethernet LAN to the extent possible to avoid duplication of LAN wiring. Coordinate connection with owner.
      a. The BAS shall be connected to the facility LAN and shall permit at least 4 simultaneous users to access the system over the LAN, based on password level, monitor parameters, change set points, set up trends, or start/stop controlled equipment.
      b. A remote user shall have this capability without having the system data base loaded on his/her remote computer.
      c. Connection by remote Energy Management system shall be accommodated by allowing polling of BAS parameters over open protocols such as Bacnet and Modbus TCP.

2.03 STAND-ALONE DDC PANELS

A. General: Stand-alone DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each stand-alone DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules.

B. Memory: Each DDC panel shall have sufficient memory to support its own operating system and databases.

C. Point Types: Each DDC panel shall support the following types of point inputs and outputs:
   1. Digital Inputs for status/alarm contacts
   2. Digital Outputs for on/off equipment control
   3. Analog Inputs for temperature, pressure, humidity, flow, and position measurements
   4. Analog Outputs for valve and damper position control, and capacity control of primary equipment
   5. Pulse Inputs for pulsed contact monitoring

D. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, field controllers, sensors, and actuators.

E. Serial Communication Ports: Stand-alone DDC panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop workstations, PC workstations, and panel mounted or portable DDC panel operator's terminals. Stand-alone DDC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or network terminals.

F. Hardware Override Switches: The operator shall have the ability to manually override automatic or centrally executed commands at the DDC panel via local, point discrete, on-board hand/off/auto operator override switches for binary control points and gradual switches for analog control type points. These override switches shall be operable whether the panel is powered or not.

G. Hardware Override Monitoring: DDC panels shall monitor the status or position of all overrides and inform the operator that automatic control has been inhibited.

H. Local Status Indicator Lamps: The DDC panel shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

I. Integrated On-Line Diagnostics: Each DDC panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment.

J. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

K. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all stand-alone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.

L. Provide a battery backup (UPS) system to support DDC panel functions for a minimum of 15 minutes upon loss of power. The UPS system shall be provided regardless of connection to facility emergency power system.

2.04 SYSTEM SOFTWARE FEATURES

A. General:
   1. All necessary software to form a complete operating system as described in this specification and on drawings shall be provided.
   2. The software programs shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.

B. Control Software Description:
   1. Pre-Tested Control Algorithms:
      a. Two Position Control
      b. Proportional Control
      c. Proportional plus Integral Control
      d. Proportional, Integral, plus Derivative Control
      e. Automatic Control Loop Tuning
   2. Equipment Cycling Protection.
   3. Heavy Equipment Time Delays.
   4. Powerfail Motor Restart.

C. Energy Management Applications: DDC panel shall have the ability to perform any or all of the following energy management routines:
   1. Time of Day Scheduling
   2. Calendar Based Scheduling
   3. Holiday Scheduling
   4. Temporary Schedule Overrides
   5. Optimal Start/Stop
   6. Night Setback/Setup Control
   7. Economizer
   8. Peak Demand Limiting
   9. Temperature Reset

D. Custom Process Programming Capability: DDC panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

E. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to noncritical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC workstation or local I/O device, or communications with other panels on the network.

F. Historical Data and Trend Analysis: A variety of historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways:
   1. Continuous Point Histories.
   2. Control Loop Performance Trends.
   3. Extended Sample Period Trends.
   4. Data Storage and Archiving.

G. Runtime Totalization: Stand-alone DDC panels shall automatically accumulate and store runtime hours for binary input and output points.

H. Analog/Pulse Totalization: Stand-alone DDC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

I. Event Totalization: Stand-alone DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off.

2.05 APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS

A. Each stand-alone DDC controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).

B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

C. Each ASC shall have sufficient memory to support its own operating system and data bases.

D. The operator interface to any ASC point data or programs shall be through any network-resident PC workstation or portable operator's terminal connected to any DDC panel in the network.

E. Application specific controllers shall directly support the temporary use of a portable service terminal.

F. Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

G. Battery Backup (UPS): UPS shall be provided to support ASC functions for a minimum of 15 minutes upon loss of power. The UPS system shall be provided regardless of connection to facility emergency power system.

H. The modes of operation supported by each ASC shall minimally include, but not be limited to, the following:
   1. Daily/Weekly Schedules
   2. Occupancy Mode
   3. Economy Mode
   4. Temporary override Mode

I. Continuous Zone Temperature Histories: Each ASC shall automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

J. Alarm Management: Each ASC shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

K. Application Descriptions:
   1. VAV Terminal Unit Controllers:
      a. VAV terminal unit controllers shall support, but not be limited to, the control of the following configurations of VAV boxes to address current requirements as described in the Execution portion of this specification, and for future expansion.
         1) Single Duct (Cooling Only or Cooling With Reheat)
      b. VAV terminal unit controllers shall support the following types of point inputs and outputs:
         1) Proportional Cooling Outputs
         2) Heating Outputs (Proportional Analog Hot Water Control Valve or SCR Electrical)
      c. Each VAV terminal unit space temperature sensor shall include setpoint potentiometer, room temperature indication, and communication port for portable operators terminal. Controller shall be capable of controlling to a discharge temperature that is reset based on the difference between space temperature and space temperature set point changes.
      d. VAV box differential pressure transmitter shall be by JCI or Setra, 0 to 1.5" pressure range, +/- 0.0008" w.c. linearity, +/- 0.00075 w.c. repeatability.
   2. Unitary Controllers:
      a. Unitary controllers shall support, but not be limited to, the following types of systems to address specific applications indicated on the drawings:
         1) Packaged Rooftops
      b. Unitary controllers shall support the following types of point inputs and outputs:
         1) Economizer Switchover Inputs
         2) Drybulb
         3) Outdoor Air Enthalpy
         4) Differential Temperature
         5) Differential Enthalpy
         6) Binary Input from a separate controller
         7) Economizer Outputs
         8) Integrated Analog with minimum position
         9) Binary output to enable self-contained economizer actuator
         10) Heating and Cooling Outputs
         11) 1 to 3 Stages
         12) Analog Output with two-pipe logic
         13) Reversing valve logic for Heat Pumps

14) Fan Output
15) On/Off Logic Control

3. AHU Controllers:
   a. AHU controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally stand-alone fashion.
   b. AHU controllers shall have a library of control routines and program logic to perform the sequence of operation.

2.06 OPERATOR INTERFACE

A. Command Entry/Menu Selection Process: Operator workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software.

B. The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

C. Graphical and Text-Based Displays: Operator workstations shall provide consistent graphical or text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all workstations.

D. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.

E. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:
   1. Start-up or shutdown selected equipment.
   2. Adjust setpoints.
   3. Add/Modify/Delete time programming.
   4. Enable/Disable process execution.
   5. Lock/Unlock alarm reporting for each point.
   6. Enable/Disable Totalization for each point.
   7. Enable/Disable Trending for each point.
   8. Override PID Loop setpoints.
   9. Enter temporary override schedules.
   10. Define Holiday Schedules.
   11. Change time/date.
   12. Enter/Modify analog alarm limits.
   13. Enter/Modify analog warning limits.
   14. View limits.
   15. Enable/Disable Demand Limiting for each meter.
   16. Enable/Disable Duty Cycle for each load.

F. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files. Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the building automation system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

G. Dynamic Color Graphic Displays:
   1. Color graphic floor plan displays, and system schematics for each piece of mechanical equipment shall be provided to optimize system performance analysis and speed alarm recognition.
   2. The BAS shall include a trend viewing utility that shall have access to all data base points. It shall be possible to display trend data in histogram (X-Y plots) format without exporting the data to another application. Refer to the enclosed sheets at the end of this section for an example of summary sheet displays.

H. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
   1. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently add/delete/modify all functions.
   2. Programming Description: Definition of operator device characteristics, DDC panels, individual points, applications, and control sequences shall be performed through fill-in-the-blank templates and graphical programming approach.
   3. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hardcopy printouts of all configuration and application data. Control process and DDC control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequences to be easily interpreted and modified at any time in the future.

2.07 STAND-ALONE DDC PANEL-MOUNTED OPERATOR'S TERMINAL:

A. Each DDC panel (except VAV terminal unit controllers) shall include a local panel-mounted operator's terminal for local command entry, instantaneous and historical data display, setpoint adjustment and program additions and modifications.
   1. The DDC panel operator terminal shall provide access to all real or calculated points in the controller to which it is connected or any other controller in the network.
   2. Operator access at all DDC panel operator terminals shall be identical to each other, as well as identical to the PC operator workstations. Any password changes shall automatically be downloaded to all controllers on the network.
   3. The DDC panel operator terminal shall provide English language prompting to eliminate the need for the user to remember command formats or point names.
   4. A multi-function touchpad shall be provided for point and command selection, as well as parameter entry.
   5. Context-Sensitive Help.
   6. Identification for all real or calculated points shall be consistent for all network devices. Use English language names to access points at the DDC panel operator's terminal.
   7. In addition to instantaneous summaries, the DDC panel operator's terminal shall allow a user to view a point history file for system points.

2.08 ELECTRONIC AND ELECTRIC CONTROL COMPONENTS

A. All sensors, pressure transmitters, transducers, etc., shall be selected such that the pressure range midpoint shall coincide with the anticipated normal operating pressure.

B. Electric Thermostats: Thermostats to be manufacturer's best commercial grade thermostat with adjustable setpoint, dials calibrated in degrees F, and digital temperature indication. Select thermostats with suitable range for service intended. Temperature measurement accuracy shall be +/- 0.5 degrees F. Thermostats located in public areas such as corridors or elsewhere as indicated on drawings shall be provided with programming lockout to prevent unauthorized adjustment. Thermostats located where subject to physical damage and/or where identified on drawings shall be provided with tamper resistant cover. Warmer / Cooler setpoint adjustment will not be acceptable.

C. Electronic Sensors/Transmitters: Sensors/transmitters to be 1000 Ohm platinum RTD type with high resistance change vs. temperature or humidity change, accurate to +/- 1.0 degrees F for temperature and +/- 2.0% for humidity at applicable range, and provide 4 to 20 MA or 0 to 5 VDC output signal. Sensors/transmitters to be suitable for room, duct, or well mounting as required by application. Room type to have built-in setpoint potentiometer and digital room temperature or humidity indication. Select for temperature/humidity range of application. Provide appropriate mounting plate and hardware. Temperature sensors used as a part of Energy (BTU) Measurement System shall meet the applicable requirements of that section. Sensors shall have setpoint adjustment through BAS only. Sensors located where subject to physical damage and/or where identified on drawings shall be provided with protective cover. Sensor stability shall be less that 0.1 °F in 5 years. Provide these devices where identified on the contract documents or if not shown on design documents provide at all locations listed within this section. Humidity sensors are to be stand-alone sensors and at a minimum provided within each Operating Room, Procedure Room, Decontam and Clean work within Central Sterile Department if not already shown on the contract documents.

D. Smoke Detectors: Install duct-mounted smoke detectors at locations indicated on drawings and in accordance with published smoke detector installation requirements. Smoke detectors to be furnished to Division 23 by Division 26.

E. Freezestats (Low Limit Binary Type): Provide single, custom length Freon-filled capillary tube type with sensing element actuated by temperature on any one foot portion. Sensor shall be a single element with length of one linear foot for every one square foot of coil face area. Freezestats to be UL approved, manual reset type.

F. Averaging Temperature Sensors (Mixed Air, Preheat, Etc.): Provide single, custom length Freon-filled capillary tube type sensing element. Accuracy shall be +/- 0.3 degrees F. Sensor shall be single element with length of one linear foot for every one square foot of coil face area.

G. Control Panels: Control panels to be constructed of unitized steel or aluminum cabinets. Provide cabinets with hinged, locking door opening to the front. Multiple panels mounted side-by-side to be hinged to the left or on opposite sides to open in the middle. Start-stop switches, hand-off-automatic switches, pilot lights, and temperature indicating devices to be flush-mounted in panel door. All other devices to be internally mounted within panel. Local panels exposed to weather to be weatherproof construction. Panel locations to be approved by Designer and be accessible for operation and maintenance. All devices specified to be mounted on control panel that require electrical connections to be prewired to a dual, numbered terminal strip located inside panel. All lines in panel shall have number I.D. bands. Gauges shall be installed on all pneumatic lines entering or leaving the panel. All devices inside the panel or mounted on panel face shall have an engraved laminated plastic nameplate. Wiring within panel to conform to National Electrical Code, and shall be neatly bundled and laced or enclosed in panduit trough.

H. Control Valves: Two-inch and smaller water service valves to be screw connected chrome plated characterized brass ball type with characterized port to allow equal percentage throttling. Two-inch and smaller steam service valves to be screw connected globe pattern type with constructed of high grade cast brass. Two-and-one-half inch and larger to be flange connected, brass-body characterized ball-type with ductile iron flanges and stainless steel trim. Valve pressure rating to be in accordance with piping and fitting specifications. (Minimum 125 psi operating pressure.) Valve actuators to be selected to close valves against pump shutoff head or maximum steam inlet pressure. Provide stainless steel stem with removable composition disc and self adjusting spring-loaded Teflon packing. Provide stainless steel seats on all valves used for steam service. Two position water valves to be line size or one line size smaller than connecting piping with maximum 1 psi water pressure drop. Modulating water control valves shall have minimum rangeability of 400:1 defined as minimum controllable flow divided by the maximum controllable flow. Two position steam valves to have maximum pressure drop of 20 percent of inlet steam pressure. Modulating steam valves to have modified linear flow characteristics and be sized for pressure drop as indicated on drawings or if not indicated for 80 percent of inlet steam pressure but not to exceed 50 percent of inlet absolute pressure. Output signal of 4-20mA or 0-10 V shall be used to control the position of all modulating valves. Tri-state, pulse type, or similar non-proportional control valves/actuators are not acceptable.

I. Control Valves for specialized applications – Rotary ball type: Use for steam control valves at CV-1. Valves shall be constructed of a carbon steel body, stainless steel V-notch ball and shaft, low friction bearings and a TFM 1700 ball seat. Valve sizes 1, 1.5 & 2 inches shall be ANSI Class 150/300 multi-rated and have Universal End Connections for use with NPT or ANSI Class 150/300 wafer connections. Valve sizes 3, 4, 6 inch shall have ANSI Class 150 or 300 flanges as required by application. Control valves shall be rated ANSI Class VI leakage rate, 0°F to 400°F temperature range and maximum 250 PSI allowable shutoff pressure. Valves are for use with water, steam and percentage glycol water mixes. Valves have 90 degree rotation, 400:1 rangeability with equal percentage control characteristic. Valve and linkage shall carry a 3 year warranty from the date of installation.

J. Automatic Control Dampers: Ultra low-leak automatic control dampers to be Arrow Pin Lock opposed-blade dampers for modulating control and parallel blades for 2-position control or approved equal. Frames and blades to be minimum 16 gauge extruded aluminum or galvanized steel construction with 4" to 6" deep frame and 8" maximum width blades. Pivot rods to be 1/2" diameter, extruded aluminum or plated steel. Bearings to be corrosion resistant. Install blade linkage hardware in angle or channel frame section out of airstream. All hardware to be corrosion resistant. Seals to be replaceable extruded vinyl or silicone rubber blade seals and flexible metal compression type jamb seals. Dampers to have maximum 4 cfm per square foot leakage at 1" water gauge static pressure and 8 cfm per square foot leakage at 4" water gauge static pressure, verified by independent testing laboratory.

K. Electronic Actuators: Actuators shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. End switches to deactivate the actuator at the end of rotation

or magnetic clutch is not acceptable. For power-failure/safety applications, a mechanical, spring return mechanism shall be used. Non-mechanical forms of fail-safe are not acceptable. All spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by changing mounting orientation. Proportional actuators shall accept a 2 to 10 VDC or 4 to 20 mA and provide a 2 to 10 VDC position feedback signal. 24 VAC/DC actuators shall not require more than 15 VA for AC or 8 watts for DC applications. All non-spring return actuators shall have an external manual gear release to aid in installation and allow manual positioning when the actuator is not powered. All actuators shall have an external direction of rotation switch to aid in installation and provide proper control response. Actuators shall be provided with a factory-mounted 3-foot electrical cable and conduit fitting to provide easy hook-up to an electrical junction box. Provide cover mounted control transformer for 120-VAC power supply. The actuators shall be U.L. listed.

L. Volumetric Devices: Fan Inlet Air Flow Sensors and Indicating Transmitters
   1. Fan Inlet Piezometer Air Flow Sensors shall be factory mounted in the air handling units. They shall be piezometer type average velocity sensors designed for installation inside the inlet ring of centrifugal fans accurate to +/- 1.5% measurement accuracy. There shall be no portions of device protruding into inlet cone.
   2. The airflow transmitter shall be an industrial quality, electronic solid state, ultra low span, +/- 0.25% accuracy transmitter with integral square root, scaling, and output filter with indication. Each transducer shall be provided with a microprocessor digital readout meter, operating independent of all other control devices. This unit to provide a direct digital readout of the air volume as derived from the total and static input signals received from the respective air flow measuring element. The meter shall have a digital readout and 3 way zeroing valve for zero verification and calibration. Readout to be flush mounted on the enclosure door. The meter shall be calibrated to an accuracy of +/- 0.25% full scale at 70 °F. Output signal shall be 4-20mA. Area factor input for respective inlet probes to be adjustable via a keypad. Provide individual airflow transmitters, especially selected for the required spans of each of the above primary processor.
   3. Transducers/Transmitters shall be Paragon Controls Inc. MicroTrans model or Air Monitor Inc. Veltron model for air handling units with single supply fans and single return fans.
   4. For Air Handling Units with 2 or more supply fans AND 2 or more return fans, the transmitter shall be Paragon Controls, Inc. FAATS-1000 fan array airflow totaling system. Output signal shall be 4-20mA and shall measure airflow for each individual fan within a fan array system as well as the total airflow rate of each array. For outdoor applications on rooftop units, FAATS device shall be mounted on exterior of unit in a NEMA 4 rated enclosure.

M. Room Differential Pressure Alarm System: Room differential pressure devices shall be TSI PresSura or equal by Anemostat or Tekair. Provide a unit outside of each patient isolation room, protective environment room, operating room and, and C-section room. Refer to the architectural floor plans for exact number of rooms. Provide unit with audible and visual alarm, digital display of room pressure differential, through-the-wall pressure sensor and transformer. Provide BacNet interface for device monitoring through the BAS. System accuracy shall be +/- 10% of pressure reading ± 0.00001 in H2O with range of +/- 0.2000" w.c. Output signal shall be: 4-20mA. The device shall be provided with a door switch and field adjustable timer to minimize nuisance alarm indication due to door opening.

N. Hot and Chilled Water Differential Pressure Transmitter: Static pressure measuring stations with +/- 0.25% FS accuracy, suitable for line installation at pressure to 250 psig. Provide 3-valve manifold brass body factory assembled and suitable for pipe or wall mounting. Setra Model 230 – 3V or approved equal. Output signal shall be 4-20mA. Select unidirectional or bidirectional type with transmitter span matched to application. Provide hard wire connection to pump controller rather than network connection.

O. Duct Static Pressure Devices: Static pressure measuring stations with +/- 2% accuracy equal to Paragon Controls PE-5000 or equal by Setra or Air Monitor Group shall be provided. Industrial quality, electronic solid state, 1/2 percent accuracy static pressure transmitters equal to Paragon Controls Model DPT-4001 shall be provided. Transmitter span shall be matched to application. Duct probe shall be 6063-T5 anodized aluminum. Output signal shall be 4-20mA.

P. Transformers: Provide all 24-volt control transformers necessary to convert 120-volt line voltage power to control voltage at control devices.

Q. Relays, Hand-Off-Auto Switches, Pilot Lights: Provide all relays, hand-off-auto switches, and pilot lights necessary to accomplish automatic control of the mechanical systems. See electrical drawings for starters provided integral with hand-off-autos, pilot lights, and auxiliary contacts.

R. Pressure Switches: Pressure switches shall have contact action and pole configuration as required by application, U.L. listing, and adjustable setpoint.

S. Current Sensing Relays:
   1. Acceptable Manufacturer: Hawkeye Model 908, H308 (H540 for small fractional HP motor applications) or approved equivalent.
   2. Current sensor shall be induce powered from the monitored load and shall have an adjustable operating range from 2.5 - 135 A, 0.75 – 50 A or 0.25 – 20 A selected for application. Visual indicators (LEDs) shall indicate output status and sensor power. Adjustable trip setpoint to +/- 1%. Current sensor output shall be N.O., solid state, 0.1A @ 30 VAC/DC.
   3. The current sensor shall have a sensing range sensitivity selected that will enable BAS to distinguish between small motors operating with and without belts and small pump motors operating with and without water flow.

PART 3 EXECUTION

3.01 INSTALLATION

A. Components:
   1. Provide sensors, transmitters, controllers, actuators, valves, dampers, and related items, necessary to accomplish control sequence shown on drawings. Install all such devices except as noted herein to the contrary.
   2. Deliver control valves to the job site to be installed by Mechanical Tradesman under supervision of Control Tradesman.
   3. Deliver automatic dampers to the job site to be installed by Mechanical Tradesman under supervision of Control Tradesman.
   4. Mechanical Tradesmen to install flow switches, immersion wells, pressure tapping, and all associated shut-off cocks required for control systems.
   5. The control equipment and connecting piping shall be installed in a neat and workmanlike manner by trained mechanics in the direct employ of the control manufacturer.
   6. All exposed tubing and conduit shall be run parallel to or at right angles to the building structure, and shall be concealed in all finished spaces. Tubing and conduit may be run exposed in mechanical rooms or areas where other piping is exposed.
   7. Prepare coordinated composite wiring diagram showing all interlock wiring associated with starters, control panels, and controls.
   8. Drawings and Layouts: The controls contractor shall provide to the mechanical contractor complete schematic drawings for the entire control system for submittal to the Designer for approval before work shall begin. Brochures describing each item of control equipment or component shall be included.
   9. Provide sequence of operation written so that building engineer can read and understand control scheme.
   10. As-built drawings to be framed under plexiglass and placed in each respective equipment room area.

B. Electrical:
   1. Division 23 (Mechanical Tradesman) shall furnish and install low-voltage control wiring, including conduit, conductors, and terminations for same. Division 23 shall also furnish and install control components associated with the low-voltage control systems and shall wire and connect components in accordance with approved wiring diagrams.
   2. Division 26 (Electrical Tradesman) shall furnish and install power wiring including conduit, conductors, and terminations to motors, safety switches, starters, relays, valve and damper actuators, and other components requiring power as indicated on the electrical drawings, by the specifications, and in accordance with approved wiring diagrams. Division 26 shall also furnish and install starters as scheduled on the electrical drawings.
   3. Division 23 to furnish and install all local area network wiring, including conduit, conductors, and terminations for same. The local area network (LAN) shall be configurable as either a bus or a star, or a combination of the two. The LAN shall use twisted pair, coax, or fiber optic cable, or any combination of the three to meet noise immunity and/or distance requirements. The network design shall provide a high speed data transfer rate for alarm and report generation of no less than 100 Mb (Mb/s).
   4. Division 23 to furnish all input and output control wiring, including conduit, conductors, and terminations for same. All input and output control wiring shall be #18 twisted and shielded cable. No input or output point shall be more than 250 feet from its respective panel. All shields to be grounded at the control panel. All shields at the

sensors or transducers to be folded back and taped. All cable splices shall have joints soldered and taped including the shield. No mechanical connections will be acceptable. All connections within the panels must be made with connectors of appropriate size and design for the terminals being applied. All cables must be labeled and identified on corresponding termination drawings. A copy of the termination drawing shall be adequately protected and left in its respective panel.

5. Install all control wiring associated with DDC/BAS in minimum 1/2" size EMT. Provide all associated couplings, connectors, and fittings.
6. All wiring shall be in accordance with local regulations and the National Electrical Code.

C. Room Devices:
   1. Room devices shall be mounted so that the top of the device is 48" above the floor and aligned with the top of the light switch plates and 8" from the light switch if shown on the drawings adjacent to the light switch.
   2. Room device locations shall be coordinated with door swings, light switches, and other wall-mounted items.

D. Pressure/Temperature test ports shall be installed on the entering and leaving side of all heat transfer coils, heat exchangers (HVAC and domestic, both hot and cold fluid), control valves, flow meters, pumps, etc. Installation of P/T ports will facilitate the "Sensor Calibration Check" phase of the functional performance testing (FPT).

E. The contractor shall provide Tee type connections (and associated stop cocks or caps) in the pressure sensor tubing at all differential pressure sensors, including ductwork static pressure, high static pressure, airflow measuring devices, hot and cold water differential pressure, etc., that will allow field test measurements to be taken without interrupting the BAS reading. Providing this type connection will facilitate the sensor calibration check phase of functional performance testing and maintenance, by allowing simultaneous comparison of the BAS reading versus the actual field-measured parameter.

F. Calibrated balancing valves, flow elements and meters shall be installed in strict accordance with the manufacturer's recommendations for orientation, required straight length of upstream and downstream piping, etc., and in no case shall the pressure ports be pointed downward, in order to prevent the accumulation of trash and debris inside the ports. The ports shall be installed in such a manner that allows unobstructed access for the TAB agency to plug into the ports for purposes of measuring and verifying the differential pressure of the valve.

3.02 QUALITY CONTROL

A. Control system to be set up and checked out by factory-trained competent technician skilled in the setting and adjustment of temperature controls used in this project. This mechanic to be experienced in type systems associated with this control system.

B. At time of final observation, Control Contractor to demonstrate the entire sequence of operation for the systems to the Engineer. At this time, Engineer to observe function of entire control system, observe temperature control operations, damper positions, necessary to assure that temperature control system is operating as intended by mechanical design.

C. Final acceptance of system not to occur until sequence of operation check has taken place and certified by Engineer's representative.

D. The Control Tradesman to be responsible for returning to job during the opposite season to verify operation of control system. Engineer to be given notice of this return and to accompany Control Tradesman to observe the sequence of operation.

3.03 INSTRUCTION AND ADJUSTMENT

A. On completion of the job, the controls contractor shall have completely adjusted the entire control system. He shall arrange to instruct the Owner's representative on operation of the control system and supply him with three (3) copies of the control operating and instruction manuals.

B. The Controls Contractor shall obtain from the Owner's representative a signed receipt that he has received the instruction manuals and complete instruction on the operation of the system.

C. Contractor Adjustment: At the completion of the job, the controls contractor must submit to the Architect a letter stating that he has made final calibrations and adjustments to the system and that the Owner's operating personnel have been instructed in its use.

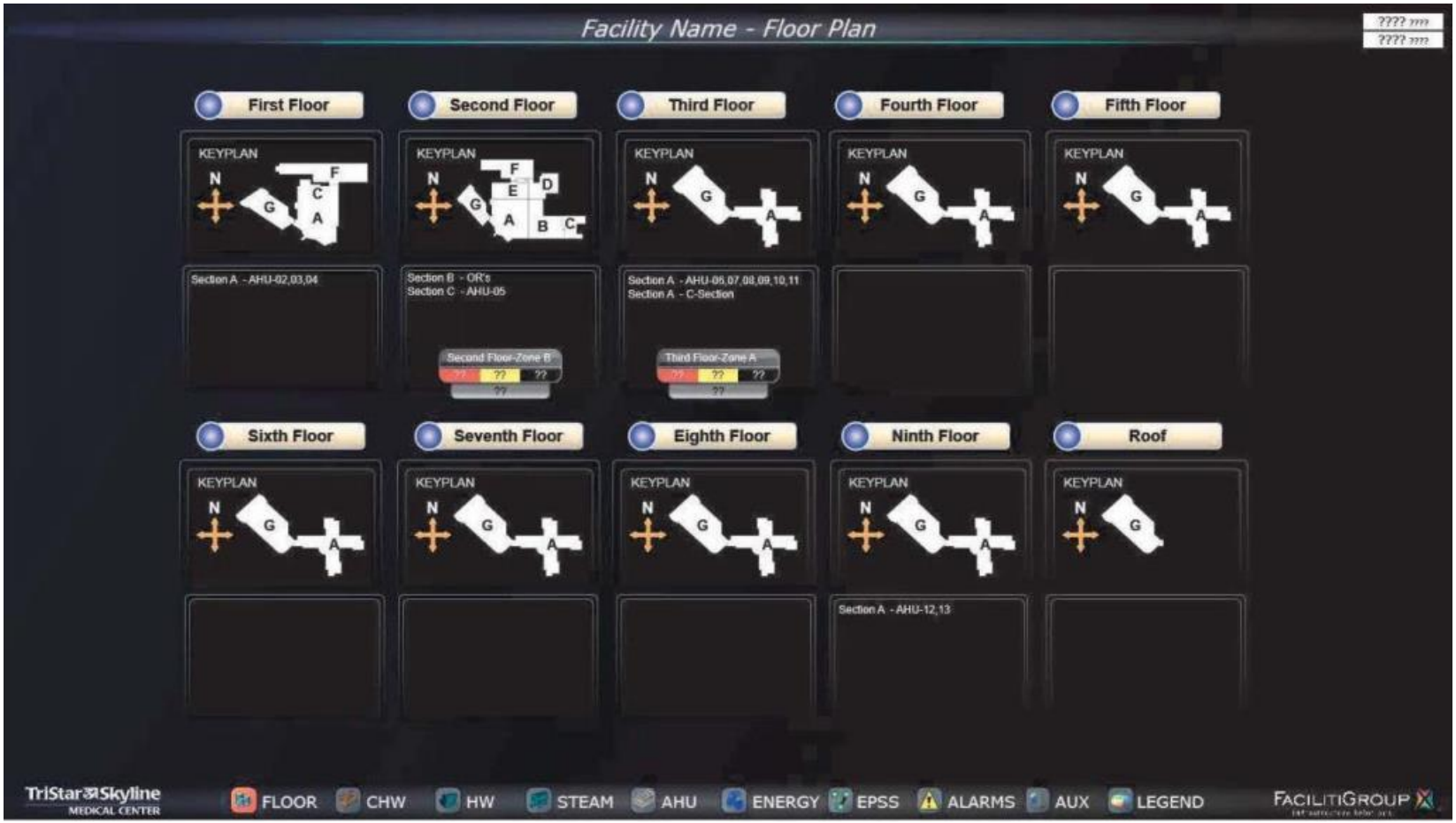
3.04 WARRANTY SERVICE

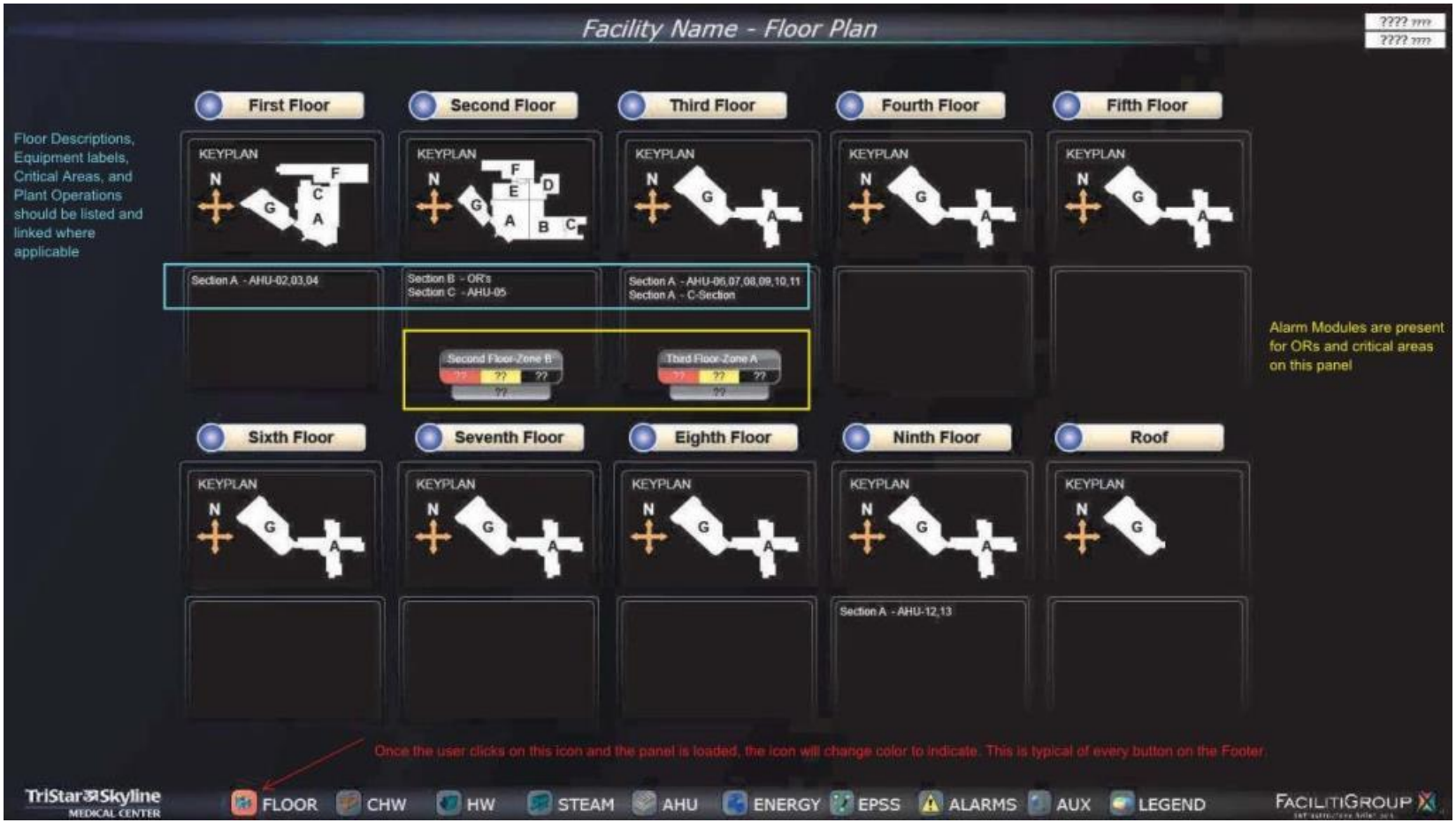
A. Warranty servicing shall be for a period not less than 12 months after final acceptance of the job by the owner and include the following provisions:
   1. Emergency maintenance service on regular working hour basis during warranty.
   2. Replacing defective parts and components as required.
   3. Servicing by factory trained and employed service representatives of system manufacturer.
   4. Maintaining of system programming.

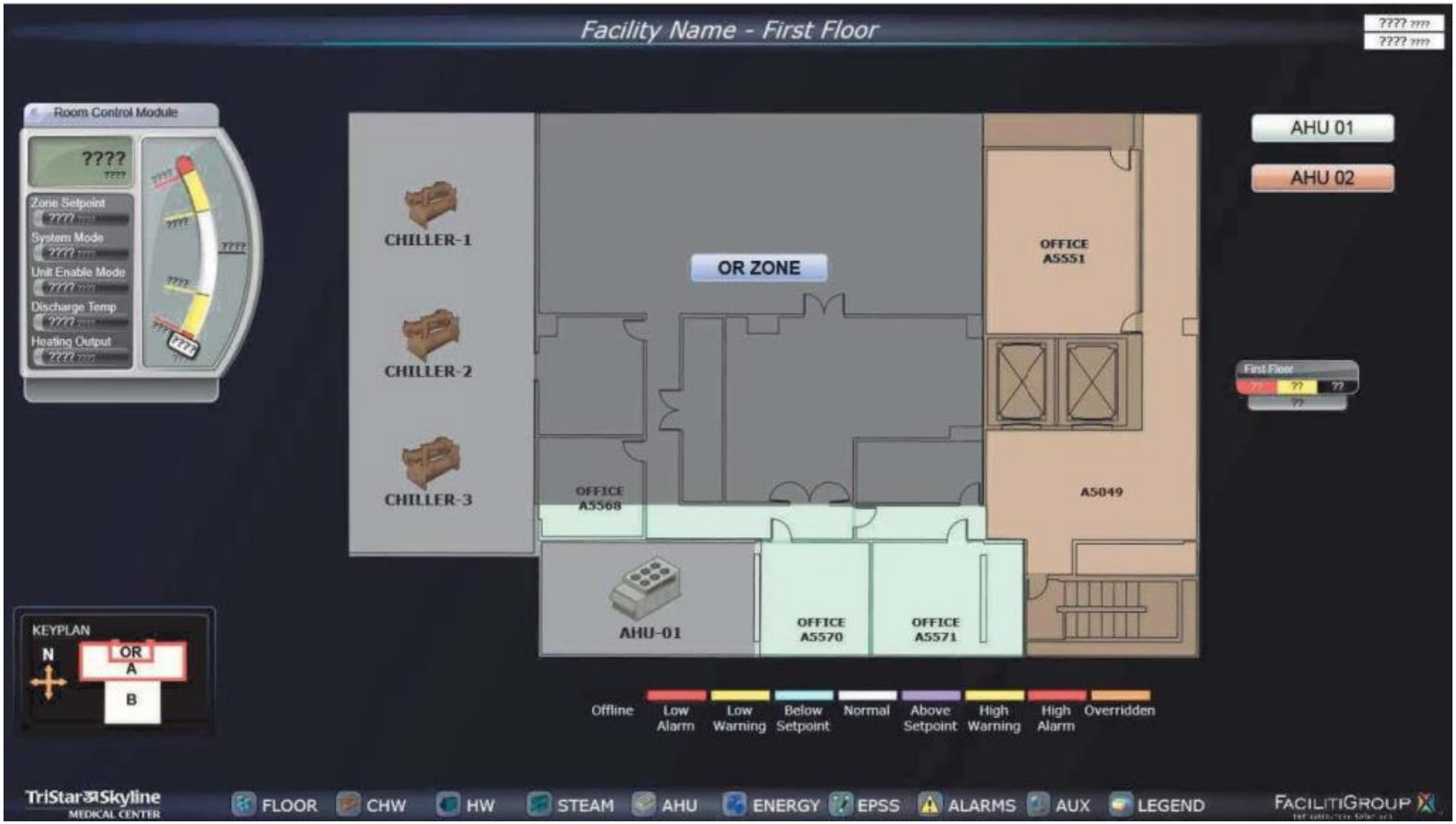
END OF SECTION

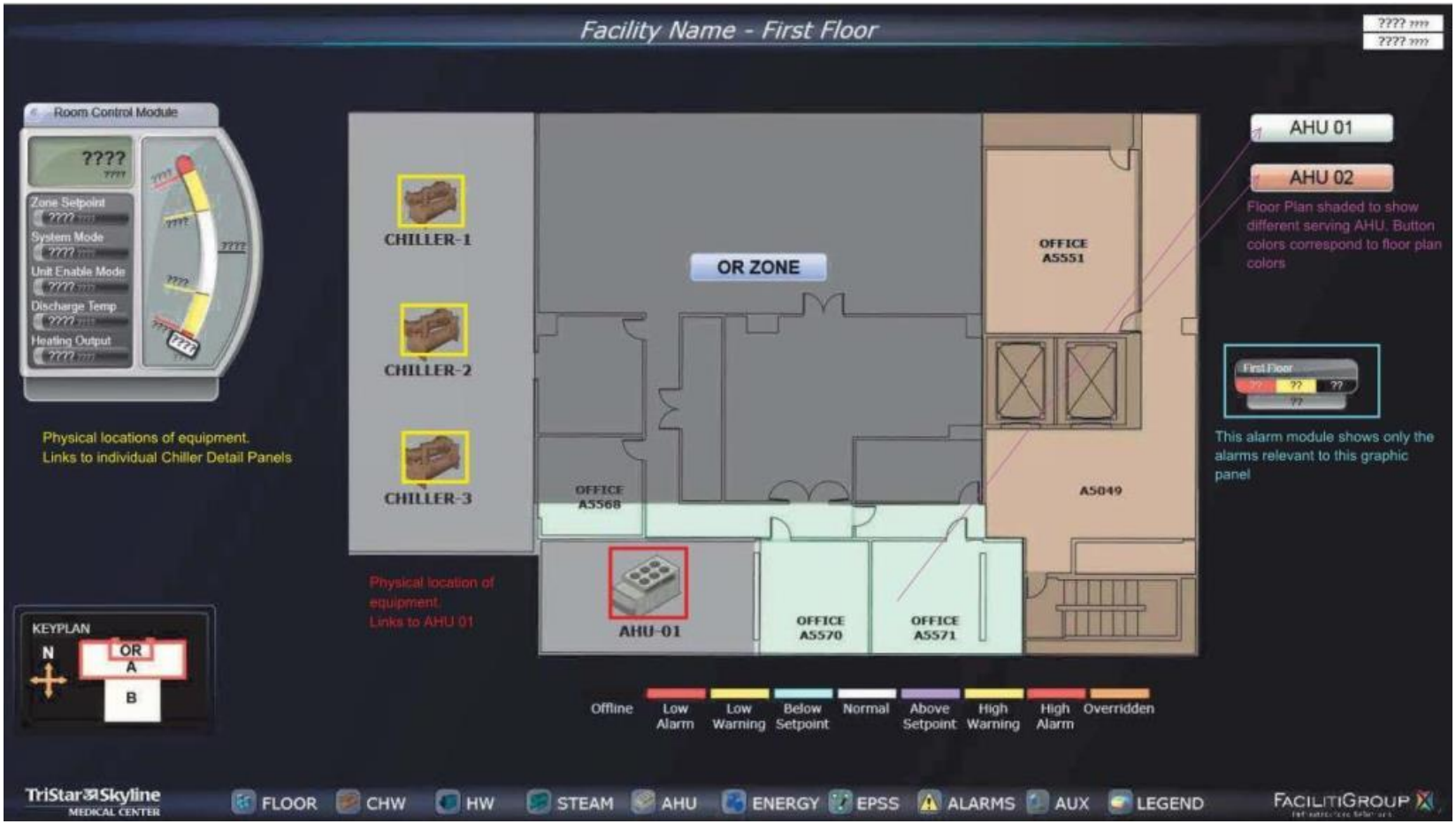

FACILITIGROUP
Infrastructure Solutions
TriStar Skyline
MEDICAL CENTER
Johnson Controls
Chilled Water System
CH-1
CH-2
Supply Temp
% RLA
kW / Ton
Condenser Water System
CT-1
CT-2
Speed
delta T
Tons
Chilled Water System
CH-3
CH-4
Supply Temp
% RLA
kW / Ton
extra box to be deleted if not used
Air Handlers
Sa Temp
Sa Static
AHU 01 - Area Served
AHU 02 - Area Served
AHU 03 - Area Served
AHU 04 - Area Served
AHU 05 - Area Served
AHU 06 - Area Served
AHU 07 - Area Served
AHU 08 - Area Served
AHU 09 - Area Served
AHU 10 - Area Served
AHU 11 - Area Served
AHU 12 - Area Served
AHU 13 - Area Served
AHU 14 - Area Served
AHU 15 - Area Served
AHU 16 - Area Served
AHU 17 - Area Served
AHU 18 - Area Served
Steam System
BLR-1
BLR-2
% Firing Range
Steam Flow
Efficiency
Hot Water System
HX-1
HX-2
HW Sup Temp
HW Ret Temp
Pump Status
Hot Water System
HWBLR-1
HWBLR-2
% Firing Range
Supply Temp
Efficiency
extra box to be deleted if not used
TriStar Skyline
MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

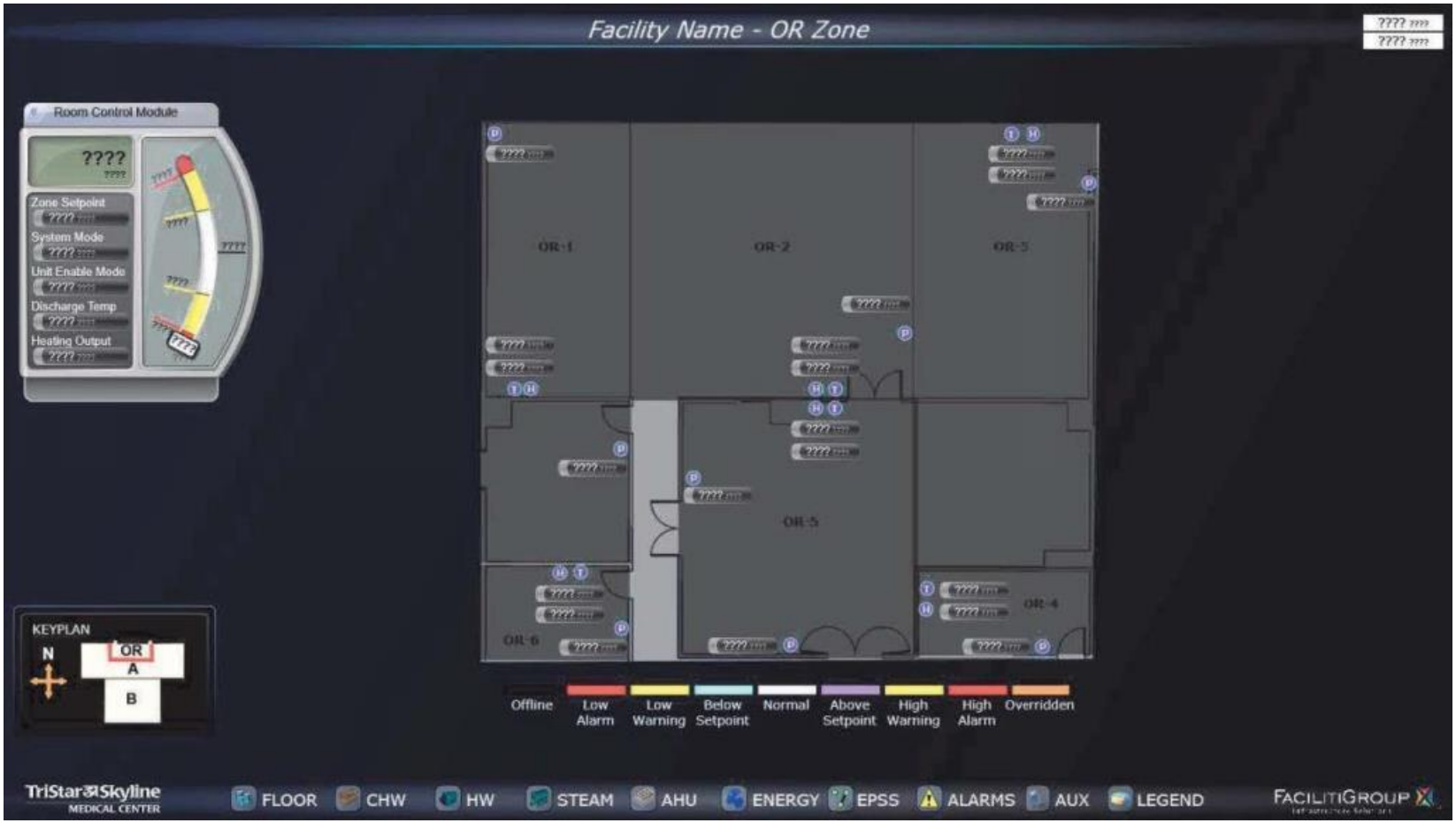

Outside Air Temperature
Outside Air Relative Humidity
Typical of ALL panels
Links to facility's Energy portal on HCAFI.com
FACILITIGROUP
Infrastructure Solutions
TriStar Skyline
MEDICAL CENTER
Links to Facility Public Website
Johnson Controls
Links to Contact Panel for JCI Rep, Energy Service Center, Utility providers
Links to individual equipment detail panel
Chilled Water System
CH-1
CH-2
Supply Temp
% RLA
kW / Ton
Condenser Water System
CT-1
CT-2
Speed
delta T
Tons
Chilled Water System
CH-3
CH-4
Supply Temp
% RLA
kW / Ton
Links to individual System Panel
extra box to be deleted if not used
The facility logo on the footer will now become the HOME button and will link to the Dashboard. Typical of ALL panels
Links to AHU Summary
Links to individual air handling units
Air Handlers
Sa Temp
Sa Static
AHU 01 - Area Served
AHU 02 - Area Served
AHU 03 - Area Served
AHU 04 - Area Served
AHU 05 - Area Served
AHU 06 - Area Served
AHU 07 - Area Served
AHU 08 - Area Served
AHU 09 - Area Served
AHU 10 - Area Served
AHU 11 - Area Served
AHU 12 - Area Served
AHU 13 - Area Served
AHU 14 - Area Served
AHU 15 - Area Served
AHU 16 - Area Served
AHU 17 - Area Served
AHU 18 - Area Served
Steam System
BLR-1
BLR-2
% Firing Range
Steam Flow
Efficiency
Hot Water System
HX-1
HX-2
HW Sup Temp
HW Ret Temp
Pump Status
Hot Water System
HWBLR-1
HWBLR-2
% Firing Range
Supply Temp
Efficiency
Summarizes all alarms for the system.
extra box to be deleted if not used
Links to the facility's EnergyScript portal on HCAFI.com.
Typical of ALL panels
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

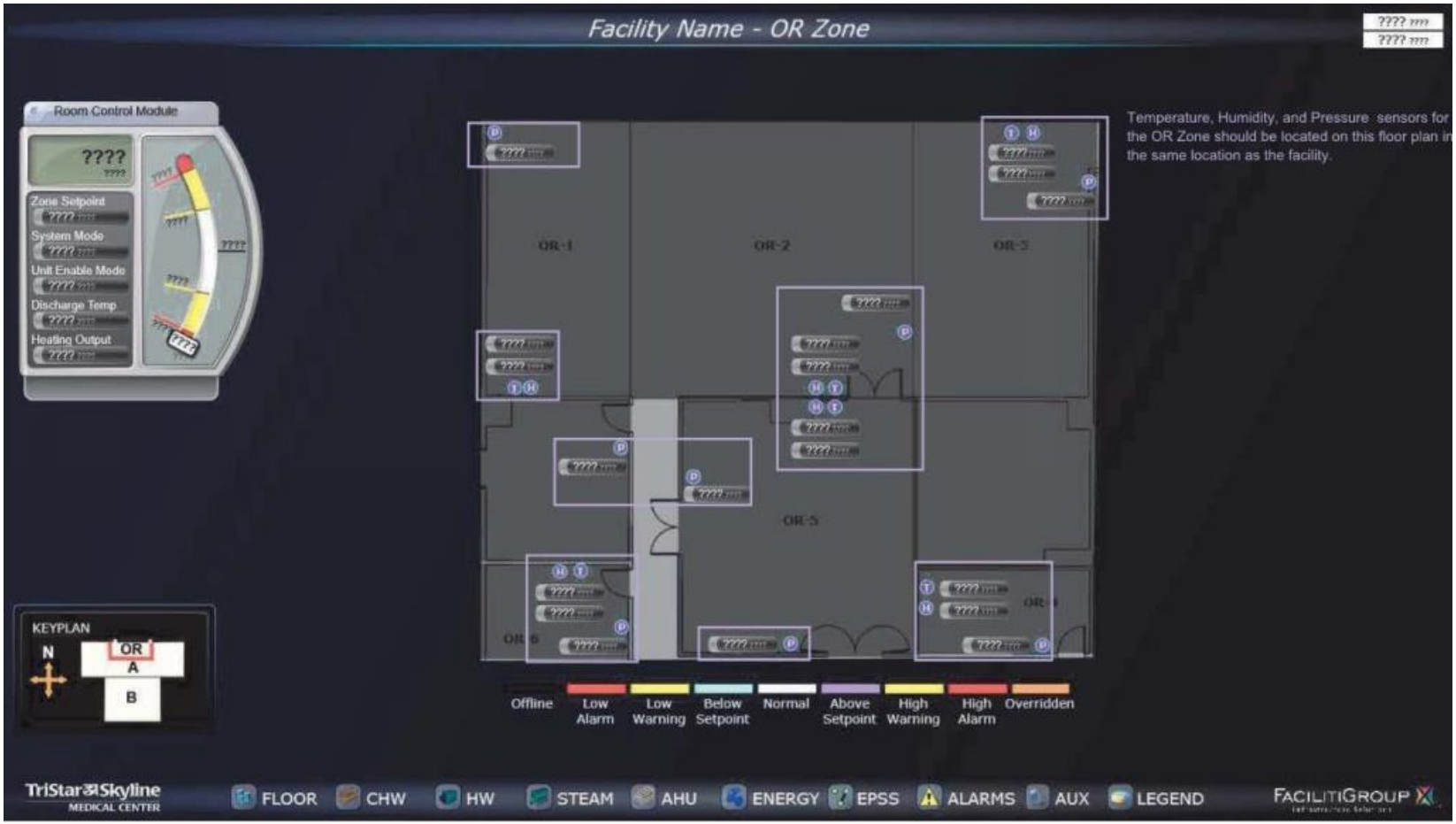

Facility Name - Floor Plan
???? ????
???? ????
First Floor
Second Floor
Third Floor
Fourth Floor
Fifth Floor
KEYPLAN
Section A - AHU-02,03,04
Section B - OR's
Section C - AHU-05
Second Floor-Zone B
Section A - AHU-06,07,08,09,10,11
Section A - C-Section
Third Floor-Zone A
Sixth Floor
Seventh Floor
Eighth Floor
Ninth Floor
Roof
Section A - AHU-12,13
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

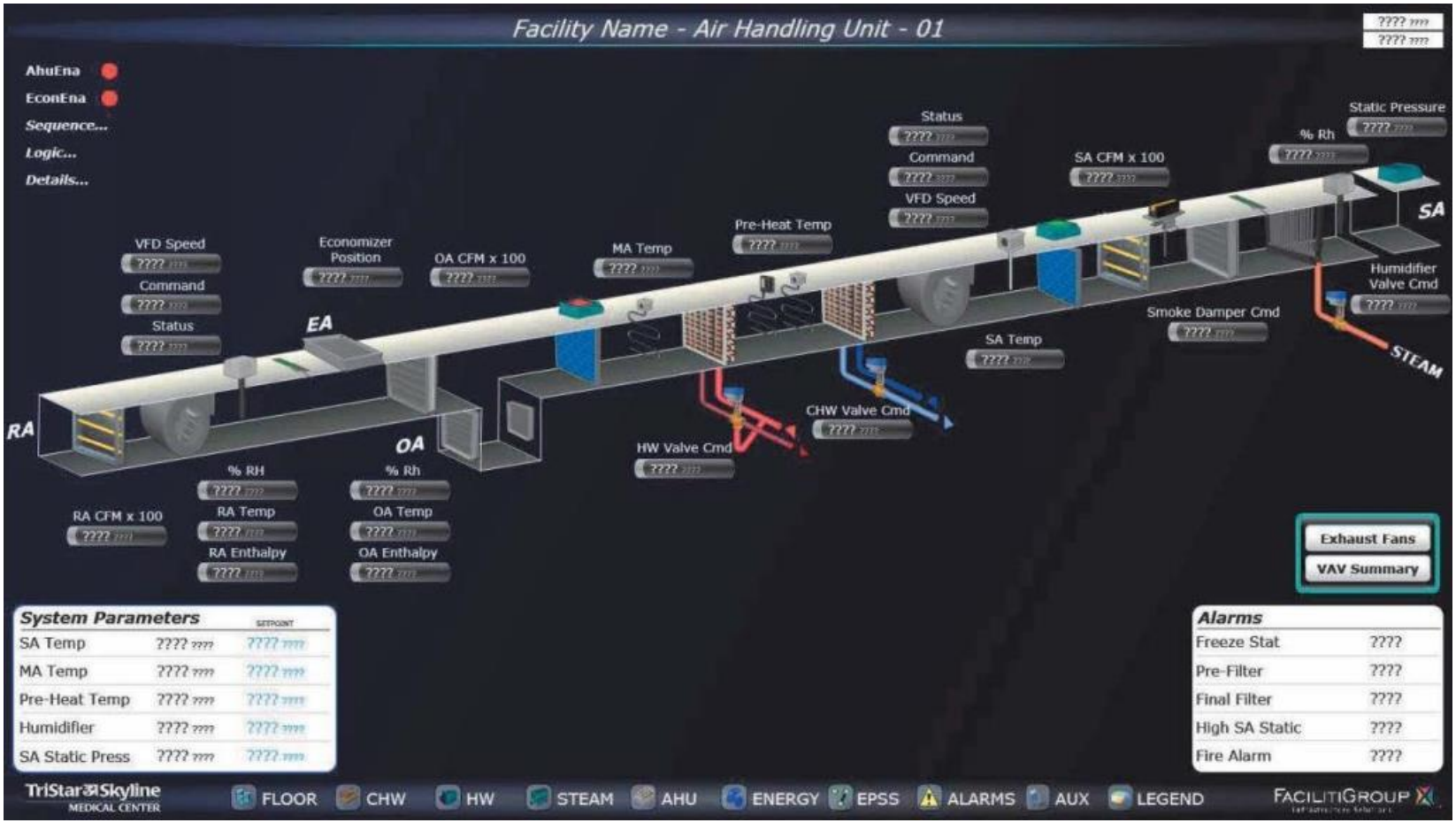

Facility Name - Floor Plan
???? ????
???? ????
First Floor
Second Floor
Third Floor
Fourth Floor
Fifth Floor
Floor Descriptions, Equipment labels, Critical Areas, and Plant Operations should be listed and linked where applicable
KEYPLAN
Section A - AHU-02,03,04
Section B - OR's
Section C - AHU-05
Section A - AHU-06,07,08,09,10,11
Section A - C-Section
Second Floor-Zone B
Third Floor-Zone A
Alarm Modules are present for ORs and critical areas on this panel
Sixth Floor
Seventh Floor
Eighth Floor
Ninth Floor
Roof
Section A - AHU-12,13
Once the user clicks on this icon and the panel is loaded, the icon will change color to indicate. This is typical of every button on the Footer.
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

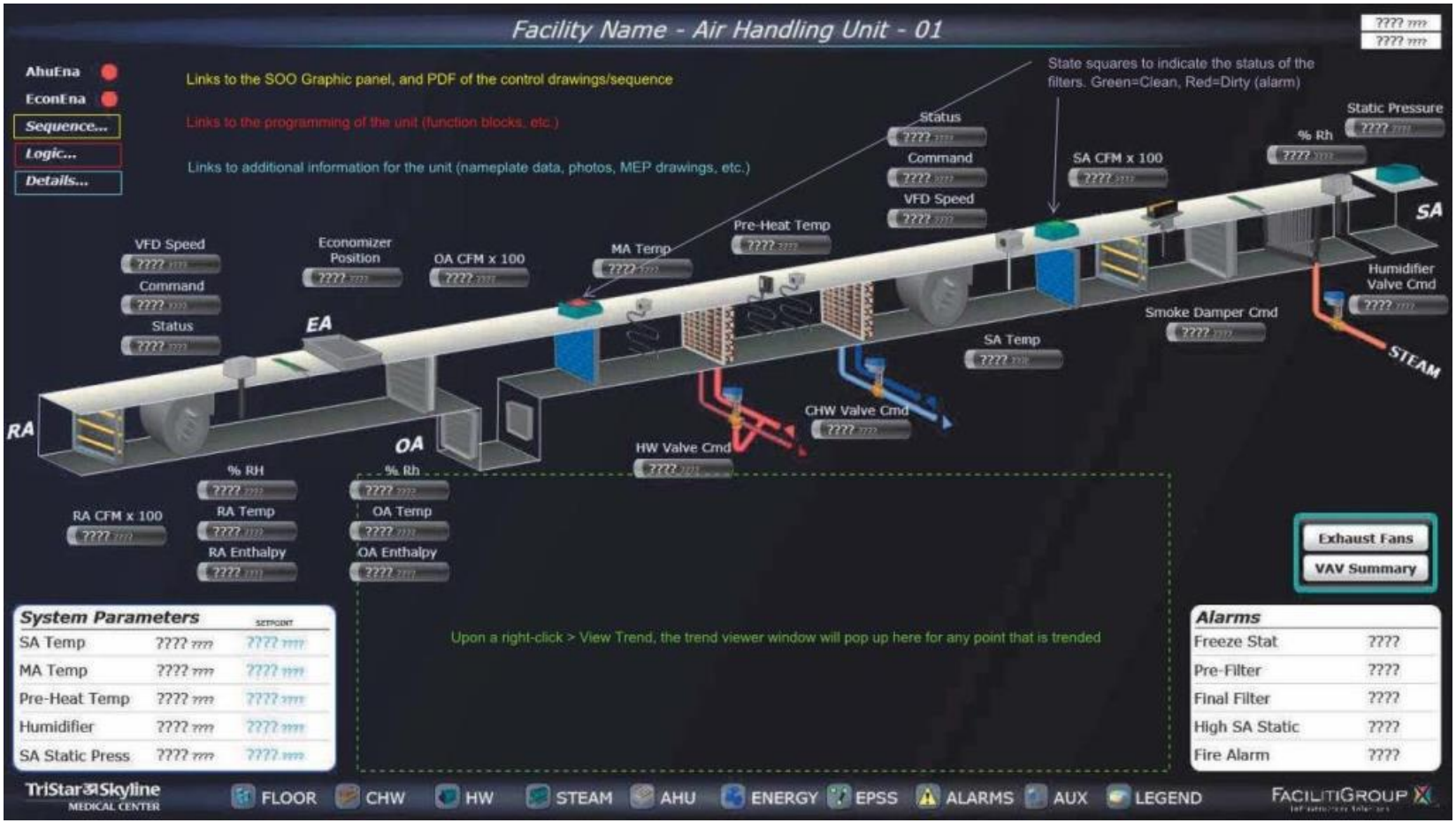

Facility Name - First Floor
Room Control Module
????
Zone Setpoint
System Mode
Unit Enable Mode
Discharge Temp
Heating Output
CHILLER-1
CHILLER-2
CHILLER-3
OR ZONE
OFFICE A5551
A5049
OFFICE A5568
AHU-01
OFFICE A5570
OFFICE A5571
AHU 01
AHU 02
First Floor
KEYPLAN
N
OR
A
B
Offline
Low Alarm
Low Warning
Below Setpoint
Normal
Above Setpoint
High Warning
High Alarm
Overridden
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

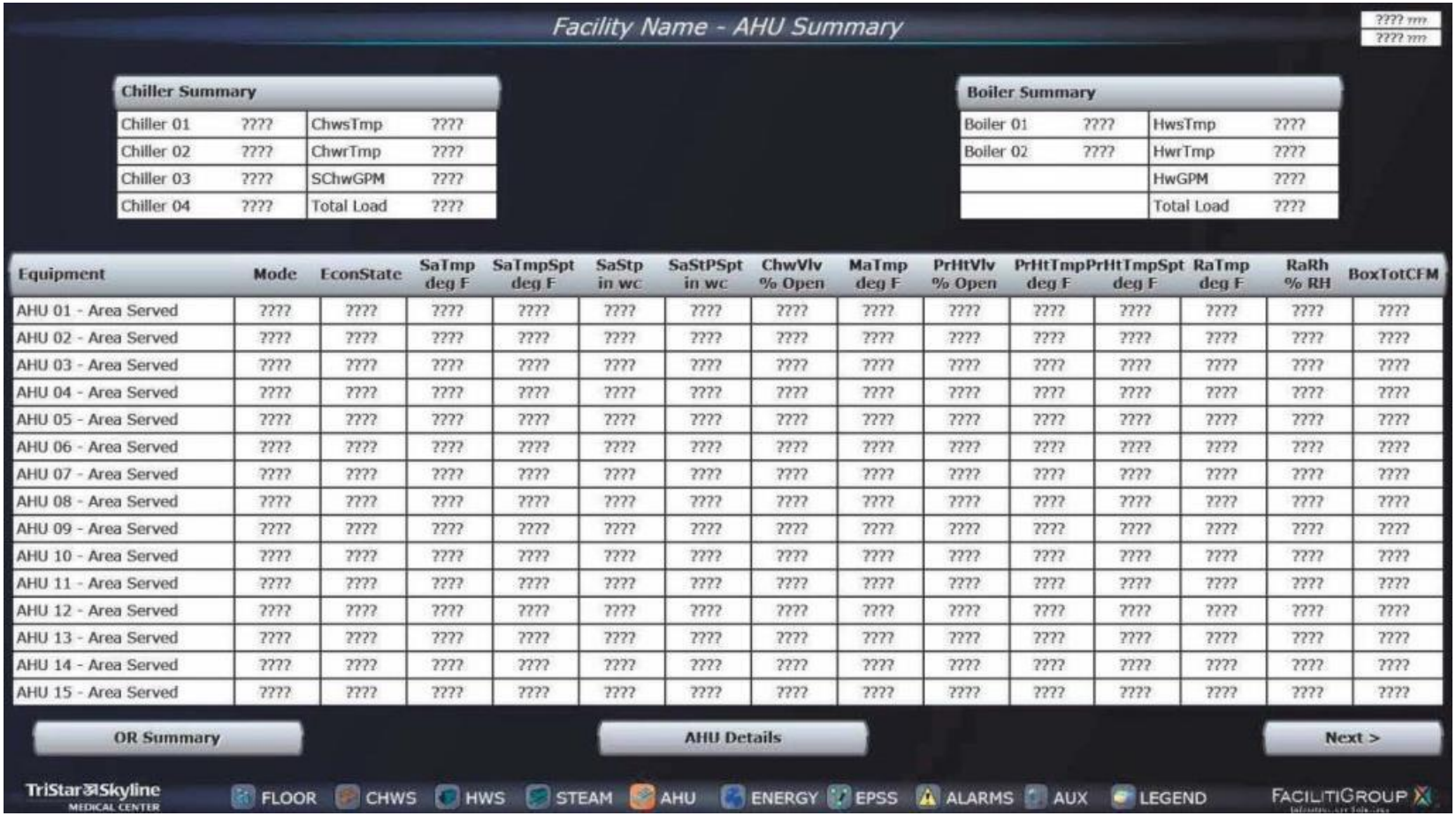

Facility Name - First Floor
Room Control Module
????
Zone Setpoint
System Mode
Unit Enable Mode
Discharge Temp
Heating Output
Physical locations of equipment.
Links to individual Chiller Detail Panels
CHILLER-1
CHILLER-2
CHILLER-3
OR ZONE
OFFICE A5551
OFFICE A5568
A5049
AHU-01
OFFICE A5570
OFFICE A5571
Physical location of equipment.
Links to AHU 01
AHU 01
AHU 02
Floor Plan shaded to show different serving AHU. Button colors correspond to floor plan colors
This alarm module shows only the alarms relevant to this graphic panel
KEYPLAN
N
OR
A
B
Offline
Low Alarm
Low Warning
Below Setpoint
Normal
Above Setpoint
High Warning
High Alarm
Overridden
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

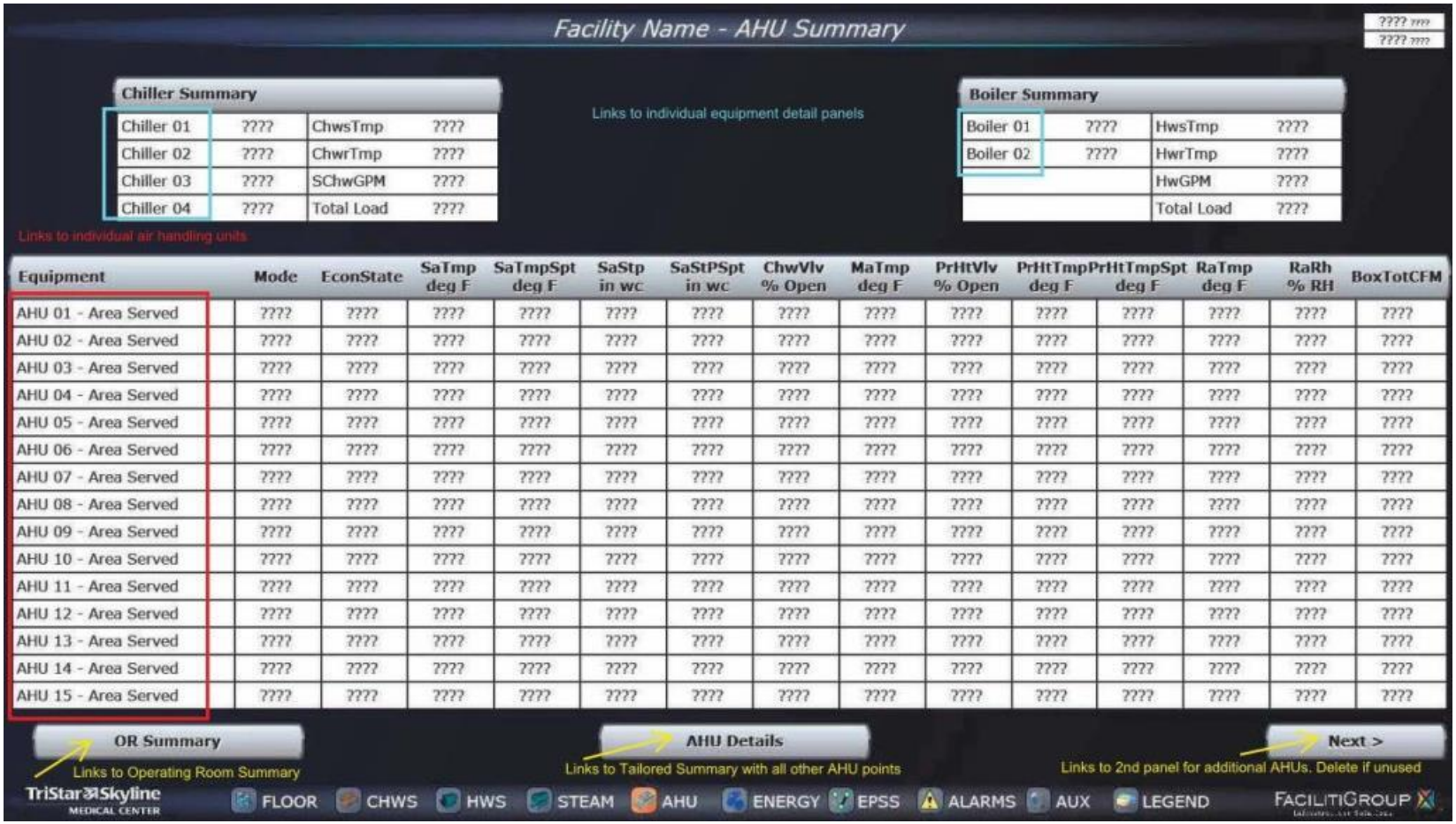

Facility Name - OR Zone
Room Control Module
Zone Setpoint
System Mode
Unit Enable Mode
Discharge Temp
Heating Output
OR-1
OR-2
OR-3
OR-5
OR-6
OR-4
KEYPLAN
N
OR
A
B
Offline
Low Alarm
Low Warning
Below Setpoint
Normal
Above Setpoint
High Warning
High Alarm
Overridden
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

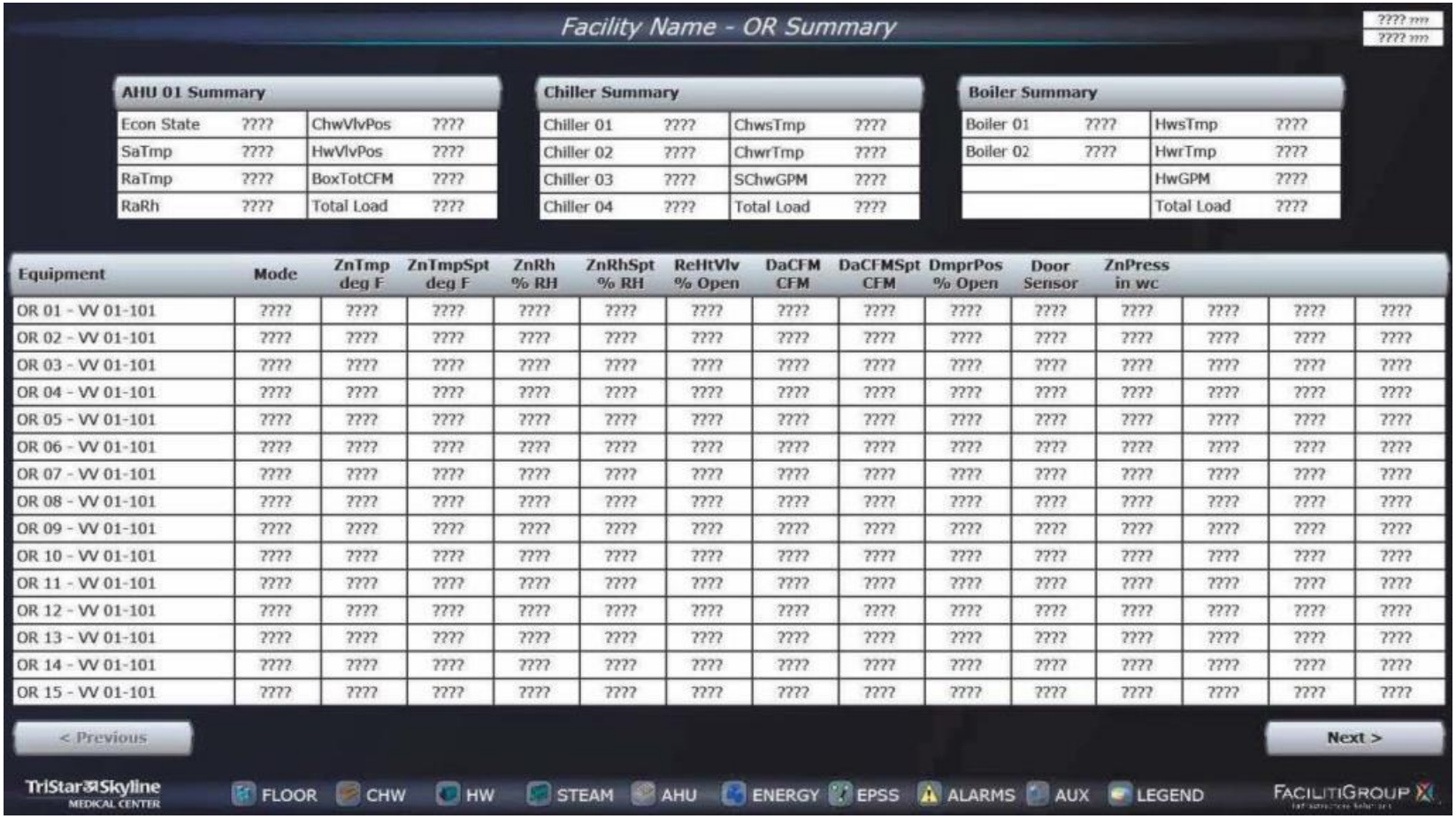

Facility Name - OR Zone
Room Control Module
Zone Setpoint
System Mode
Unit Enable Mode
Discharge Temp
Heating Output
Temperature, Humidity, and Pressure sensors for the OR Zone should be located on this floor plan in the same location as the facility.
OR-1
OR-2
OR-3
OR-5
KEYPLAN
N
OR
A
B
Offline
Low Alarm
Low Warning
Below Setpoint
Normal
Above Setpoint
High Warning
High Alarm
Overridden
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

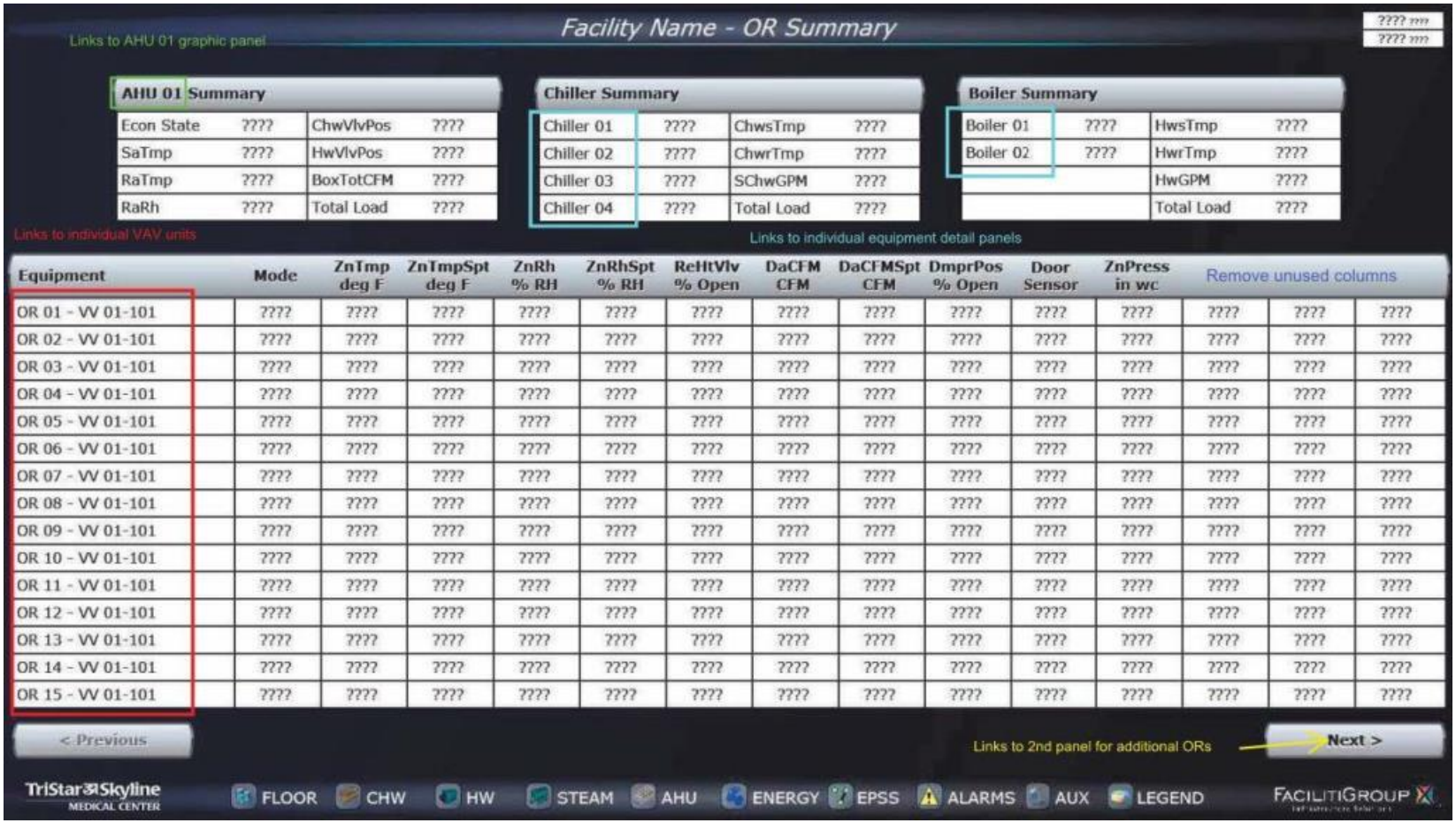

Facility Name - Air Handling Unit - 01
AhuEna
EconEna
Sequence...
Logic...
Details...
Status
Command
VFD Speed
Static Pressure
% Rh
SA CFM x 100
SA
Humidifier Valve Cmd
Smoke Damper Cmd
SA Temp
STEAM
Pre-Heat Temp
MA Temp
OA CFM x 100
Economizer Position
VFD Speed
Command
Status
EA
RA
OA
CHW Valve Cmd
HW Valve Cmd
% RH
RA Temp
RA Enthalpy
RA CFM x 100
% Rh
OA Temp
OA Enthalpy
Exhaust Fans
VAV Summary
System Parameters
SETPOINT
SA Temp
MA Temp
Pre-Heat Temp
Humidifier
SA Static Press
Alarms
Freeze Stat
Pre-Filter
Final Filter
High SA Static
Fire Alarm
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

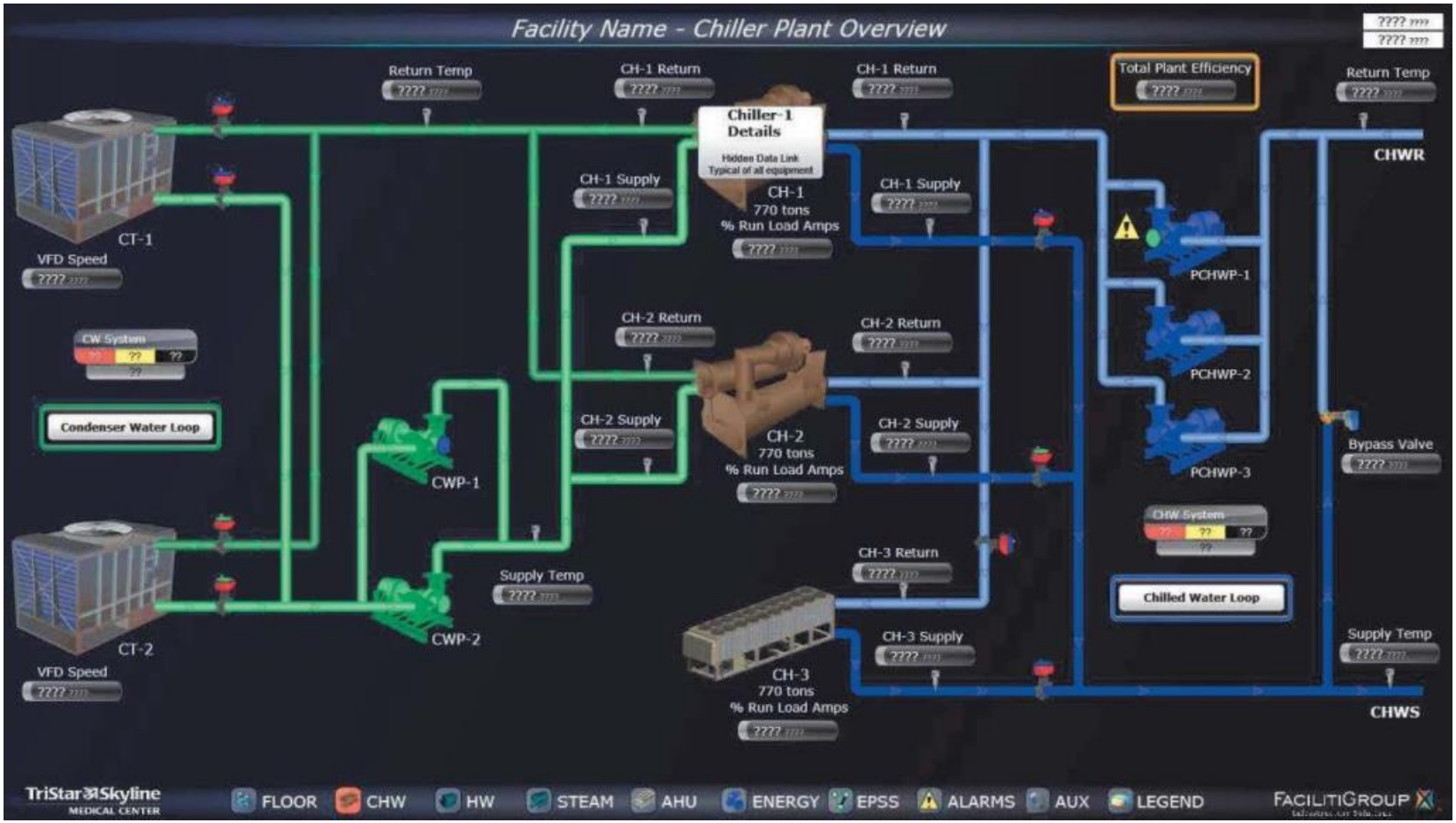

Facility Name - Air Handling Unit - 01
AhuEna
EconEna
Sequence...
Logic...
Details...
Links to the SOO Graphic panel, and PDF of the control drawings/sequence
Links to the programming of the unit (function blocks, etc.)
Links to additional information for the unit (nameplate data, photos, MEP drawings, etc.)
State squares to indicate the status of the filters. Green=Clean, Red=Dirty (alarm)
Status
Command
VFD Speed
SA CFM x 100
% Rh
Static Pressure
SA
VFD Speed
Command
Status
EA
Economizer Position
OA CFM x 100
MA Temp
Pre-Heat Temp
Humidifier Valve Cmd
Smoke Damper Cmd
SA Temp
STEAM
CHW Valve Cmd
HW Valve Cmd
RA
OA
% RH
RA Temp
RA Enthalpy
RA CFM x 100
% Rh
OA Temp
OA Enthalpy
Exhaust Fans
VAV Summary
System Parameters
SETPOINT
SA Temp
MA Temp
Pre-Heat Temp
Humidifier
SA Static Press
Upon a right-click > View Trend, the trend viewer window will pop up here for any point that is trended
Alarms
Freeze Stat
Pre-Filter
Final Filter
High SA Static
Fire Alarm
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

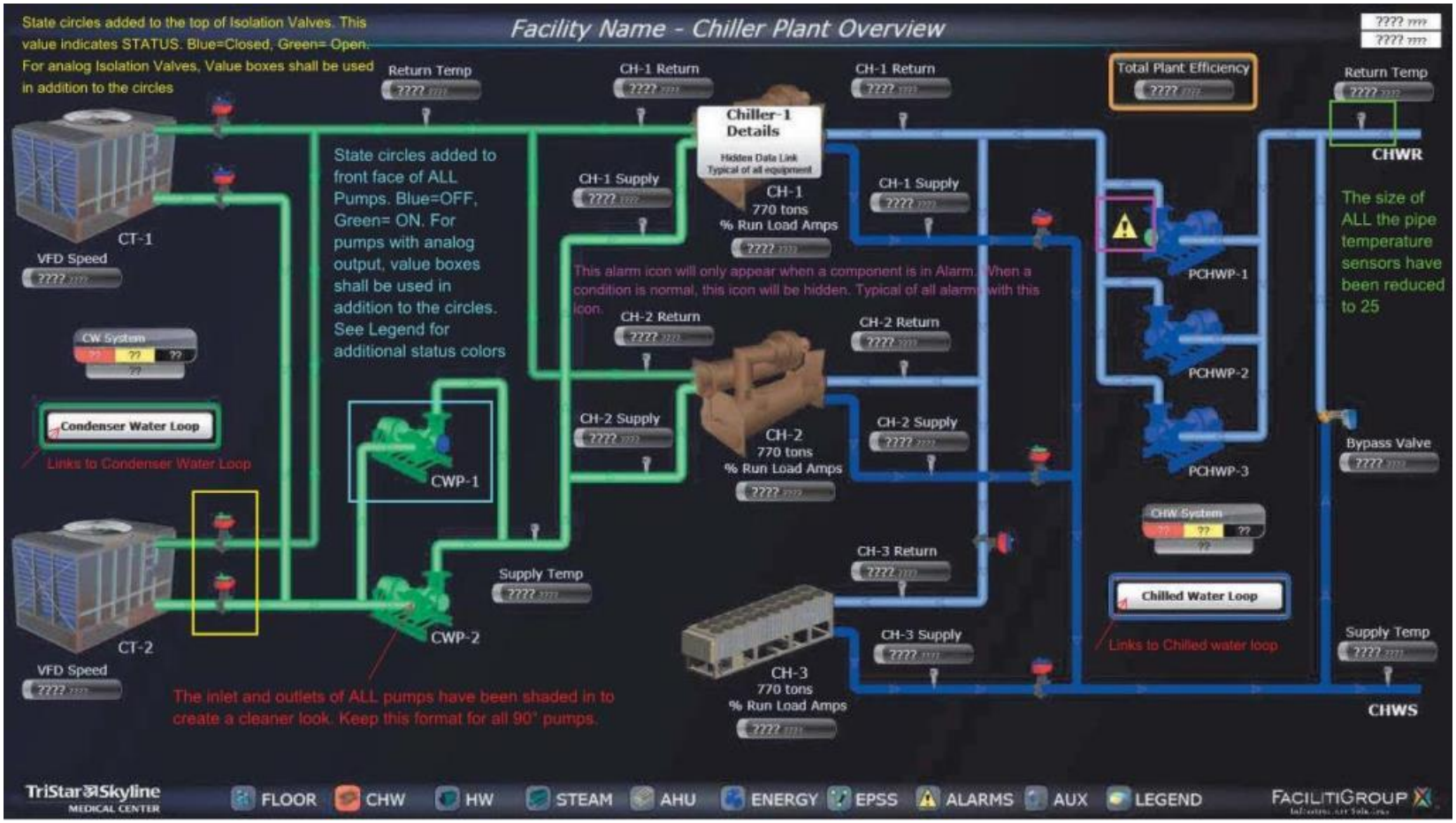

Facility Name - AHU Summary
???? ????
???? ????
Chiller Summary
Chiller 01 ???? ChwsTmp ????
Chiller 02 ???? ChwrTmp ????
Chiller 03 ???? SChwGPM ????
Chiller 04 ???? Total Load ????
Boiler Summary
Boiler 01 ???? HwsTmp ????
Boiler 02 ???? HwrTmp ????
HwGPM ????
Total Load ????
Equipment Mode EconState SaTmp deg F SaTmpSpt deg F SaStp in wc SaStPSpt in wc ChwVlv % Open MaTmp deg F PrHtVlv % Open PrHtTmp deg F PrHtTmpSpt deg F RaTmp deg F RaRh % RH BoxTotCFM
AHU 01 - Area Served
AHU 02 - Area Served
AHU 03 - Area Served
AHU 04 - Area Served
AHU 05 - Area Served
AHU 06 - Area Served
AHU 07 - Area Served
AHU 08 - Area Served
AHU 09 - Area Served
AHU 10 - Area Served
AHU 11 - Area Served
AHU 12 - Area Served
AHU 13 - Area Served
AHU 14 - Area Served
AHU 15 - Area Served
OR Summary
AHU Details
Next >
TriStar Skyline MEDICAL CENTER
FLOOR CHWS HWS STEAM AHU ENERGY EPSS ALARMS AUX LEGEND
FACILITIGROUP

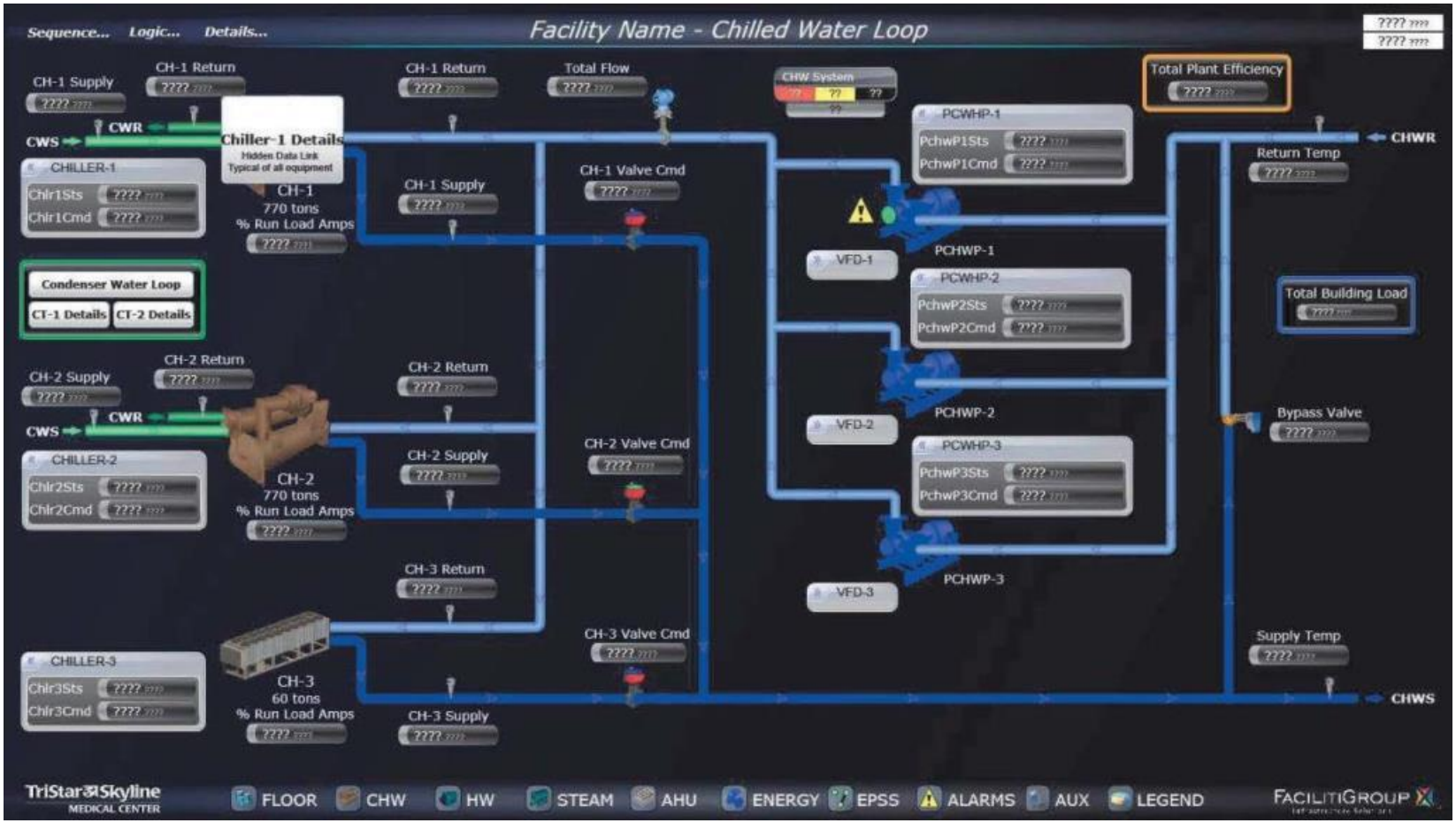

Facility Name - AHU Summary
???? ????
???? ????
Chiller Summary
Chiller 01 ???? ChwsTmp ????
Chiller 02 ???? ChwrTmp ????
Chiller 03 ???? SChwGPM ????
Chiller 04 ???? Total Load ????
Links to individual equipment detail panels
Boiler Summary
Boiler 01 ???? HwsTmp ????
Boiler 02 ???? HwrTmp ????
HwGPM ????
Total Load ????
Links to individual air handling units
Equipment Mode EconState SaTmp deg F SaTmpSpt deg F SaStp in wc SaStPSpt in wc ChwVlv % Open MaTmp deg F PrHtVlv % Open PrHtTmp deg F PrHtTmpSpt deg F RaTmp deg F RaRh % RH BoxTotCFM
AHU 01 - Area Served
AHU 02 - Area Served
AHU 03 - Area Served
AHU 04 - Area Served
AHU 05 - Area Served
AHU 06 - Area Served
AHU 07 - Area Served
AHU 08 - Area Served
AHU 09 - Area Served
AHU 10 - Area Served
AHU 11 - Area Served
AHU 12 - Area Served
AHU 13 - Area Served
AHU 14 - Area Served
AHU 15 - Area Served
OR Summary
Links to Operating Room Summary
AHU Details
Links to Tailored Summary with all other AHU points
Next >
Links to 2nd panel for additional AHUs. Delete if unused
TriStar Skyline MEDICAL CENTER
FLOOR CHWS HWS STEAM AHU ENERGY EPSS ALARMS AUX LEGEND
FACILITIGROUP

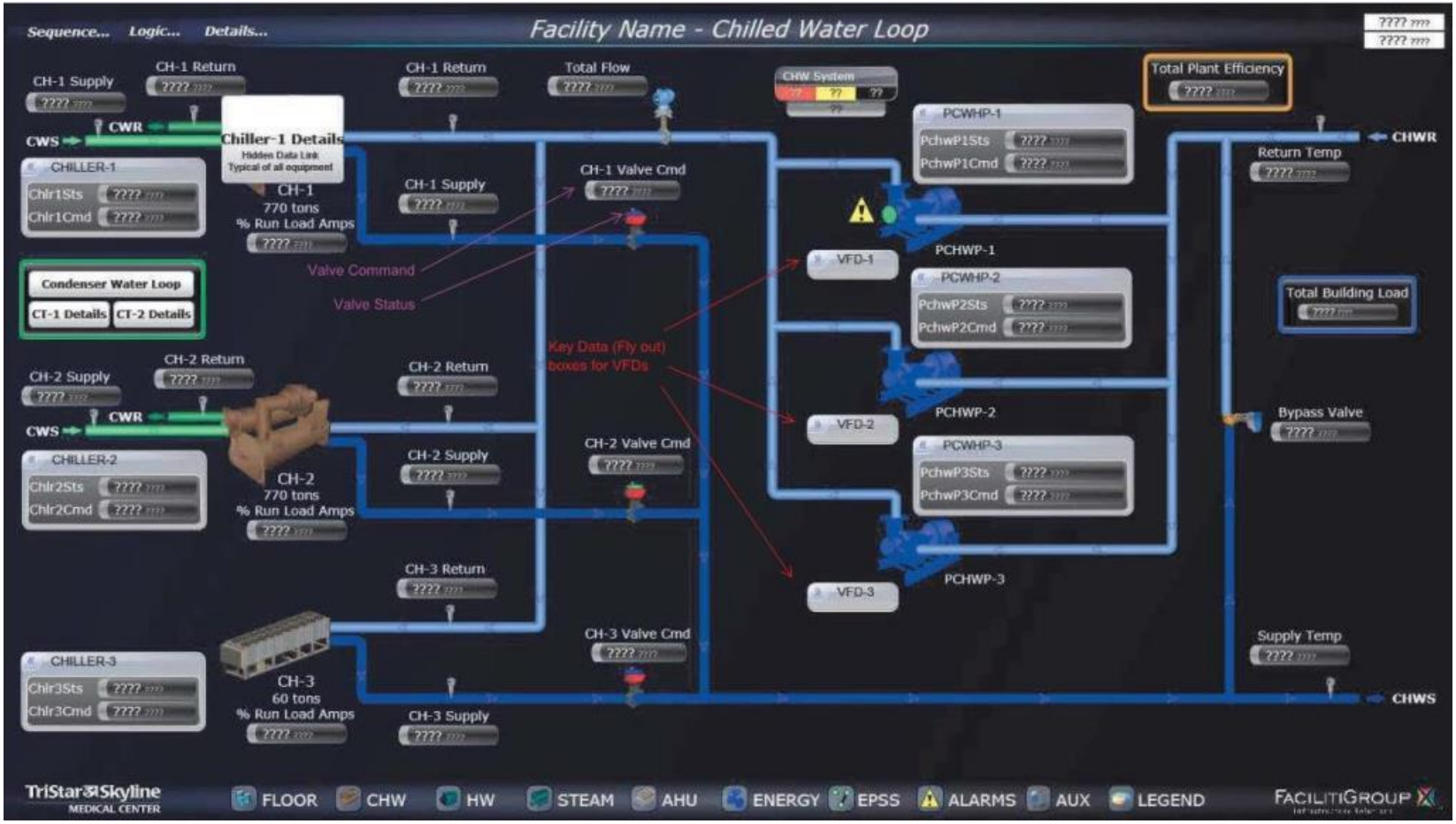

Facility Name - OR Summary
???? ????
???? ????
AHU 01 Summary
Econ State ???? ChwVlvPos ????
SaTmp ???? HwVlvPos ????
RaTmp ???? BoxTotCFM ????
RaRh ???? Total Load ????
Chiller Summary
Chiller 01 ???? ChwsTmp ????
Chiller 02 ???? ChwrTmp ????
Chiller 03 ???? SChwGPM ????
Chiller 04 ???? Total Load ????
Boiler Summary
Boiler 01 ???? HwsTmp ????
Boiler 02 ???? HwrTmp ????
HwGPM ????
Total Load ????
Equipment | Mode | ZnTmp deg F | ZnTmpSpt deg F | ZnRh % RH | ZnRhSpt % RH | ReHtVlv % Open | DaCFM CFM | DaCFMSpt CFM | DmprPos % Open | Door Sensor | ZnPress in wc
OR 01 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 02 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 03 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 04 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 05 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 06 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 07 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 08 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 09 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 10 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 11 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 12 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 13 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 14 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
OR 15 - VV 01-101 | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ???? | ????
< Previous
Next >
TriStar Skyline MEDICAL CENTER
FLOOR CHW HW STEAM AHU ENERGY EPSS ALARMS AUX LEGEND
FACILITIGROUP

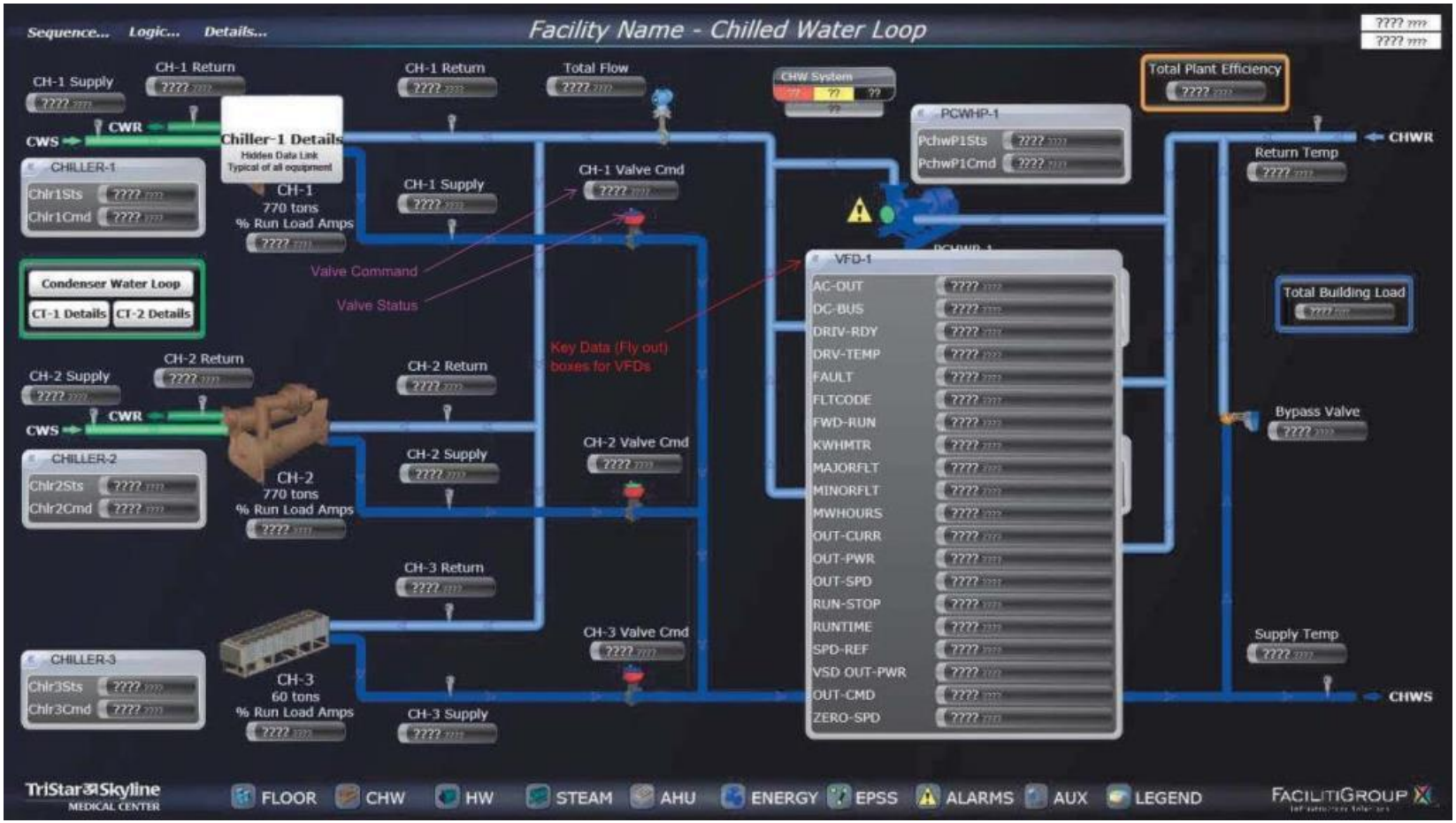

Facility Name - OR Summary
???? ????
???? ????
Links to AHU 01 graphic panel
AHU 01 Summary
Econ State ???? ChwVlvPos ????
SaTmp ???? HwVlvPos ????
RaTmp ???? BoxTotCFM ????
RaRh ???? Total Load ????
Chiller Summary
Chiller 01 ???? ChwsTmp ????
Chiller 02 ???? ChwrTmp ????
Chiller 03 ???? SChwGPM ????
Chiller 04 ???? Total Load ????
Boiler Summary
Boiler 01 ???? HwsTmp ????
Boiler 02 ???? HwrTmp ????
HwGPM ????
Total Load ????
Links to individual VAV units
Links to individual equipment detail panels
Equipment Mode ZnTmp deg F ZnTmpSpt deg F ZnRh % RH ZnRhSpt % RH ReHtVlv % Open DaCFM CFM DaCFMSpt CFM DmprPos % Open Door Sensor ZnPress in wc
Remove unused columns
OR 01 - VV 01-101
OR 02 - VV 01-101
OR 03 - VV 01-101
OR 04 - VV 01-101
OR 05 - VV 01-101
OR 06 - VV 01-101
OR 07 - VV 01-101
OR 08 - VV 01-101
OR 09 - VV 01-101
OR 10 - VV 01-101
OR 11 - VV 01-101
OR 12 - VV 01-101
OR 13 - VV 01-101
OR 14 - VV 01-101
OR 15 - VV 01-101
< Previous
Links to 2nd panel for additional ORs
Next >
TriStar Skyline MEDICAL CENTER
FLOOR CHW HW STEAM AHU ENERGY EPSS ALARMS AUX LEGEND
FACILITIGROUP

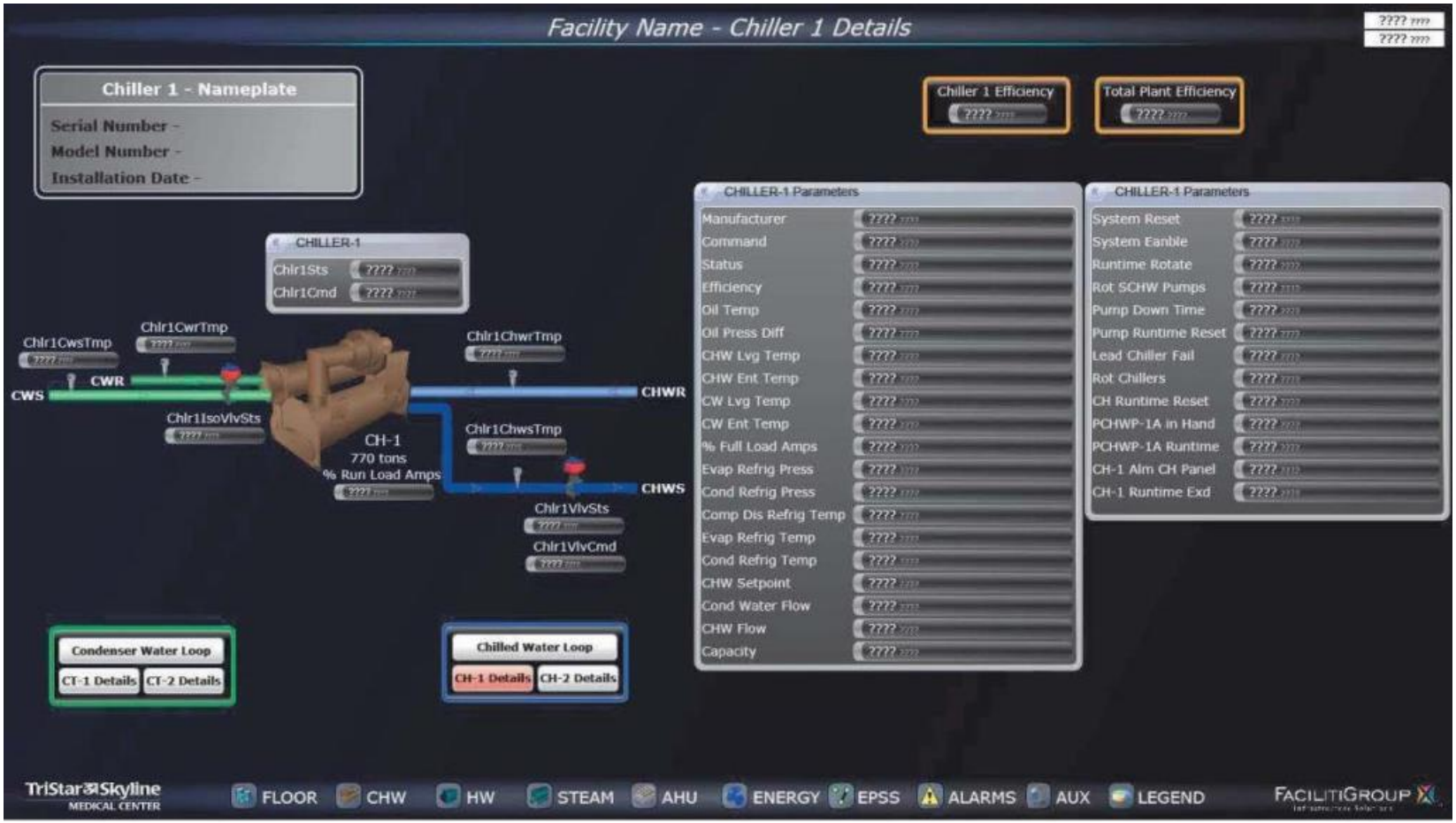

Facility Name - Chiller Plant Overview
Return Temp
CH-1 Return
CH-1 Return
Total Plant Efficiency
Return Temp
CHWR
Chiller-1 Details
Hidden Data Link Typical of all equipment
CH-1
770 tons
% Run Load Amps
CH-1 Supply
CH-1 Supply
CT-1
VFD Speed
PCHWP-1
CW System
CH-2 Return
CH-2 Return
PCHWP-2
Condenser Water Loop
CH-2 Supply
CH-2 Supply
CH-2
770 tons
% Run Load Amps
Bypass Valve
PCHWP-3
CWP-1
CHW System
CH-3 Return
Supply Temp
Chilled Water Loop
CT-2
VFD Speed
CWP-2
CH-3 Supply
Supply Temp
CH-3
770 tons
% Run Load Amps
CHWS
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

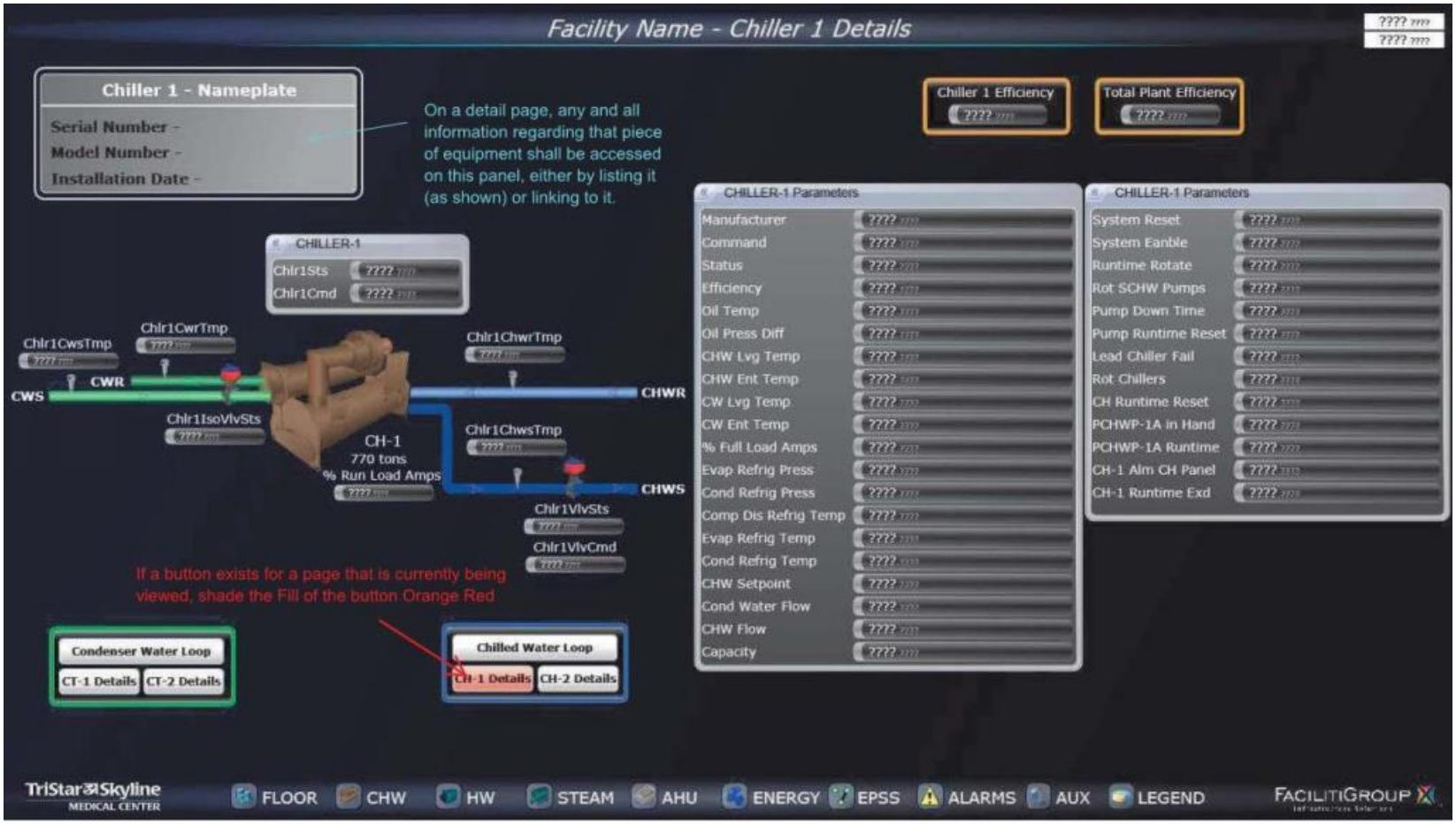

State circles added to the top of Isolation Valves. This value indicates STATUS. Blue=Closed, Green= Open.
For analog Isolation Valves, Value boxes shall be used in addition to the circles
Facility Name - Chiller Plant Overview
Return Temp
CH-1 Return
CH-1 Return
Total Plant Efficiency
Return Temp
CHWR
Chiller-1 Details
Hidden Data Link Typical of all equipment
CH-1
770 tons
% Run Load Amps
CH-1 Supply
CH-1 Supply
CT-1
VFD Speed
State circles added to front face of ALL Pumps. Blue=OFF, Green= ON. For pumps with analog output, value boxes shall be used in addition to the circles. See Legend for additional status colors
This alarm icon will only appear when a component is in Alarm. When a condition is normal, this icon will be hidden. Typical of all alarms with this icon.
PCHWP-1
PCHWP-2
PCHWP-3
The size of ALL the pipe temperature sensors have been reduced to 25
CW System
CH-2 Return
CH-2 Return
Condenser Water Loop
Links to Condenser Water Loop
CH-2 Supply
CH-2 Supply
CH-2
770 tons
% Run Load Amps
Bypass Valve
CWP-1
CHW System
CH-3 Return
Supply Temp
Chilled Water Loop
CT-2
VFD Speed
CWP-2
CH-3 Supply
Supply Temp
Links to Chilled water loop
CH-3
770 tons
% Run Load Amps
The inlet and outlets of ALL pumps have been shaded in to create a cleaner look. Keep this format for all 90° pumps.
CHWS
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

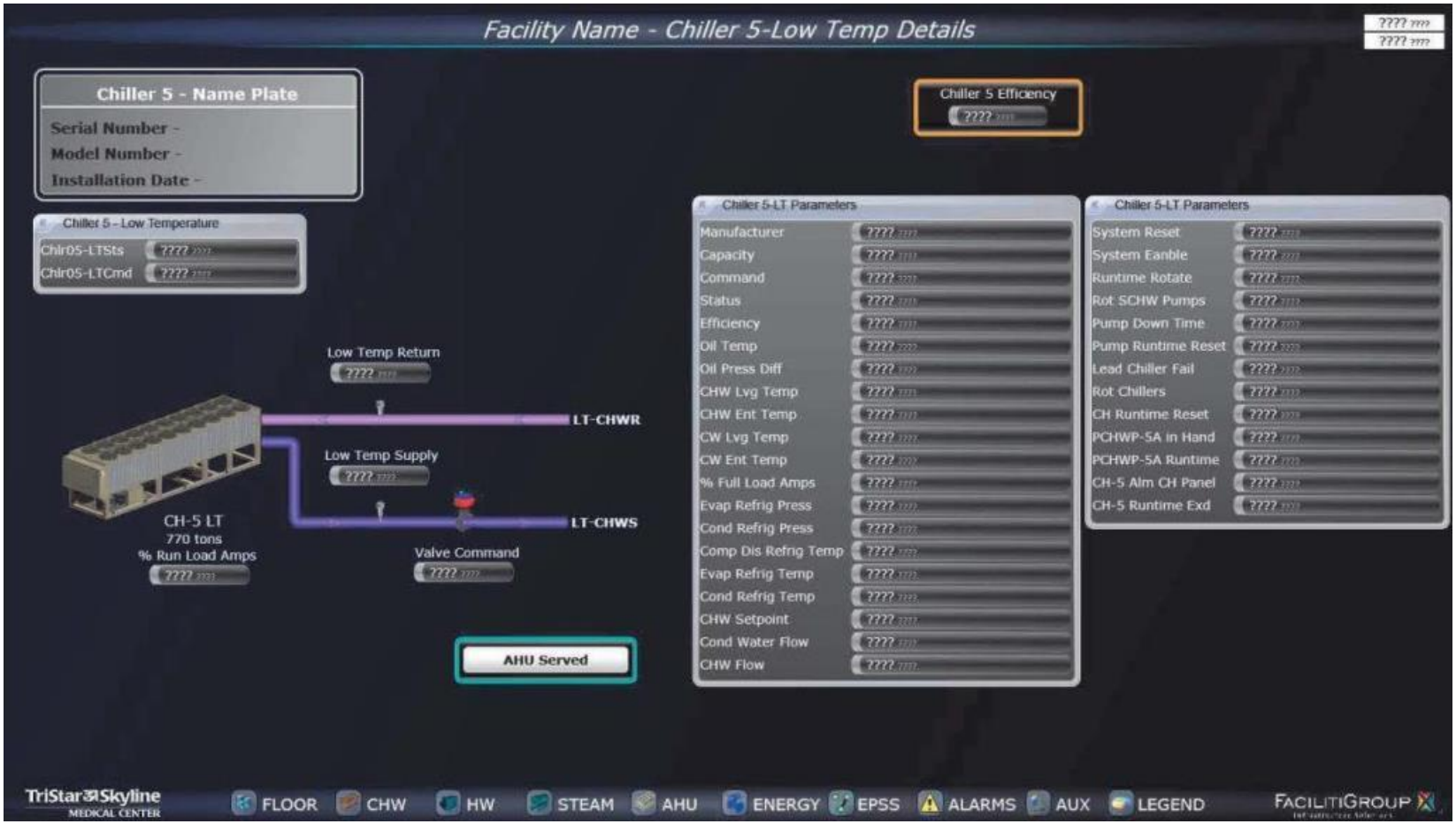

Sequence... Logic... Details...
Facility Name - Chilled Water Loop
CH-1 Supply
CH-1 Return
CWS
CWR
Chiller-1 Details
Hidden Data Link
Typical of all equipment
CHILLER-1
Chlr1Sts
Chlr1Cmd
CH-1
770 tons
% Run Load Amps
CH-1 Return
Total Flow
CH-1 Supply
CH-1 Valve Cmd
Condenser Water Loop
CT-1 Details
CT-2 Details
CH-2 Supply
CH-2 Return
CWS
CWR
CHILLER-2
Chlr2Sts
Chlr2Cmd
CH-2
770 tons
% Run Load Amps
CH-2 Return
CH-2 Supply
CH-2 Valve Cmd
CH-3 Return
CHILLER-3
Chlr3Sts
Chlr3Cmd
CH-3
60 tons
% Run Load Amps
CH-3 Supply
CH-3 Valve Cmd
CHW System
PCWHP-1
PchwP1Sts
PchwP1Cmd
PCHWP-1
VFD-1
PCWHP-2
PchwP2Sts
PchwP2Cmd
PCHWP-2
VFD-2
PCWHP-3
PchwP3Sts
PchwP3Cmd
PCHWP-3
VFD-3
Total Plant Efficiency
CHWR
Return Temp
Total Building Load
Bypass Valve
Supply Temp
CHWS
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

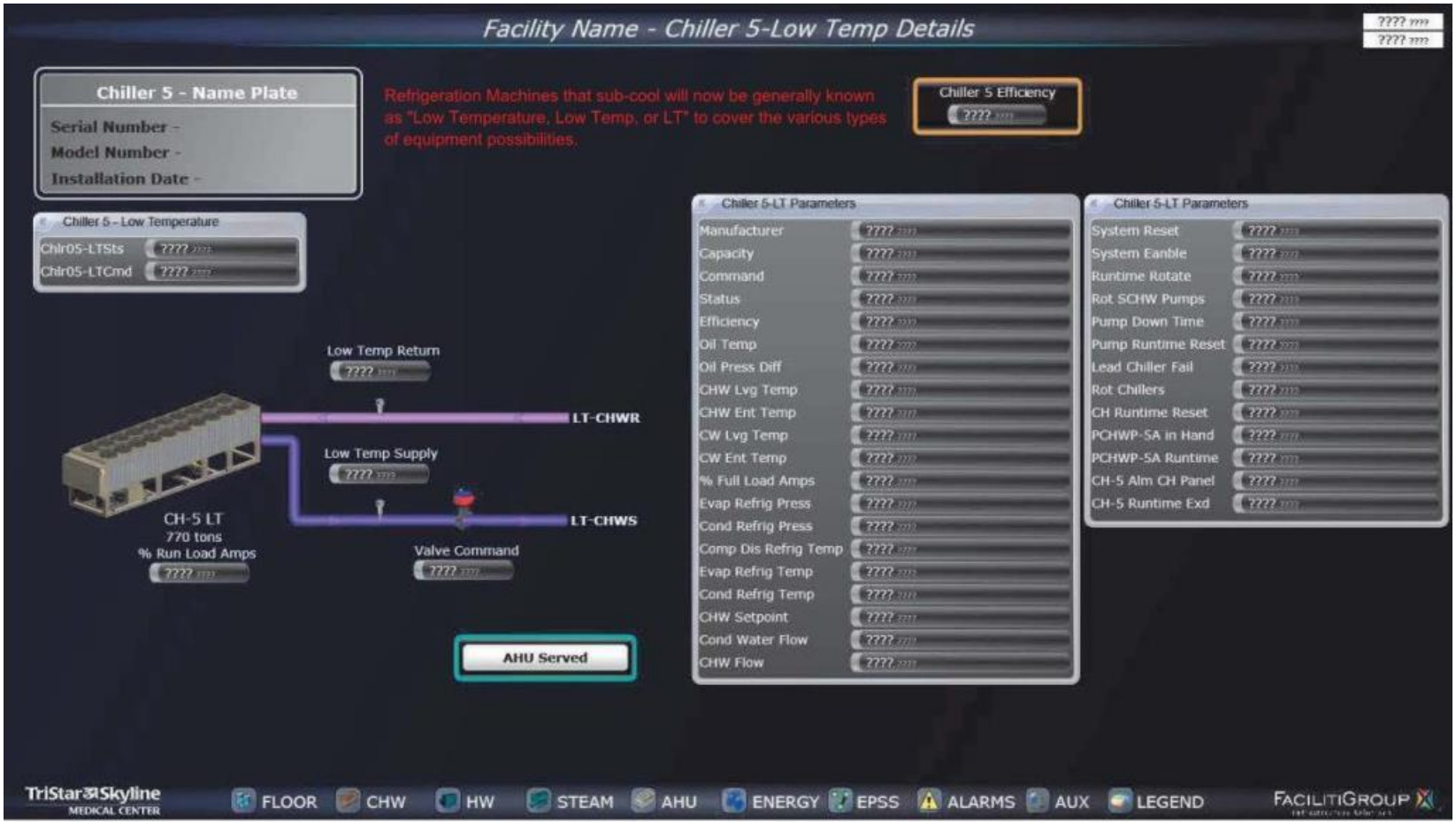

Sequence...
Logic...
Details...
Facility Name - Chilled Water Loop
CH-1 Supply
CH-1 Return
CWR
CWS
CHILLER-1
Chlr1Sts
Chlr1Cmd
Chiller-1 Details
Hidden Data Link
Typical of all equipment
CH-1
770 tons
% Run Load Amps
CH-1 Return
Total Flow
CH-1 Supply
CH-1 Valve Cmd
Valve Command
Valve Status
Condenser Water Loop
CT-1 Details
CT-2 Details
CH-2 Return
CH-2 Supply
CWR
CWS
CHILLER-2
Chlr2Sts
Chlr2Cmd
CH-2
770 tons
% Run Load Amps
CH-2 Return
CH-2 Supply
CH-2 Valve Cmd
Key Data (Fly out)
boxes for VFDs
CH-3 Return
CHILLER-3
Chlr3Sts
Chlr3Cmd
CH-3
60 tons
% Run Load Amps
CH-3 Valve Cmd
CH-3 Supply
CHW System
PCWHP-1
PchwP1Sts
PchwP1Cmd
PCHWP-1
VFD-1
PCWHP-2
PchwP2Sts
PchwP2Cmd
PCHWP-2
VFD-2
PCWHP-3
PchwP3Sts
PchwP3Cmd
PCHWP-3
VFD-3
Total Plant Efficiency
CHWR
Return Temp
Total Building Load
Bypass Valve
Supply Temp
CHWS
TriStar Skyline
MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

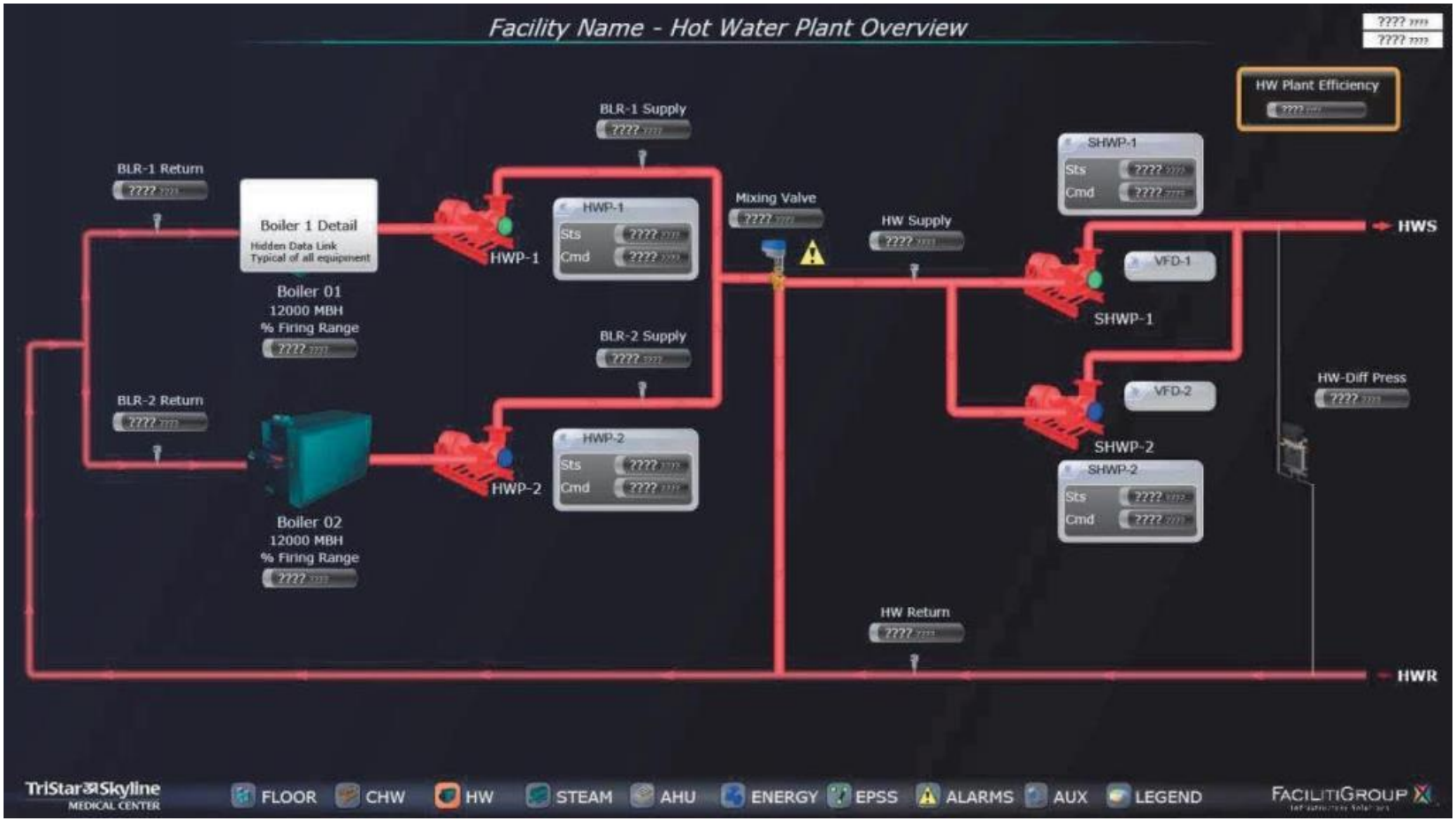

Sequence... Logic... Details...
Facility Name - Chilled Water Loop
CH-1 Supply
CH-1 Return
CWS
CWR
Chiller-1 Details
Hidden Data Link
Typical of all equipment
CHILLER-1
Chlr1Sts
Chlr1Cmd
CH-1
770 tons
% Run Load Amps
CH-1 Return
Total Flow
CH-1 Supply
CH-1 Valve Cmd
Valve Command
Valve Status
Condenser Water Loop
CT-1 Details
CT-2 Details
CH-2 Supply
CH-2 Return
CWS
CWR
CHILLER-2
Chlr2Sts
Chlr2Cmd
CH-2
770 tons
% Run Load Amps
CH-2 Return
CH-2 Supply
CH-2 Valve Cmd
Key Data (Fly out) boxes for VFDs
CH-3 Return
CHILLER-3
Chlr3Sts
Chlr3Cmd
CH-3
60 tons
% Run Load Amps
CH-3 Supply
CH-3 Valve Cmd
CHW System
PCWHP-1
PchwP1Sts
PchwP1Cmd
VFD-1
AC-OUT
DC-BUS
DRIV-RDY
DRV-TEMP
FAULT
FLTCODE
FWD-RUN
KWHMTR
MAJORFLT
MINORFLT
MWHOURS
OUT-CURR
OUT-PWR
OUT-SPD
RUN-STOP
RUNTIME
SPD-REF
VSD OUT-PWR
OUT-CMD
ZERO-SPD
Total Plant Efficiency
CHWR
Return Temp
Total Building Load
Bypass Valve
Supply Temp
CHWS
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

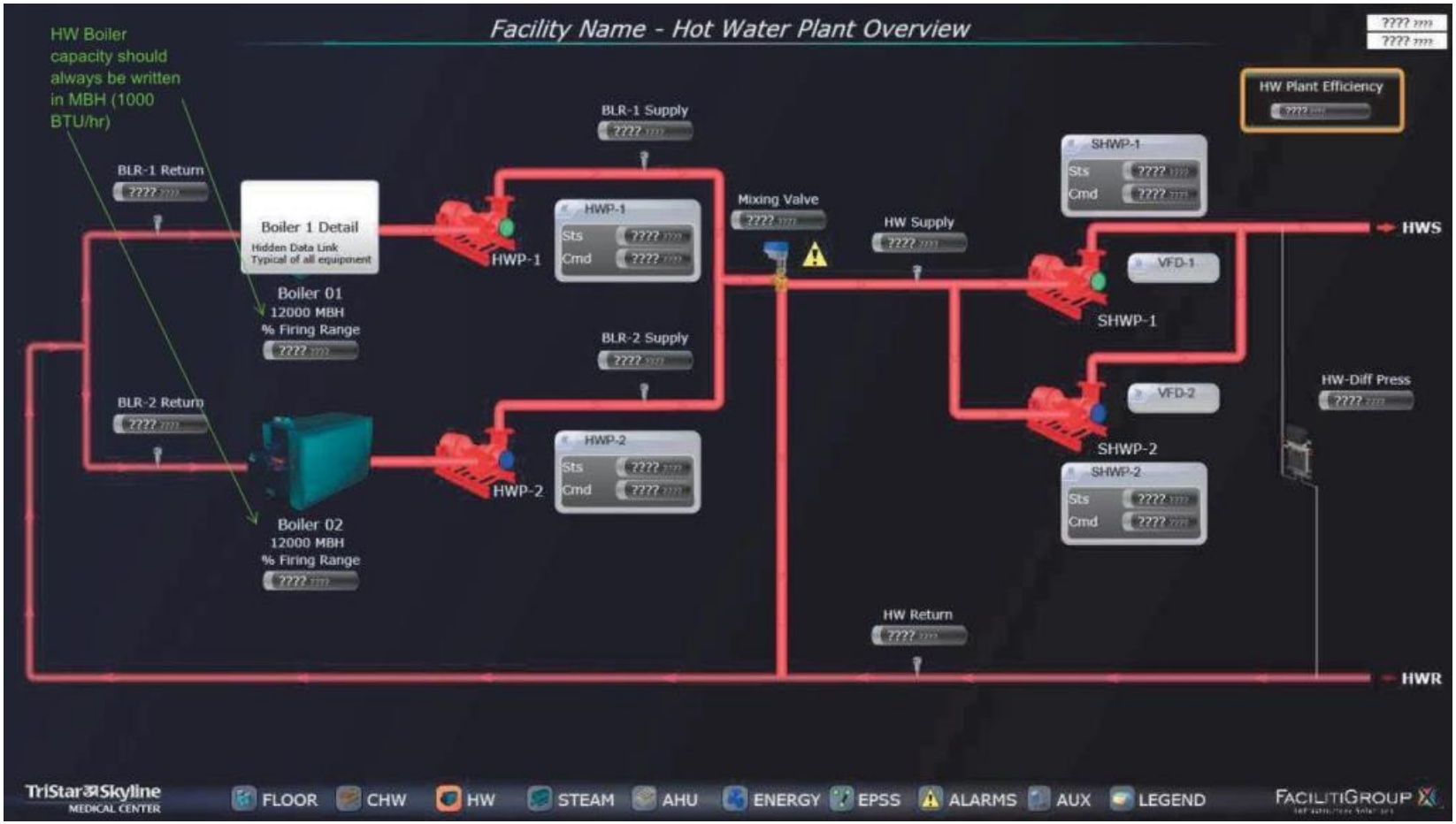

Facility Name - Chiller 1 Details
Chiller 1 - Nameplate
Serial Number -
Model Number -
Installation Date -
Chiller 1 Efficiency
Total Plant Efficiency
CHILLER-1
Chlr1Sts
Chlr1Cmd
Chlr1CwsTmp
Chlr1CwrTmp
Chlr1ChwrTmp
CWS
CWR
CHWR
Chlr1IsoVlvSts
CH-1
770 tons
% Run Load Amps
Chlr1ChwsTmp
CHWS
Chlr1VlvSts
Chlr1VlvCmd
CHILLER-1 Parameters
Manufacturer
Command
Status
Efficiency
Oil Temp
Oil Press Diff
CHW Lvg Temp
CHW Ent Temp
CW Lvg Temp
CW Ent Temp
% Full Load Amps
Evap Refrig Press
Cond Refrig Press
Comp Dis Refrig Temp
Evap Refrig Temp
Cond Refrig Temp
CHW Setpoint
Cond Water Flow
CHW Flow
Capacity
CHILLER-1 Parameters
System Reset
System Eanble
Runtime Rotate
Rot SCHW Pumps
Pump Down Time
Pump Runtime Reset
Lead Chiller Fail
Rot Chillers
CH Runtime Reset
PCHWP-1A in Hand
PCHWP-1A Runtime
CH-1 Alm CH Panel
CH-1 Runtime Exd
Condenser Water Loop
CT-1 Details
CT-2 Details
Chilled Water Loop
CH-1 Details
CH-2 Details
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

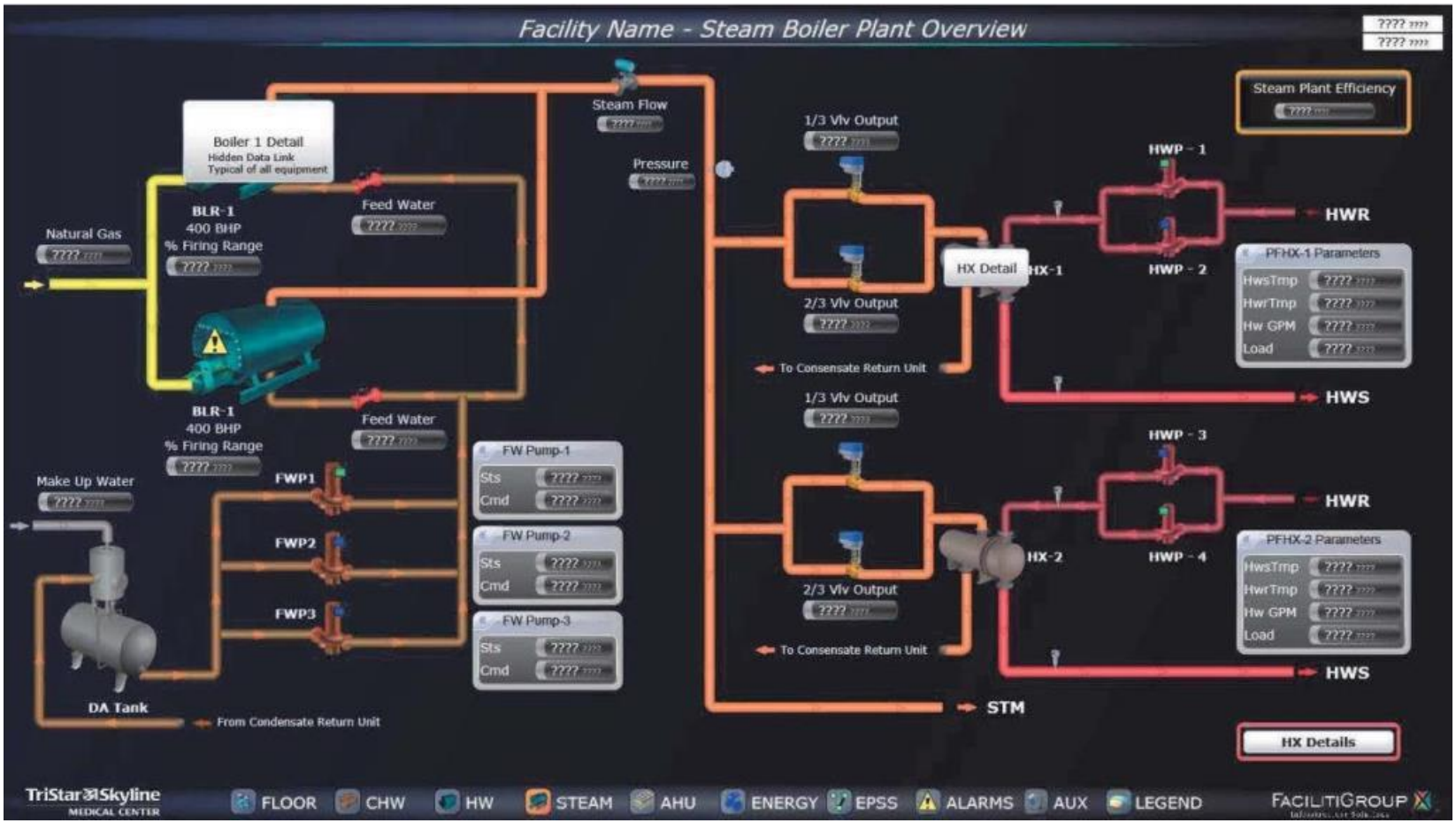

Facility Name - Chiller 1 Details
Chiller 1 - Nameplate
Serial Number -
Model Number -
Installation Date -
On a detail page, any and all information regarding that piece of equipment shall be accessed on this panel, either by listing it (as shown) or linking to it.
Chiller 1 Efficiency
Total Plant Efficiency
CHILLER-1
Chlr1Sts
Chlr1Cmd
CHILLER-1 Parameters
Manufacturer
Command
Status
Efficiency
Oil Temp
Oil Press Diff
CHW Lvg Temp
CHW Ent Temp
CW Lvg Temp
CW Ent Temp
% Full Load Amps
Evap Refrig Press
Cond Refrig Press
Comp Dis Refrig Temp
Evap Refrig Temp
Cond Refrig Temp
CHW Setpoint
Cond Water Flow
CHW Flow
Capacity
CHILLER-1 Parameters
System Reset
System Eanble
Runtime Rotate
Rot SCHW Pumps
Pump Down Time
Pump Runtime Reset
Lead Chiller Fail
Rot Chillers
CH Runtime Reset
PCHWP-1A in Hand
PCHWP-1A Runtime
CH-1 Alm CH Panel
CH-1 Runtime Exd
Chlr1CwsTmp
Chlr1CwrTmp
Chlr1ChwrTmp
CWR
CWS
CHWR
Chlr1IsoVlvSts
CH-1
770 tons
% Run Load Amps
Chlr1ChwsTmp
CHWS
Chlr1VlvSts
Chlr1VlvCmd
If a button exists for a page that is currently being viewed, shade the Fill of the button Orange Red
Condenser Water Loop
CT-1 Details
CT-2 Details
Chilled Water Loop
CH-1 Details
CH-2 Details
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

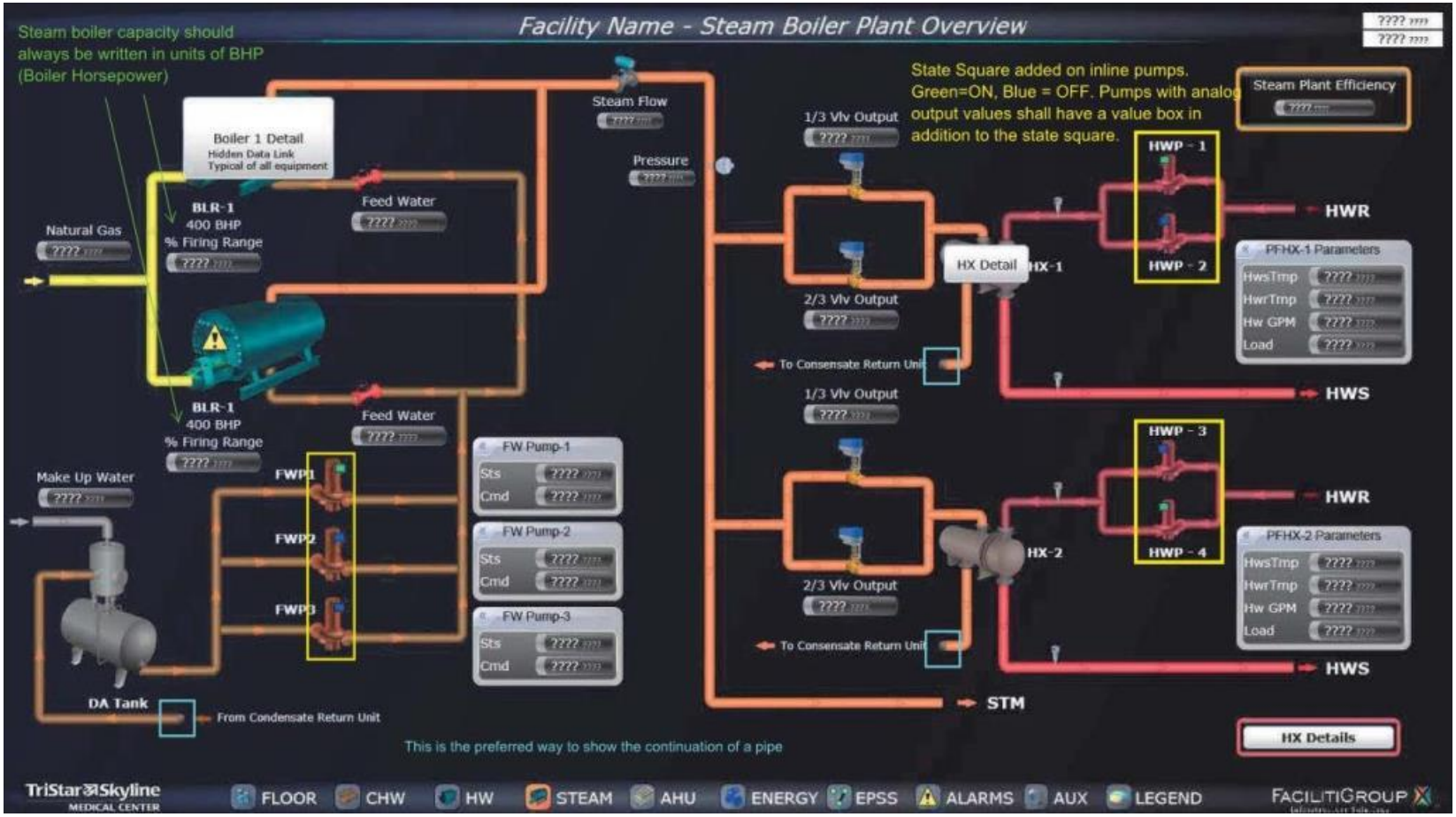

Facility Name - Chiller 5-Low Temp Details
Chiller 5 - Name Plate
Serial Number -
Model Number -
Installation Date -
Chiller 5 Efficiency
Chiller 5 - Low Temperature
Chlr05-LTSts
Chlr05-LTCmd
Low Temp Return
LT-CHWR
Low Temp Supply
LT-CHWS
CH-5 LT
770 tons
% Run Load Amps
Valve Command
AHU Served
Chiller 5-LT Parameters
Manufacturer
Capacity
Command
Status
Efficiency
Oil Temp
Oil Press Diff
CHW Lvg Temp
CHW Ent Temp
CW Lvg Temp
CW Ent Temp
% Full Load Amps
Evap Refrig Press
Cond Refrig Press
Comp Dis Refrig Temp
Evap Refrig Temp
Cond Refrig Temp
CHW Setpoint
Cond Water Flow
CHW Flow
Chiller 5-LT Parameters
System Reset
System Eanble
Runtime Rotate
Rot SCHW Pumps
Pump Down Time
Pump Runtime Reset
Lead Chiller Fail
Rot Chillers
CH Runtime Reset
PCHWP-5A in Hand
PCHWP-5A Runtime
CH-5 Alm CH Panel
CH-5 Runtime Exd
TriStar Skyline
MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

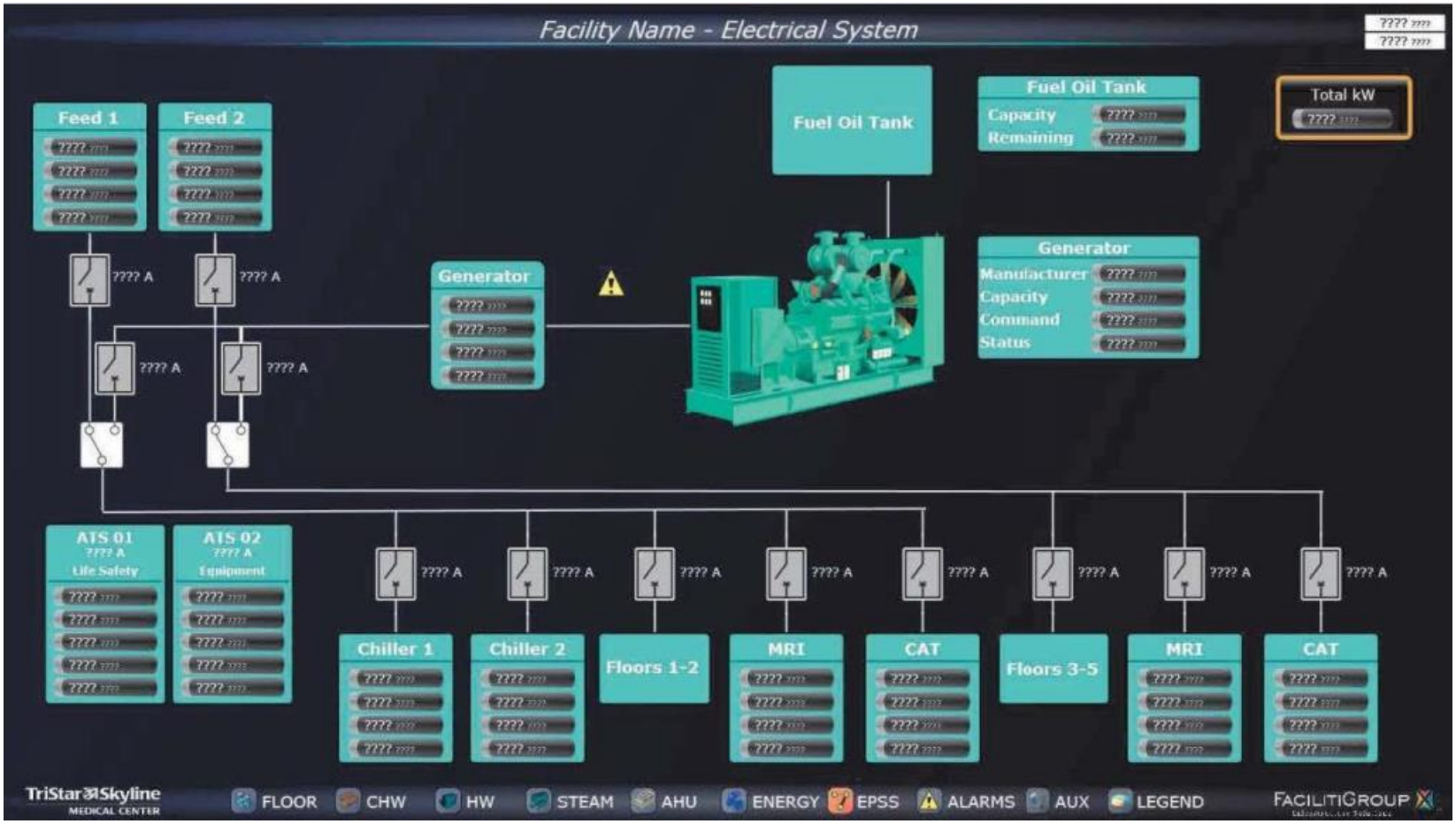

Facility Name - Chiller 5-Low Temp Details
Chiller 5 - Name Plate
Serial Number -
Model Number -
Installation Date -
Refrigeration Machines that sub-cool will now be generally known as "Low Temperature, Low Temp, or LT" to cover the various types of equipment possibilities.
Chiller 5 Efficiency
Chiller 5 - Low Temperature
Chlr05-LTSts
Chlr05-LTCmd
Low Temp Return
LT-CHWR
Low Temp Supply
LT-CHWS
CH-5 LT
770 tons
% Run Load Amps
Valve Command
AHU Served
Chiller 5-LT Parameters
Manufacturer
Capacity
Command
Status
Efficiency
Oil Temp
Oil Press Diff
CHW Lvg Temp
CHW Ent Temp
CW Lvg Temp
CW Ent Temp
% Full Load Amps
Evap Refrig Press
Cond Refrig Press
Comp Dis Refrig Temp
Evap Refrig Temp
Cond Refrig Temp
CHW Setpoint
Cond Water Flow
CHW Flow
Chiller 5-LT Parameters
System Reset
System Eanble
Runtime Rotate
Rot SCHW Pumps
Pump Down Time
Pump Runtime Reset
Lead Chiller Fail
Rot Chillers
CH Runtime Reset
PCHWP-5A in Hand
PCHWP-5A Runtime
CH-5 Alm CH Panel
CH-5 Runtime Exd
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

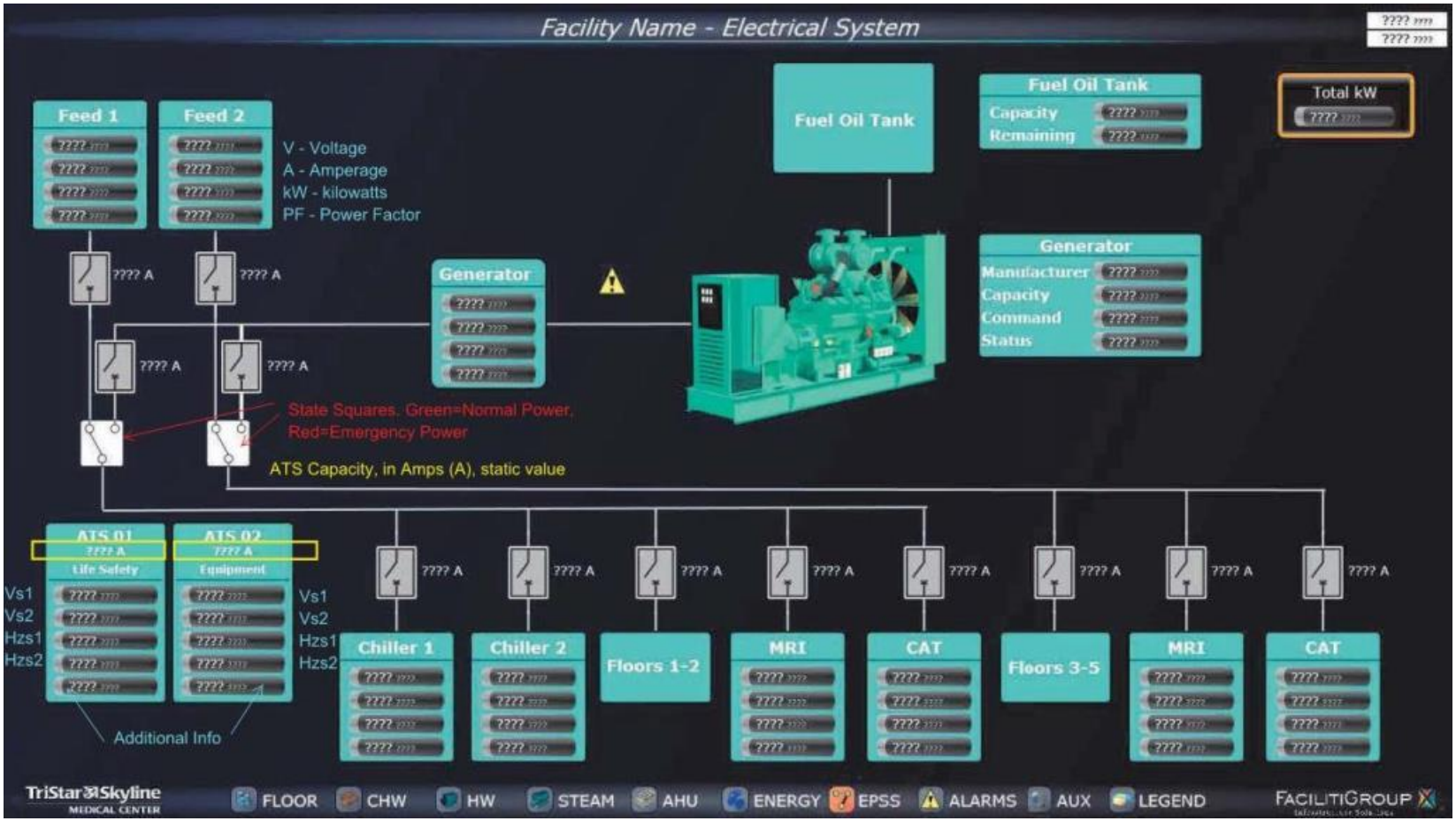

Facility Name - Hot Water Plant Overview
HW Plant Efficiency
BLR-1 Supply
BLR-1 Return
Boiler 1 Detail
Hidden Data Link
Typical of all equipment
Boiler 01
12000 MBH
% Firing Range
HWP-1
HWP-1
Sts
Cmd
Mixing Valve
HW Supply
SHWP-1
Sts
Cmd
HWS
VFD-1
SHWP-1
BLR-2 Supply
BLR-2 Return
HWP-2
HWP-2
Sts
Cmd
VFD-2
SHWP-2
SHWP-2
Sts
Cmd
HW-Diff Press
Boiler 02
12000 MBH
% Firing Range
HW Return
HWR
TriStar Skyline
MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

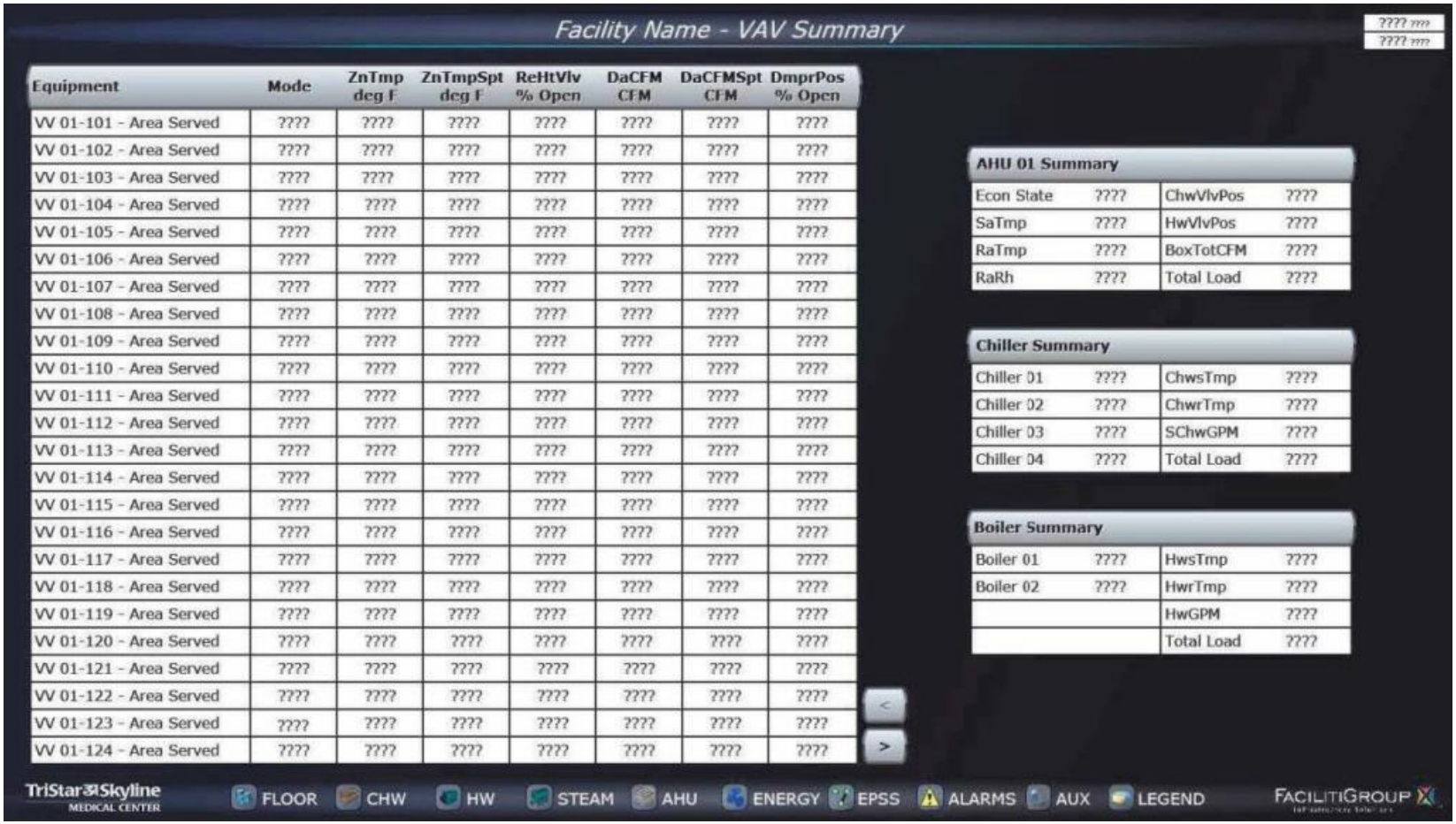

Facility Name - Hot Water Plant Overview
HW Boiler capacity should always be written in MBH (1000 BTU/hr)
HW Plant Efficiency
BLR-1 Supply
BLR-1 Return
Boiler 1 Detail
Hidden Data Link
Typical of all equipment
Boiler 01
12000 MBH
% Firing Range
HWP-1
Sts
Cmd
Mixing Valve
HW Supply
SHWP-1
VFD-1
HWS
BLR-2 Supply
BLR-2 Return
Boiler 02
12000 MBH
% Firing Range
HWP-2
VFD-2
SHWP-2
HW-Diff Press
HW Return
HWR
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

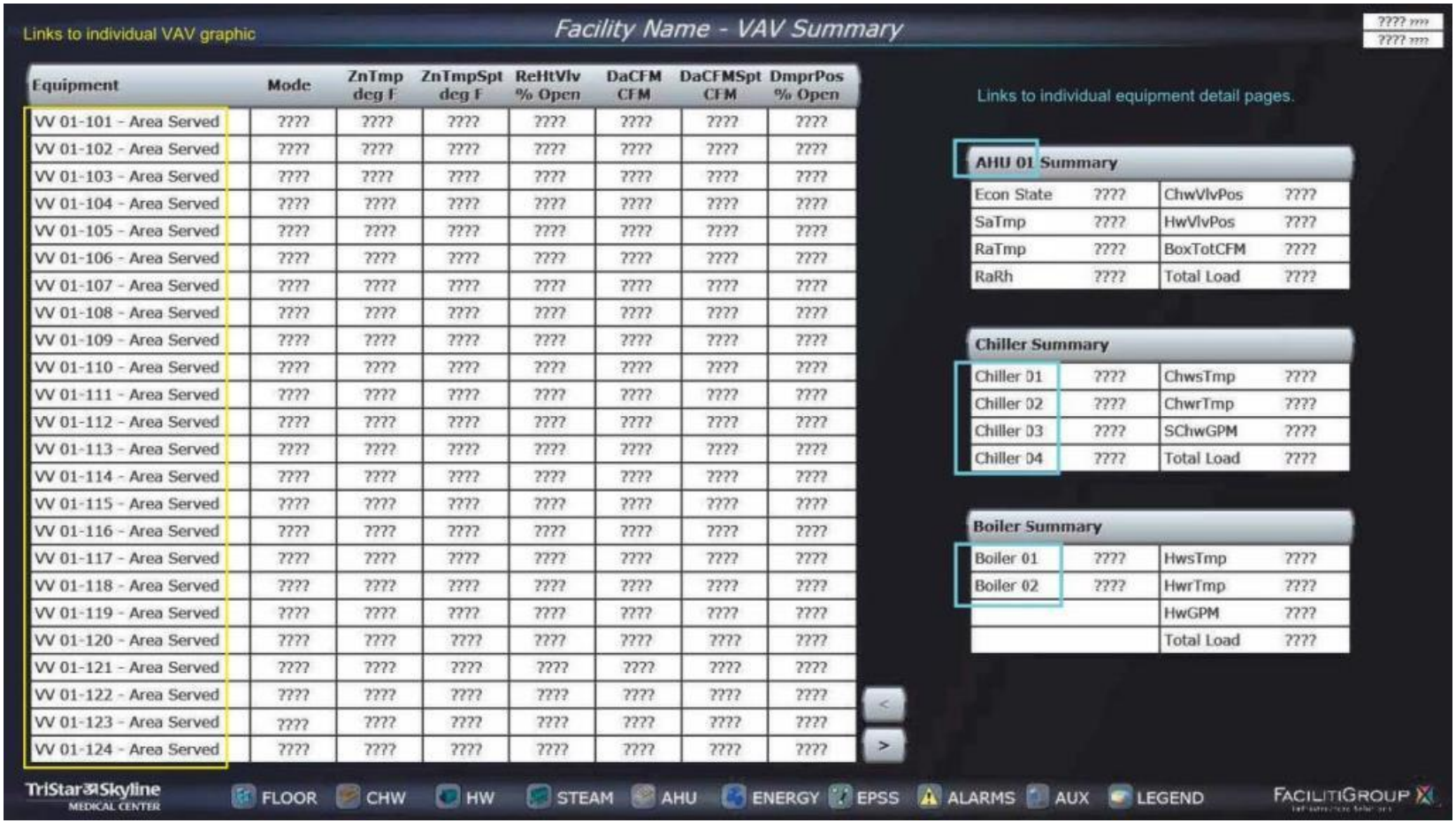

Facility Name - Steam Boiler Plant Overview
Boiler 1 Detail
Hidden Data Link
Typical of all equipment
Steam Flow
Pressure
Natural Gas
BLR-1
400 BHP
% Firing Range
Feed Water
BLR-1
400 BHP
% Firing Range
Feed Water
Make Up Water
FWP1
FWP2
FWP3
FW Pump-1
Sts
Cmd
FW Pump-2
Sts
Cmd
FW Pump-3
Sts
Cmd
DA Tank
From Condensate Return Unit
1/3 Vlv Output
2/3 Vlv Output
To Consensate Return Unit
HX Detail
HX-1
HWP - 1
HWP - 2
HWR
HWS
PFHX-1 Parameters
HwsTmp
HwrTmp
Hw GPM
Load
1/3 Vlv Output
2/3 Vlv Output
To Consensate Return Unit
HX-2
HWP - 3
HWP - 4
HWR
HWS
PFHX-2 Parameters
HwsTmp
HwrTmp
Hw GPM
Load
STM
Steam Plant Efficiency
HX Details
TriStar Skyline
MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP


Facility Name - Steam Boiler Plant Overview
Steam boiler capacity should always be written in units of BHP (Boiler Horsepower)
Boiler 1 Detail
Hidden Data Link
Typical of all equipment
BLR-1
400 BHP
% Firing Range
Natural Gas
Feed Water
Steam Flow
Pressure
State Square added on inline pumps. Green=ON, Blue = OFF. Pumps with analog output values shall have a value box in addition to the state square.
Steam Plant Efficiency
1/3 Vlv Output
2/3 Vlv Output
HX Detail
HX-1
HX-2
HWP - 1
HWP - 2
HWP - 3
HWP - 4
HWR
HWS
PFHX-1 Parameters
PFHX-2 Parameters
HwsTmp
HwrTmp
Hw GPM
Load
To Consensate Return Unit
Make Up Water
FWP1
FWP2
FWP3
FW Pump-1
FW Pump-2
FW Pump-3
Sts
Cmd
DA Tank
From Condensate Return Unit
STM
This is the preferred way to show the continuation of a pipe
HX Details
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP


Facility Name - Electrical System
Feed 1
Feed 2
Fuel Oil Tank
Fuel Oil Tank
Capacity
Remaining
Total kW
Generator
Manufacturer
Capacity
Command
Status
Generator
ATS 01
Life Safety
ATS 02
Equipment
Chiller 1
Chiller 2
Floors 1-2
MRI
CAT
Floors 3-5
MRI
CAT
TriStar Skyline
MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP


Facility Name - Electrical System
Feed 1
Feed 2
V - Voltage
A - Amperage
kW - kilowatts
PF - Power Factor
Fuel Oil Tank
Fuel Oil Tank
Capacity
Remaining
Total kW
Generator
Manufacturer
Capacity
Command
Status
Generator
State Squares. Green=Normal Power,
Red=Emergency Power
ATS Capacity, in Amps (A), static value
ATS 01
Life Safety
ATS 02
Equipment
Vs1
Vs2
Hzs1
Hzs2
Additional Info
Chiller 1
Chiller 2
Floors 1-2
MRI
CAT
Floors 3-5
MRI
CAT
TriStar Skyline
MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP


Facility Name - VAV Summary
???? ????
???? ????
Equipment
Mode
ZnTmp deg F
ZnTmpSpt deg F
ReHtVlv % Open
DaCFM CFM
DaCFMSpt CFM
DmprPos % Open
VV 01-101 - Area Served
VV 01-102 - Area Served
VV 01-103 - Area Served
VV 01-104 - Area Served
VV 01-105 - Area Served
VV 01-106 - Area Served
VV 01-107 - Area Served
VV 01-108 - Area Served
VV 01-109 - Area Served
VV 01-110 - Area Served
VV 01-111 - Area Served
VV 01-112 - Area Served
VV 01-113 - Area Served
VV 01-114 - Area Served
VV 01-115 - Area Served
VV 01-116 - Area Served
VV 01-117 - Area Served
VV 01-118 - Area Served
VV 01-119 - Area Served
VV 01-120 - Area Served
VV 01-121 - Area Served
VV 01-122 - Area Served
VV 01-123 - Area Served
VV 01-124 - Area Served
????
AHU 01 Summary
Econ State
SaTmp
RaTmp
RaRh
ChwVlvPos
HwVlvPos
BoxTotCFM
Total Load
Chiller Summary
Chiller 01
Chiller 02
Chiller 03
Chiller 04
ChwsTmp
ChwrTmp
SChwGPM
Boiler Summary
Boiler 01
Boiler 02
HwsTmp
HwrTmp
HwGPM
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP


Links to individual VAV graphic
Facility Name - VAV Summary
???? ????
???? ????
Equipment
Mode
ZnTmp deg F
ZnTmpSpt deg F
ReHtVlv % Open
DaCFM CFM
DaCFMSpt CFM
DmprPos % Open
VV 01-101 - Area Served
VV 01-102 - Area Served
VV 01-103 - Area Served
VV 01-104 - Area Served
VV 01-105 - Area Served
VV 01-106 - Area Served
VV 01-107 - Area Served
VV 01-108 - Area Served
VV 01-109 - Area Served
VV 01-110 - Area Served
VV 01-111 - Area Served
VV 01-112 - Area Served
VV 01-113 - Area Served
VV 01-114 - Area Served
VV 01-115 - Area Served
VV 01-116 - Area Served
VV 01-117 - Area Served
VV 01-118 - Area Served
VV 01-119 - Area Served
VV 01-120 - Area Served
VV 01-121 - Area Served
VV 01-122 - Area Served
VV 01-123 - Area Served
VV 01-124 - Area Served
????
Links to individual equipment detail pages.
AHU 01 Summary
Econ State ???? ChwVlvPos ????
SaTmp ???? HwVlvPos ????
RaTmp ???? BoxTotCFM ????
RaRh ???? Total Load ????
Chiller Summary
Chiller 01 ???? ChwsTmp ????
Chiller 02 ???? ChwrTmp ????
Chiller 03 ???? SChwGPM ????
Chiller 04 ???? Total Load ????
Boiler Summary
Boiler 01 ???? HwsTmp ????
Boiler 02 ???? HwrTmp ????
HwGPM ????
Total Load ????
<
>
TriStar Skyline MEDICAL CENTER
FLOOR
CHW
HW
STEAM
AHU
ENERGY
EPSS
ALARMS
AUX
LEGEND
FACILITIGROUP

SECTION 232113

HYDRONIC PIPING

PART 1 GENERAL

1.01 WORK INCLUDED

A. Submit pipe, valves, and fittings and have approved before starting installation. Pipe, valves, and fittings to be new, and marked clearly with manufacturers' name, weight, and classification or working pressure.

B. Piping to run approximately as shown on drawings or as structural and architectural conditions permit.

C. Provide seismic analysis and bracing of all piping systems in accordance with Section 230547 - Seismic Restraint of Mechanical Equipment and Suspended Utilities.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

A. Subject to compliance with requirements, provide products by the following:
   1. Ferguson Enterprises
      Contact: Bettina Dawson
      Office: (615) 316-1920
      Cell: (931) 239-0466
      Email: HCA@Ferguson.com

2.02 STEEL PIPES

A. Butt welded, electric resistance welded, or seamless black steel pipe, ANSI B 36.10, ASTM A-53, Grade "B" or "A", Schedule 40 for piping 10" and smaller,0.375 wall thickness for piping 12" thru 24" diameter, for the following services:
   1. Chilled water supply and return piping 2-1/2" and larger.
   2. Heating hot water supply and return piping 2-1/2" and larger.
   3. Mill wrap all uninsulated underground steel pipe with Republic X-Tru-Coat or equal.

2.03 STEEL PIPE FITTINGS

A. Flanges, fittings, unions and other products recognized as regularly available products to be marked in accordance with MSS SP-25. Markings on products of small size or shape may be omitted in the sequence allowed by MSS SP-25, except manufacturers' name or trademark.

B. Fittings 2-1/2" and larger to be standard weight, carbon steel, buttwelding fittings conforming to ASTM A-234 and ANSI B16.9.

C. Branch connections from mains or headers 2-1/2" or larger to be welded tees or welding outlets. Outlets to be equal to Weldolets or Threadolets manufactured by Bonney Forge. Forged outlets to be used only if branch line is at least one pipe size smaller than main or header. Stub-in welded piping is not acceptable. T-drill branch tee connections shall not be allowed for HVAC piping.

D. Fittings 2" and smaller to be threaded, Class 150, standard, malleable iron fittings, conforming to ANSI B16.3 and ASTM A-197.

E. Contractor's option to use welded steel for pipe sizes 1-1/2" and 2" in size.

F. Flanges to be 150 lb. carbon steel conforming to ASTM A-105, ASTM A-181, and ANSI B16.5.

G. Unions to be Class 150 malleable iron with bronze-to-iron ground joint conforming to ANSI B16.39, ANSI B1.20.1, and ASTM A-197.

H. Bolting materials to be semi-finished carbon steel bolts and hex nuts conforming to ASTM A-307. Threads and dimensions to be in accordance with ANSI B1.1 and B18.2.

I. Thread lubricant to be Crane "Formular 425" or equal. Approved Teflon tape may be used at Contractor's option.

J. Gaskets to be 1/8" thick "Sepco" or equal.

2.04 COPPER PIPES

A. Type "L" hard-drawn seamless copper tubing, ASTM B-88:
   1. HVAC hot water piping 2-1/8" O.D. and smaller. Piping dimensions on drawings for piping 2-1/8" and smaller are outside diameter. (O.D.).
   2. HVAC chilled water piping 2-1/8" O.D. and smaller. Piping dimensions on drawings for piping 2-1/8" and smaller is outside diameter (O.D.).

B. Type "K" hard-drawn seamless copper tubing: NOT APPLICABLE

C. Type "DWV" hard-drawn seamless copper tubing: Contractor's option for above-ground moisture condensate drain piping.

D. Copper Pipe Fittings:
   1. Provide sweat fittings, ASTM B-62, dimensions conforming to ANSI B16.22, wrought copper, with sweep patterns for copper tubing.
   2. Dielectric connection: Provide Epco Sales, dielectric couplers at junction of steel pipe and equipment with copper piping systems. Use of steel or cast iron fittings in copper piping systems prohibited.
   3. Fittings for drainage piping to be drainage pattern type.

E. Unions to be brass ground joint, 250-pound working pressure.

F. Nipples used in conjunction with copper pipe to be brass.

2.05 VALVES

A. Valves are specified by Nibco model numbers to establish quality levels unless otherwise noted. Milwaukee or Apollo are considered equal manufacturers. Provide clamp lock hand lever operators on valves less than 8 inches. Provide hand wheel and closed housing worm gear on valves 8 inches and larger unless indicated otherwise below. Provide chain operators for all equipment room and powerhouse valves 4 inch and larger which are located over 6 feet 6 inches above the finish floor.

B. Gate Valves:
   1. Gate valves for 2-1/2" and larger steel piping systems to be Class 125, cast iron body, bronze mounted, flanged ends Nibco Model F617-O. Valves to have solid wedge disc, outside stem and yoke with rising stem, and bolted bonnet.
   2. Gate valves for 2" and smaller steel piping systems to be Class 125, bronze body, screwed ends, Nibco Model T111. Valve to have solid disc, rising stem, and union bonnet.
   3. Gate valves for copper piping systems to be Class 125, bronze body, solder ends, Nibco Model S111. Valve to have either solid or split wedge disc, inside screw, rising stem, and screwed bonnet.

C. Globe Valves:
   1. Globe valves 2-1/2" and larger to be Class 125, cast iron body, bronze mounted, flanged ends, Nibco Model F718-B. Valves to have renewable seat and disc, outside stem and yoke with rising stem, and bolted bonnet.
   2. Globe valves 2" and smaller to be Class 150, bronze body, screwed ends, Nibco Model T235Y. Valve to be plug type with renewable seat and disc, rising stem, and union bonnet.

D. Ball Valves:
   1. Ball valves for copper water piping systems 2-1/8" O.D. and smaller to be equal to Apollo "3" Figure 82-200, solder ends, and for 2-5/8" thru 3-1/8" O.D. to be equal to Apollo Figure 70-100, threaded ends. Valves to have bronze body, chromium plated bronze ball, teflon seats, stuffing box ring and seals, and quarter turn on-off. Provide memory stops for valves used for balancing service. Valves to be rated for 400-psi WOG at 200 degrees F. Install threaded end valves with brass adapters.

2. Ball valves for PVC piping systems 2" and smaller to be equal to Celanese Piping System Chemtrol TU series, Schedule 80 PVC with teflon seats and vitron seals. Valves for pipe 3" and larger to be Celanese Piping System Chemtrol DE series, Schedule 80 PVC with teflon seats and vitron seals. Valves to be rated for 150 psi at 75 degrees F.

E. Butterfly Valves: Butterfly valves for steel water piping systems to be Crane Monarch Figure 24N, Centerline Series LT, or approved equal industrial quality lug type with threaded holes. Valves to provide bubble-tight shut-off at 150 psi working pressure and 200 degrees F. Valves to have ductile iron body, "EPT" seats and stem seals, 316 stainless steel or bronze disc, 316 or 416 stainless steel stems. Valves 4" and larger to have weatherproofed sealed gear operator consisting of fully enclosed worm, worm gear, and worm shaft with handwheel to provide necessary torque for close-off and infinite throttling positions. Valves 3" and smaller to have 10 position lever lock handle suitable for on-off and manual throttling service. All operators to have valve position indicator and memory stop.

F. Check Valves:
1. Check valves for copper water piping systems to be swing type, Class 125, bronze body, screwed ends, Nibco Model T/S413.
2. Check valves for steel water piping systems to be swing type, Class 125, cast iron body, bronze mounted, flanged ends, Nibco Model F918B. Valve to have Buna-N disc and bolted cap.
3. Check valves for steel water piping systems to be Nibco Model F910B. Body to be iron with cadmium plated ductile iron disc plates. Stem to be 316 stainless steel, seat to be EPT. Valve to be suitable for 200 psi working pressure at 200 degrees F.

2.06 STRAINERS

A. Provide cleanable "Y" type strainers in pump suction lines. Strainers to have iron body with screwed bronze or bolted iron cap. Strainer baskets to be brass. Water strainers to be Monel 20 mesh screen. Strainers to be line size complete with blow-down hose bibbs. When Suction Diffusers are specified for end suction pumps, strainers are not required. Strainers to be as follows:
1. Screwed 125# - Crane 988-1/2.
2. Screwed 250# - Crane 990-1/2.
3. Flanged 125# - Crane 989-1/2.
4. Flanged 250# - Crane 991-1/2.
5. Solder joint 250# - Muessco 353-1/2.

2.07 HANGERS

A. Seismic application: The use of single-sided or friction type C-clamps with retention straps for hanging pipe is expressly prohibited on the project.

B. Non-insulated steel piping 1/2" thru 24" with no longitudinal movement to be Grinnell Figure 260, MSS SP-69 Type 1, adjustable clevis hanger.

C. Insulated steel piping 1/2" thru 24", galvanized piping 1/2" thru 24", copper piping 1/2" O.D. thru 4" O.D., with no longitudinal movement to be Grinnell Figure 260, MSS SP-69 Type 1, adjustable clevis hanger with Figure 167, MSS SP-69 TYPE 40, galvanized steel insulation protection shield sized for maximum 10' span on 4 psi compressive strength insulation.

D. Non-insulated cast iron soil pipe thru 8" to be Grinnell Figure 104, MSS SP-69 TYPE 6, adjustable swivel ring, split ring type, and pipe 10" thru 15" Grinnell Figure 260, MSS SP-69 TYPE 1, adjustable clevis hanger.

E. Non-insulated copper tubing 1/2" O.D. thru 4" O.D. with no longitudinal movement to be Grinnell Figure CT-99C, MSS SP-69 TYPE 9, plastic coated adjustable tubing ring hanger.

F. Insulated steel piping 1" thru 30" with longitudinal movement to be Grinnell Figure 171, MSS SP-69 TYPE 41, pipe roll complete with Figure 160, MSS SP-69 TYPE 39A or 39B, pipe insulation protection saddle sized for proper pipe size and insulation thickness.

G. Insulated copper piping 1/2" O.D. thru 2-1/8" O.D. with longitudinal movement to be Grinnell Figure 171, MSS SP-69 TYPE 41, pipe roll complete with Figure 167, MSS SP-69 TYPE 40, galvanized steel insulation protection shield sized for maximum 10' span on 4 psi compressive strength insulation.

H. Support copper pipe risers by Grinnell Figure CT-121C, MSS SP-69 TYPE 8, plastic coated riser clamps at floor penetrations.

I. Support steel pipe risers by Grinnell Figure 261, MSS SP-69 TYPE 8, riser clamps at floor slab penetrations.

J. Support three or more parallel lines by trapeze hangers utilizing Unistrut channel or equal in bottom mounting arrangement with rod hanging support.

K. Adequately size hangers on insulated piping for insulation to pass continuously through hangers. Insulated piping to be supported outside insulation covering.

L. Provide concrete inserts, Grinnell Figure 282, MSS SP-69 TYPE 18, universal concrete insert, for attaching hangers to building structure. Inserts to be adequately sized and correctly positioned to support piping, valves, etc., when full of water and system is in operation.

M. Attention is called to pipe spring isolation specified to be furnished by this Contractor.

N. Support all piping by heavy steel, adjustable hangers, or brackets suitably fastened to structural portion of building. Place hangers in accordance with following tables:

STEEL PIPE SUPPORTS	
SIZE (IN.)	DISTANCE BETWEEN SUPPORTS (FT.)
3/4 - 1-1/4	8
1-1/2 - 2-1/2	10
3	12
4 - 6	14
8 - 12	16
14 - 24	20

COPPER TUBING SUPPORTS	
SIZE (IN.)	DISTANCE BETWEEN SUPPORTS (FT.)
5/8	6
7/8 - 1-1/8	8
1-3/8 - 2-1/8	10
2-5/8 - 5-1/8	12
6-1/8 - 8-1/8	14

O. Perforated metal, strap iron, or band iron hangers are not permitted. Offsets in hangers are not allowed. Pipe risers to be supported at regular intervals in pipe shafts within the limits of good practice.

P. See Insulation Section for requirements at pipe hangers.

Q. Support horizontal piping across roof in accordance with Specification Section 230549.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping not to interfere with opening of doors or other moving parts. Do not install piping near or directly over any portion of electrical equipment.

B. Provide chromium-plated escutcheon plates for exposed uninsulated pipes projecting through floors or walls in finished spaces. Mechanical rooms and janitor closets are not considered "finished" spaces.

C. Hang piping so equipment, flanges, and connections do not bear weight of piping.

D. Adequately support vertical lines at their bases or by a suitable hanger placed in horizontal line near riser or by a base fitting set on pedestal.

E. Pipes not to be hung or supported by pumps. No torque to be applied to pumps by connecting pipes. After final pipe adjustments and initial operation of the pumps, this Contractor to recheck alignment of pumps and realign as required.

F. Run piping in straight lines; riser lines to be plumb with such offsets only as indicated or necessary. No sagging of lines permitted.

G. Unless otherwise shown on drawings, lines to be installed to drain to sumps or sewer.

H. Ream pipe after cutting to full bore. Remove foreign matter from inside of pipe before installing. Keep installed piping free from dirt and scale and protect open ends from foreign matter. Use temporary plugs or other approved methods of open end closure.

I. Threads to be right-hand, pipe standard, clean cut, full depth, and tapered. Joints to be made tight without caulking. Approved pipe joint lubricant to be used, applied in thin layer to the male thread only.

J. Install copper fittings with suitable flux and 95/5 solder. Type K copper pipe to be joined by means of suitable flux and silver or phos-copper.

K. Piping to have sufficient number of flanges or unions for convenient installation and removal of piping and equipment.

L. Remake or replace defective, leaking, or otherwise unsatisfactory joints or material. Peening, caulking, or doping of piping is not permitted.

M. Install piping to prevent stresses and strains to piping and hangers from expansion or contraction. Provision for proper loops, offsets, or expansion joints to be responsibility of Contractor. Make provision for servicing and removal of equipment without dismantling piping.

3.02 FIRE-RATED PARTITIONS

A. Provide permanent firestop system at all piping penetrations of fire-rated walls and floors. Review details on drawing as well as this specification for permissible firestop systems. The firestop system shall have been tested and approved in accordance with ASTM E119 and U.L. 1479 (ASTM E814) and classified for up to 2 hours fire rating. Firestop system shall be type detailed on drawings or intumescent type capable of expanding up to 8 times its original volume. Firestop system to be 3M, Hilti, Nelson, Johns Manville, or Specified Technologies. Firestop system shall be installed in strict accordance with published U.L. approved installation instructions. Piping to pass through the fire-rated partition insulated or non-insulated as specified and detailed. Submit U.L. approved installation drawing for each type of penetration prior to construction.

3.03 NON-RATED PARTITIONS

A. Piping to pass through the walls insulated or non-insulated as specified. Wall should be finished to fit neatly around the piping. Firestopping is not required at non-rated partitions.

3.04 PIPE SLEEVES

A. Pipe sleeves shall be provided at non-rated partitions and floor penetrations. Pipe sleeves to be Schedule 40 or 18 gage steel. Sleeves to extend 1-1/2" in excess of partition depth on each side. Sleeves penetrating floors in wet areas, including all mechanical rooms, shall extend a minimum of 1 inch above the floor.
   1. Piping requiring sleeves:
      a. Heating hot water
      b. Chilled water
      c. Copper pipes thru masonry walls

3.05 PIPING IN TRANSFORMER, ELECTRICAL, AND ELEVATOR EQUIPMENT ROOMS

A. Refer to drawings. No water piping permitted in transformer, electrical, or elevator equipment rooms.

3.06 VALVE ACCESS

A. Locate all shutoff and control valves for easy access and operation. Where valves must necessarily be located in enclosed spaces, they shall be provided with access panels of sufficient size for operation. Furnish these access panels to proper trades for installation.

3.07 AIR VENTING

A. Provide manual air vents at high points of vertical risers and at each water coil to eliminate air from HVAC water systems.

3.08 WATER DRAINING

A. Provide 3/4" hose end gate valves at low points and bottom of each riser to drain HVAC water systems.

END OF SECTION

SECTION 232116

HYDRONIC PIPING SPECIALTIES

PART 1 GENERAL

1.01 WORK INCLUDED

A. Steam-to-water heat exchanger (convertor).

B. Expansion tank.

C. Tank air control fitting.

D. Tangential air separator.

E. Suction diffuser.

F. P.T. test plugs.

G. Pressure/Temperature test kit.

H. Pressure gauges.

I. Digital thermometers.

J. Thermometer test wells.

K. Hydronic Pressure Reducing Valves.

L. Relief valves.

M. Flow measuring station.

N. Flow balancing valve.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Bell and Gossett ITT, Dieterich Standard, Flow Design, Gerand, Mueller, Peterson Engineering, Taco, Thrush, John Wood Industrial Products, Weiss Instruments, Inc.

2.02 EQUIPMENT

A. Steam-to-water heat exchanger:
   1. Multi-pass, shell and tube construction with "U-bend" removable tube bundle, steam in shell, water in tubes.
   2. Tubes: Removable U-tube type bundle with minimum 3/4 inch OD seamless copper tubes.
   3. Shell: Steel construction.
   4. Heads: Cast iron or steel with steel tube sheets and tube supports.
   5. Tube and shell side shall be rated for 125 psi working pressure at 375 degrees F.
   6. Construction to be in accordance with ASME code for pressure vessels.
   7. Provide steel saddle and attaching U-bolts for mounting.
   8. Unit shall be stamped with ASME "U" symbol.
   9. Heat exchanger to be Bell & Gossett ITT Type SU, or approved equal.
   10. The heat exchanger manufacturer shall provide a filled-out FORM U-1 MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS, as required by the provisions of the ASME Code Rules, Section VIII, Division 1. This form shall be signed by both the installing contractor and local inspector, after final installation and startup has been completed, and a copy submitted to the Owner and the Cx team for record purposes.

B. Tank Air Control Fittings:
   1. Furnish an air control tank fitting containing an air separating trap and water control baffle to provide unrestricted airflow to the compression tank and air-free water flow from the tank.
   2. Fittings to be equipped with manual vent tube.
   3. Construct fitting for 125 psi working pressure at 240 degrees F.
   4. Fitting to be Bell & Gossett ITT Airtrol tank fitting, or approved equal.

C. Diaphragm Tank:
   1. Tanks to be pre-charged, vertical, diaphragm type constructed of carbon steel in accordance with ASME Boiler and Pressure Vessel Code.
   2. Tank to be constructed and ASME stamped for 125 psi working pressure at 240 degrees F.
   3. Unit shall be stamped with ASME "U" symbol.
   4. Diaphragm to be replaceable heavy-duty butyl rubber.
   5. Tank to have system connection, drain connection, and charging valve connection.
   6. Provide tanks with mounting saddles for horizontal installations and floor mounting base for vertical installations.

D. Tangential Air Separator:
   1. Provide an external air separation unit consisting of a steel tank, strainer, and collector tube.
   2. Unit to have flanged tangential inlet and outlet connections.
   3. Design internal perforated stainless air collector tube to direct released air into compression tank.
   4. Removable stainless steel system strainer to have 3/16 inch diameter perforations and free area of not less than five times cross-sectional area of connecting pipe.
   5. Construct unit in accordance with ASME Boiler and Pressure Vessel Code and stamp for 125 psig working pressure at 350 degrees F.
   6. Unit shall be stamped with ASME "U" symbol.
   7. Provide blowdown connection on bottom of unit to facilitate routine cleaning of unit.
   8. Unit to prevent accumulation of air in hydraulic heating and/or cooling system and prevent noises caused by entrained air in piping.
   9. Separator to be Bell & Gossett ITT Rolairtrol, or approved equal.

E. Suction Diffuser:
   1. Provide at each end-suction pump a Suction Diffuser with integral strainer.
   2. Unit to consist of cast iron, angle type body with steel inlet vanes and combination diffuser-strainer-orifice cylinder with 3/16 inch diameter openings for pump protection.
   3. Equip orifice cylinder with a disposable, fine mesh strainer which shall be removed after system start-up.
   4. Design orifice cylinder to withstand pressure differential equal to pump shutoff head and have a free area equal to five times cross-sectional area of pump suction opening.
   5. Vane length to be not less than 2-1/2 times the pump connection diameter.
   6. Suction diffuser shall be provided with bottom blowdown connection, inlet gauge port, and adjustable support foot to carry weight of suction piping.
   7. Suction diffuser to be constructed for 125 psi working pressure.
   8. Suction diffusers to be manufactured by Bell & Gossett ITT, Taco, Mueller, or approved equal.

F. P.T. Test Plugs:
   1. Provide 1/4 inch solid brass pressure/temperature test plugs at each BAS temperature sensor and at the entering and leaving connections of coils, chillers, hot water boilers, and heat exchangers.
   2. Nordel self-closing valve to be rated for 275 degrees F. service.
   3. Plugs to be manufactured by Flow Design, Peterson Engineering, SISCO, or approved equal.

G. Pressure/Temperature Test Kit:
   1. Provide Owner complete portable pressure and temperature test kit.
   2. Kit to be complete with pressure test gauge, necessary connector hoses, temperature test thermometer with adapter, shutoff and vent valves and carrying case.
   3. Readout kit to be manufactured by Bell & Gossett ITT or approved equal.

H. Pressure Gauges:
   1. Gauges in mechanical rooms to be 3-1/2" dial equal to Trerice Model No. 800LFB with glycerin liquid fill, nylon, steel, or aluminum case, acrylic plastic window, brass movement, phosphor bronze bourdon tube, and brass socket. Accuracy to be guaranteed within one percent.
   2. Gauges in the powerhouse/central energy plant to be 4-1/2" dial equal to Trerice Model No. 450LFSS with glycerin liquid fill, reinforced polypropylene case, acrylic window, stainless steel movement, stainless steel tube and socket. Accuracy to be guaranteed within one-half of one percent.
   3. Select scale range of gauges to indicate design pressure near midpoint of scale.
   4. Provide each gauge with 1/4 inch size, brass construction needle valve equal to Trerice Model No. 735-2.
   5. Provide each gauge with impulse dampener equal to Trerice Model No. 870.

I. Digital Thermometers:
   1. Provide solar digital vari-angle Weiss Instruments, Inc., Model DVU-35 (no substitutions) with adjustable angle (rear, front, and side) thermometers across entering and leaving heat exchanger, and AHU coils where equipment is protected from weather.
   2. Provide solar digital vari-angle Weiss Instruments, Inc. Model 5DVU35-300 (no substitutions) with adjustable angle thermometer for applications where device is exposed to weather.
   3. Each thermometer to be self-powered and within 1% accuracy. Stem assembly to be industrial glass.

J. Thermometer Wells:
   1. Provide Trerice or equal stainless steel thermometer wells for water temperature sensors and at other locations shown on drawings.
   2. Test wells to be stainless steel with 2-1/2 inch extension neck and screw plug cap with chain and shall be filled with light clear oil.

K. Hydronic System Pressure Reducing Valves:
   1. Provide pressure reducing valves for each hydronic system as shown on drawings.
   2. Each valve to be equipped with antisyphon check valve and removable strainer.
   3. Valve body to be brass or bronze construction.
   4. Select valve for operation at midpoint of adjustment range.
   5. Factory set valve for design pressure and provide adjustable range for final system operating pressure adjustment at job site.

L. Relief Valves:
   1. Provide relief valves for each hydronic system as shown on drawings.
   2. Valve to be constructed to ASME code requirements, tested by National Board, and labeled with ASME symbol.
   3. Valve body to be bronze construction.
   4. Valves to be diaphragm type operating with slow opening and closing feature.
   5. Valve to seat against face of EPDM rubber.
   6. Set differential between opening and closing pressure to prevent water flash and water hammer.
   7. Valve to include manual lever for testing valve.

M. Flow Measuring Station:
   1. Venturi type with provisions for connecting a portable differential pressure meter for flow measurement.
   2. Venturi to be provided with metal tag showing size, gpm, and required meter reading for specified gpm.
   3. Sizes 1/2 inch thru 2 inch to be brass threads; 2-1/2 and above for butt welding.
   4. Meter connections to have built-in check valves.
   5. Venturi to be suitable for maximum working pressure of 125 psig at 250 degrees F.
   6. Venturi to be Gerand Venturi, Flow Design Flowset Venturi, or approved equal.

N. Flow Balancing Valve:
   1. Balancing/shut-off valve to be ball type with bronze/brass body, chromium plated bronze ball, Teflon seats, blowout proof stem with Teflon packing and nut, and full size quarter turn handle with grip and memory stop.
   2. The flow measuring element shall be a low loss/high signal Venturi type of one to ten rangeability equipped with dual Schrader type pressure test ports and caps for connection to a portable differential pressure meter.
   3. Meter connections to have built-in check valves.
   4. Valves to provide for leak tight shutoff service at full rated working pressure.

5. Sizes 1/2" through 2" to be threaded ends with brass adapters; sizes 2-1/2" and larger to be flanged.
6. Valves and Venturis to be rated for 125 psig working pressure at 250 degrees F.
7. Combination flow measuring, balancing, and shutoff valves to be Bell & Gossett Circuit Setter Plus or approved equal Ball valve up to 3” or Globe valve 4” to 12” type.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install hydronic specialties in strict accordance with manufacturers’ published installation instructions.

B. Provide 1/2" manual air vents at top of pipe risers and other locations where air can be trapped or collected.

C. Provide 3/4" hose end gate valve drains at bottom of pipe risers and other locations to drain water systems.

D. Pipe relief valve outlets from hydronic systems to nearest floor drain.

E. Support pump inlet and strainer fittings with floor mounted pipe and flange supports.

F. Locate thermometers and pressure gauges no higher than 7 feet above finished floor elevation.

END OF SECTION

SECTION 232123

HYDRONIC PUMPS

PART 1 GENERAL

1.01 WORK INCLUDED

A. Pump to be non-overloading, single-stage, bronze fitted, centrifugal type pump driven by single-speed, squirrel-cage motors.

B. Pump manufacturer shall furnish and be responsible for the selection, compatibility, and performance of each unit consisting of pump, motor, coupling, and base plate.

C. Pumps to be Bell & Gossett, Armstrong, Taco, Peerless, Aurora, Paco, Weinman or Grundfos.

D. NOTE: Motor horsepower indicated on schedule to allow non-overloading operation of pump. Pumps requiring larger motors will not be acceptable.

E. Pumps shall not be selected requiring impeller sizes within 10 percent of maximum impeller size for that pump size and/or have an efficiency of 75 percent or less.

PART 2 PRODUCTS

2.01 END-SUCTION, FLEXIBLE COUPLED PUMPS

A. Construct pump casing of high-grade cast iron structurally designed for the working pressure and temperature shown on drawings. Hydrostatically test casing at one and one-half times the design working pressure.

B. Pump casing to have gauge ports at suction and discharge, and vent and drain ports at top and bottom of casing.

C. Pump to include back-pullout design to permit fast, easy access for servicing pump without disturbing suction or discharge piping.

D. Pump volute to be solidly mounted to base through a pedestal support.

E. Impeller to be bronze and of enclosed type. Impeller to be dynamically balanced and key-locked to the shaft.

F. Shaft to be carbon steel designed for minimum deflection (not to exceed 0.002") at sealing faces at maximum load.

G. Provide grease-lubricated ball bearings in housings sealed to exclude moisture and dirt. Bearings to include design features that positively prevent over-lubrication.

H. Provide replaceable bronze casing wearing rings to provide proper running clearance.

I. Pump to be furnished with mechanical seal with all metal parts 303 stainless steel with Buna-N Elastomers, Ni-Resist seat, and carbon washer. Unit to be equipped with bronze key-locked shaft sleeve extending full length of seal box.

2.02 IN-LINE PUMPS

A. Volute to be cast iron, designed for 175 psi working pressure, include suction and discharge nozzles of equal size, gauge tappings, and drain fittings.

B. Impeller to be bronze enclosed type, hydraulically and dynamically balanced, keyed to shaft and secured by suitable locking cap screw.

C. Shaft to be steel. Replaceable shaft sleeve to be aluminum bronze. Shaft sleeve to completely cover wetted area under mechanical seal.

D. Standard mechanical seal to be provided to seal off liquid cavity.

E. Pump to be designed so pump internals can be serviced without disturbing connecting pipe.

2.03 MOTOR

A. See separate Section 230513.

2.04 COUPLING AND BASE PLATE FOR BASE MOUNTED PUMPS

A. Manufacturer to furnish and mount pump and motor on common steel base plate with drip rim.

B. Manufacturer to furnish and mount flexible coupling. Fasten metal coupling guard to pump base plate.

C. NAMEPLATE: Provide pump and motor with stainless steel or aluminum nameplate securely fastened to casings. Nameplates to provide all data necessary for equipment identification and replacement.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide base-mounted pumps with soleplates, bedplates, or base plates carefully leveled, grouted, and bolted in place on concrete pads or foundations. Grout to be expanding type containing catalyzed metallic aggregate. After grout has set, cut flush with bedplate and seal to prevent fraying deterioration at edges.

B. Install pipe supports on each side of in-line pumps to prevent undue strain on piping system.

C. Make hot alignment check on couplings between motors and pumps. Operate equipment until components have reached operating temperature before hot check is made. Reposition equipment as required and repeat hot alignment check until parallel and angular alignments in both plan and elevation are within limits set by equipment manufacturer.

D. Provide Suction Diffusers on each pump where show on the documents.

END OF SECTION

SECTION 232213

STEAM AND CONDENSATE PIPING

PART 1 GENERAL

1.01 SUBMITTALS – SHOP DRAWINGS

A. Submit pipe, valves, and fittings and have approved before starting installation. Pipe, valves, and fittings to be new, and marked clearly with manufacturers' name, weight, and classification or working pressure.

B. Complete shop drawings showing all piping, fittings, valves and elevations for approval before starting installation. Piping to run approximately as shown on drawings or as structural and architectural conditions permit.

C. Low pressure steam to be up to 15 psi. Medium pressure steam to be up to 60 psi.

D. Provide seismic support and bracing of all piping systems in accordance with Section 230547 Seismic Restraint of Mechanical Equipment and Suspended Utilities.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

A. Subject to compliance with requirements, provide products by the following:
   1. Ferguson Enterprises
      Contact: Bettina Dawson
      office (615) 316-1920
      cell (931)239-0466
      email: HCA@Ferguson.com

2.02 STEEL PIPES

A. Welded or seamless black steel pipe, ASTM A-53, Grade "B" for the following services:
   1. Low/medium pressure steam: Schedule 80; sizes 1/2" through 2" IPS.
   2. Low/medium pressure steam: Schedule 40; sizes 2-1/2" through 10" IPS.

B. Seamless black steel pipe ASTM A-53, Grade "A" for the following:
   1. Condensate return piping: Schedule 80; sizes 1/2" through 2" IPS.
   2. Condensate return piping: Schedule 40; sizes 2-1/2" through 10" IPS.

2.03 STEEL PIPE FITTINGS

A. Flanges, fittings, unions and other products recognized as regularly available products to be marked in accordance with MSS SP-25. Markings on products of small size or shape may be omitted in the sequence allowed by MSS SP-25, except manufacturers' name or trademark.

B. Fittings 2-1/2" and larger to be standard weight, carbon steel, buttwelding fittings conforming to ASTM A-234 and ANSI B16.9.

C. Fittings to be factory-forged in USA and shall not have been machined, remarked, painted, or otherwise produced domestically from non-domestic forgings.

D. Branch connections from mains or headers 2-1/2" or larger to be welded tees or welding outlets. Outlets to be equal to Weldolets or Threadolets manufactured by Bonney Forge. Forged outlets to be used only if branch line is at least one pipe size smaller than main or header. Stub-in welded piping is not acceptable. T-drill branch tee connections shall not be allowed for HVAC piping.

E. Fittings 2" and smaller to be threaded, Class 150, standard, malleable iron fittings, conforming to ANSI B16.3 and ASTM A-197. Low/medium pressure steam condensate fittings shall be Class 125, standard, cast iron fittings conforming to ANSI B16.4 and ASTM A-126.

F. Fabricate spool or transition fittings where required to connect multiple weight piping systems or equipment to piping systems as required to provide a complete system.

G. Fittings for galvanized steel pipe to be same as above except have galvanized coating. Fittings for waste, vent, and drainage piping to be drainage pattern type.

H. Flanges to be 150 lb. carbon steel conforming to ASTM A-105, ASTM A-181, and ANSI B16.5.

I. Flanges to be factory forged in U.S.A.

J. Unions to be Class 150 malleable iron with bronze-to-iron ground joint conforming to ANSI B16.39, ANSI B1.20.1, and ASTM A-197.

K. Bolting materials to be semi-finished carbon steel bolts and hex nuts conforming to ASTM A-307. Threads and dimensions to be in accordance with ANSI B1.1 and B18.2.

L. Thread lubricant to be Crane "Formular 425" or equal. Approved Teflon tape may be used at Contractor's option.

M. Gaskets to be 1/8" thick "Sepco" or equal.

2.04 VALVES

A. Valves are specified by Nibco model numbers to establish quality levels unless otherwise noted. Milwaukee or Apollo are considered equal manufacturers. Provide clamp lock hand lever operators on valves less than 8 inches. Provide hand wheel and closed housing worm gear on valves 8 inches and larger unless indicated otherwise below. Provide chain operators for all equipment room and powerhouse valves 4 inch and larger which are located over 6 feet 6 inches above the finish floor.

B. Gate Valves:
   1. Gate valves for 2-1/2" and larger steel piping systems to be Class 125, cast iron body, bronze mounted, flanged ends, Nibco Model F617O. High pressure steam and steam condensate to be Class 250, cast iron body, bronze mounted, flanged ends, Nibco Model F667O. Valves to have solid wedge disc, outside stem and yoke with rising stem, and bolted bonnet.

C. Globe Valves:
   1. Globe valves 2-1/2" and larger to be Class 125, cast iron body, bronze mounted, flanged ends, Nibco Model F718B. Valves to have renewable seat and disc, outside stem and yoke with rising stem, and bolted bonnet.
   2. Globe valves 2" and smaller to be Class 150, bronze body, screwed ends, Nibco Model T235Y. Valve to be plug type with renewable seat and disc, rising stem, and union bonnet.

D. Butterfly Valves:
   1. Butterfly valves for steel water piping systems to be Crane Monarch Figure 24N, Centerline Series LT, or approved equal industrial quality lug type with threaded holes. Valves to provide bubble-tight shut-off at 150 psi working pressure and 200 degrees F. Valves to have ductile iron body, "EPT" seats and stem seals, 316 stainless steel or bronze disc, 316 or 304 stainless steel stems. Valves 4" and larger to have weatherproofed sealed gear operator consisting of fully enclosed worm, worm gear, and worm shaft with handwheel to provide necessary torque for close-off and infinite throttling positions. Valves 3" and smaller to have 10 position lever lock handle suitable for on-off and manual throttling service. All operators to have valve position indicator and memory stop.

E. Check Valves:
   1. Check valves for steel water piping systems to be swing type, Class 125, cast iron body, bronze mounted, flanged ends, Nibco Model F918B. Valve to have Buna-N disc and bolted cap.
   2. Check valves for 2-1/2" to 12" low/medium pressure steam and steam condensate to be Class 125, cast iron body, bronze mounted, flanged ends, Nibco Model F918B.
   3. Check valves for 2" and smaller low/medium pressure steam and steam condensate to be Class 125, bronze body, screwed ends, Nibco Model T413Y.

2.05 STRAINERS

A. See Section 232216 for steam and steam condensate service strainers.

2.06 HANGERS

A. Seismic application: The use of C-clamps for hanging pipe is expressly prohibited on the project.

B. Non-insulated steel piping 1/2" thru 24" with no longitudinal movement to be Grinnell Figure 260, MSS SP-69 Type 1, adjustable clevis hanger.

C. Insulated steel piping 1/2" thru 24", with no longitudinal movement to be Grinnell Figure 260, MSS SP-69 Type 1, adjustable clevis hanger with Figure 167, MSS SP-69 TYPE 40, galvanized steel insulation protection shield sized for maximum 10' span on 4 psi compressive strength insulation.

D. Insulated steel piping 1" thru 30" with longitudinal movement to be Grinnell Figure 171, MSS SP-69 TYPE 41, pipe roll complete with Figure 160, MSS SP-69 TYPE 39A or 39B, pipe insulation protection saddle sized for proper pipe size and insulation thickness.

E. Support steel pipe risers by Grinnell Figure 261, MSS SP-69 TYPE 8, riser clamps at floor slab penetrations.

F. Support three or more parallel lines by trapeze hangers utilizing Unistrut channel or equal in bottom mounting arrangement with rod hanging support.

G. Adequately size hangers on insulated piping for insulation to pass continuously through hangers. Insulated piping to be supported outside insulation covering.

H. Provide concrete inserts, Grinnell Figure 282, MSS SP-69 TYPE 18, universal concrete insert, for attaching hangers to building structure. Inserts to be adequately sized and correctly positioned to support piping, valves, etc., when full of water and system is in operation.

I. Attention is called to pipe spring isolation specified to be furnished by this Contractor.

J. Support all piping by heavy steel, adjustable hangers, or brackets suitably fastened to structural portion of building. Place hangers in accordance with following table.

STEEL PIPE SUPPORTS	
SIZE (IN.)	DISTANCE BETWEEN SUPPORTS (FT.)
3/4 - 1-1/4	8
1-1/2 - 2-1/2	10
3	12
4 - 6	14
8 - 12	16
14 - 24	20

K. Perforated metal, strap iron, or band iron hangers are not permitted. Offsets in hangers are not allowed. Pipe risers to be supported at regular intervals in pipe shafts within the limits of good practice.

L. See Insulation Section for requirements at pipe hangers.

M. Support horizontal piping across roof in accordance with Specification Section 230549.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping not to interfere with opening of doors or other moving parts. Do not install piping near or directly over any portion of electrical equipment.

B. Unless otherwise shown on drawings, lines are to slope in the direction of steam flow a minimum of 0.25” per 10 ft. of pipe. Where horizontal piping must reduce in size, use eccentric reducers that permit the continuance of uniform pitch along the bottom of pipe.

C. Steam piping is to be installed to remove condensate. All branch lines are to be from top of the steam main, preferably at a 45 degree angle although 90 degree connections are acceptable. Where the length of branch lines is less than 10 ft., the branch line may be sloped back to main at a minimum of 0.5” per 10 feet of slope.

D. Provide chromium-plated escutcheon plates for exposed uninsulated pipes projecting through floors or walls in finished spaces. Mechanical rooms and janitor closets are not considered "finished" spaces.

E. Hang piping so equipment, flanges, and connections do not bear weight of piping.

F. Adequately support vertical lines at their bases or by a suitable hanger placed in horizontal line near riser or by a base fitting set on pedestal.

G. Pipes not to be hung or supported by equipment. After final pipe adjustments and initial operation of the equipment, Contractor to recheck alignment of distribution piping and realign hangers as required.

H. Run piping in straight lines; riser lines to be plumb with such offsets only as indicated or necessary. No sagging of lines permitted.

I. Ream pipe after cutting to full bore. Remove foreign matter from inside of pipe before installing. Keep installed piping free from dirt and scale and protect open ends from foreign matter. Use temporary plugs or other approved methods of open end closure.

J. Threads to be right-hand, pipe standard, clean cut, full depth, and tapered. Joints to be made tight without caulking. Approved pipe joint lubricant to be used, applied in thin layer to the male thread only.

K. Piping to have sufficient number of flanges or unions for convenient installation and removal of piping and equipment.

L. Remake or replace defective, leaking, or otherwise unsatisfactory joints or material. Peening, caulking, or doping of piping is not permitted.

M. Install piping to prevent stresses and strains to piping and hangers from expansion or contraction. Provision for proper loops, offsets, or expansion joints to be responsibility of Contractor. Make provision for servicing and removal of equipment without dismantling piping.

3.02 CONDENSATE REMOVAL

A. Install drip legs at all low points and natural drainage points within the system. Drip legs are to be line size up to a maximum 4”. Recommended length is 1.5 x the pipe diameter and not less than 8”. Drip legs are also to be provided at the end of mains and the bottoms of risers, ahead of pressure regulators and all automatic control valves. On straight horizontal runs with no natural drainage points, space drip legs not to exceed 300 ft. when pipe is pitched in direction of steam flow (max 150 ft. if pipe is pitched opposite the direction of steam flow).

B. Install steam traps at all drip legs and steam-fired equipment for automatic removal of condensate from system. Sizes traps appropriately for connected load and provide transition to trap connection size as required. Locate trap a minimum of 12” below equipment connections. Provide stop valves and unions at each trap to facilitate replacement. Route trap discharge to condensate return unit or discharge may be connected to the pumped condensate return line for steam systems operating over 40 PSI. However, back pressure at the trap discharge (return line pressure plus hydraulic pressure created by vertical lift) must not exceed steam main pressure. Provide swing check valve and stop valve downstream of trap before connecting to pumped return main.

C. Pipe routing on contract documents is diagrammatical and intended to show the general arrangement and pipe sizing required. Some major drip leg and trap locations may be shown on the contract documents, but contractor is responsible for providing additional locations as required to meet all requirements of this spec section and provide a complete system.

3.03 FIRE-RATED PARTITIONS

A. Provide permanent firestop system at all piping penetrations of fire-rated walls and floors. Review details on drawing as well as this specification for permissible firestop systems. The firestop system shall have been tested and approved in accordance with ASTM E119 and U.L. 1479 (ASTM E814) and classified for up to 2 hours fire rating. Firestop system shall be type detailed on drawings or intumescent type capable of expanding up to 8 times its original volume. Firestop system to be 3M, Hilti, Nelson, Johns Manville, or Specified Technologies. Firestop system shall be installed in strict accordance with published U.L. approved installation instructions. Piping to pass through the fire-rated partition insulated or non-insulated as specified and detailed. Submit U.L. approved installation drawing for each type of penetration prior to construction.

3.04 NON-RATED PARTITIONS

A. Piping to pass through the walls insulated or non-insulated as specified. Wall should be finished to fit neatly around the piping. Firestopping is not required at non-rated partitions.

3.05 PIPE SLEEVES

A. Pipe sleeves shall be provided at non-rated partitions and floor penetrations. Pipe sleeves to be Schedule 40 or 18 gage steel. Sleeves to extend 1-1/2" in excess of partition depth on each side. Sleeves penetrating floors in wet areas, including all mechanical rooms, shall extend a minimum of 1 inch above the floor.
   1. Piping requiring sleeves: Steam and steam condensate (gravity and pumped)

3.06 PIPING IN TRANSFORMER, ELECTRICAL, AND ELEVATOR EQUIPMENT ROOMS:

A. Refer to drawings. No water piping permitted in transformer, electrical, or elevator equipment rooms.

3.07 VALVE ACCESS

A. Locate all shutoff and control valves for easy access and operation. Where valves must necessarily be located in enclosed spaces, they shall be provided with access panels of sufficient size for operation. Furnish these access panels to proper trades for installation.

END OF SECTION

SECTION 232216

STEAM AND CONDENSATE SPECIALTIES

PART 1 GENERAL

1.01 INCLUDED WORK

A. This section includes requirements for:
   1. Strainers.
   2. Float and Thermostatic Steam Traps.
   3. Steam Pressure Reducing Stations.
   4. Pressure Relief Valves.
   5. Pressure Gauges.
   6. Thermometers.
   7. Steam Air Vents.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Armstrong, Muesco, SARCO, ITT-Hoffman, Fisher, Trerice, Kunkle, Spence.

2.02 STRAINERS

A. Provide cleanable, line size "Y" type strainers with blowdown valves ahead of steam traps and control valves and elsewhere shown on drawings.

B. Strainers 2 inches and smaller: Iron body, screwed ends, 250 psi steam working pressure (450 degrees F. maximum). Furnish strainers with 30 mesh 304 stainless steel or monel screens.

C. Strainers 2-1/2" to 8 inches: Iron body, bolted cast iron retainer, flanged ends, 250 psi steam working pressure (450 degrees F maximum). Furnish strainers with stainless steel screen with 3/64 (0.045) inch perforations.

2.03 STEAM TRAPS

A. Float and Thermostatic Traps:
   1. Provide fully modulating type traps with ASTM-A278 Class 30 cast iron body suitable for continuous operation.
   2. Provide stainless steel float and mechanism with heat treated chrome steel valve.
   3. Provide thermostatic air vent of balanced-pressure, phosphor bronze disc diaphragm type with stainless steel valve and seat.
   4. Provide F&T traps to drain condensate from convertors, and low and medium pressure steam main headers and branch lines.
   5. Size trap for minimum two times the capacity of the served equipment and three times the capacity of the steam headers or branch lines.
   6. Size trap using 1/2 psi pressure differential for equipment with modulating control.

2.04 STEAM PRESSURE REDUCING VALVE

A. Provide pilot-operated type pressure reducing valves designed for use on dead-end service equal to Fisher No. 92B, ITT-Hoffman Series 2000, or Spence Type ED.

B. Provide valves with iron body constructed for 250 psi steam working pressure (450 degrees F. maximum) and stainless steel diaphragm, valve plug, seat ring, and guide bushing.

2.05 PRESSURE RELIEF VALVES

A. Provide pressure relief valve equal to Kunkle Figure 252 at each pressure reducing station and elsewhere shown on drawings.

B. Provide open-lever type relief valve constructed in accordance with ASME Boiler and Unfired Pressure Vessel Codes (Sections 1 and 8, respectively), and tested and capacity rated by National Board of Boiler and Pressure Vessel Inspections.

C. Provide valve with cast iron body with 250 psi inlet flange and 125 psi outlet connection, and bronze trim.

D. Select relief valve for the reducing station upstream pressure. Size the relief valve for full installed capacity of the highest pressure reducing valve. Set relief valve to relieve at not more than 20 percent (maximum 10 psig) above the reduced pressure.

E. Provide each pressure relief valve outlet with drip-pan elbow equal to Kunkle Figure 299.

2.06 PRESSURE GAUGES

A. Provide 4-1/2" dial pressure gauges at locations shown on drawings.

B. Gauges to be equal to Trerice Model No. 600 with nylon, steel, or aluminum case, clear glass or acrylic plastic window, white dial face with black letters and pointer, monel or bronze rotary movement and nylon gear, phosphor bronze bourdon tube, silver soldered joints, and forged brass socket.

C. Accuracy to be guaranteed with 1 percent over middle half of scale range and 2 percent for remainder.

D. Select scale range of gauges to indicate design pressure near midpoint of scale.

E. Provide each gauge with 1/4" size, brass construction needle valve equal to Trerice Model No. 735-2.

F. Provide each gauge with iron coil syphon equal to Trerice Model No. 885-1 to form pocket of water between gauge and steam. Provide a 1/4" male pipe thread on each end of syphon.

2.07 THERMOMETERS

A. Provide Trerice or equal 9" scale, adjustable angle (rear, front, and side), industrial thermometers at locations shown on drawings.

B. Each thermometer to have aluminum case, clear acrylic plastic window, mercury tubing, scale with white background and black markings, brass stem, and separable brass well with 2-1/2" extension neck.

2.08 STEAM AIR VENTS

A. Provide automatic, thermostatic, balanced pressure type vents equal to ITT-Hoffman No. 75 with brass or semi-steel body construction. Provide vents with liquid-filled bellows of phosphor bronze construction and renewable stainless steel head and seat.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install items in strict accordance with manufacturers' published installation instructions.

B. Any steam condensate drain line routed to a sanitary waste drain shall be provided with a condensate cooler.

3.02 THERMOMETERS

A. Locate thermometers and pressure gauges no higher than 7'-0" above finished floor elevation.

3.03 CONTROL SYSTEM CONNECTORS

A. Weld 1" steel half coupling, Crane No. 386 or equal, or insert 1" female pipe thread connection at all points necessary for installation of pressure gauges, thermometers, and controls.

3.04 STEAM TRAPS

A. Install with union or flanged connection on both ends of trap.

B. Provide gate valve and strainer at inlet side of each steam trap.

C. Provide check valve and gate valve at discharge of each steam trap.

D. Provide a minimum 12" long drip leg and 6" long dirt leg of same pipe size as main steam line or equipment condensate return connection.

E. Do not install thermostatic elements in traps until system has been operated and dirt pockets cleaned of sediment and scale. Provide temporary covers for use prior to final installation of elements.

3.05 STEAM PRESSURE REDUCING STATIONS

A. Locate pilot operator control line connection in a straight run of pipe 10 pipe diameters or 3 feet, whichever is greater, downstream of the valve body outlet.

B. Provide pressure reducing station with pressure gage immediately upstream and downstream of each pressure reducing valve.

C. See piping diagram on drawings.

3.06 RELIEF VALVES

A. Route and terminate vent lines from relief valves to the outdoors.

B. Provide drip-pan elbow at each valve with drain connection routed to the nearest floor drain.

C. Where several relief valve vents connect to a single vent header, vent header cross section area to be equal to the sum of individual vent outlet areas.

END OF SECTION

SECTION 232223

STEAM CONDENSATE PUMPS

PART 1 GENERAL

1.01 WORK INCLUDED

A. Provide condensate return units for pumped transfer of hot condensate from steam systems as indicated on drawings.

B. Unit manufacturer to be responsible for selection, compatibility, and performance of each pump, motor, mounting and factory wiring. This includes receiver pipe connections required for installation.

C. Units to be by Aurora, Skidmore, ITT-Hoffman, Shipco, or approved equal.

PART 2 PRODUCTS

2.01 EQUIPMENT REQUIREMENTS

A. Unit to be of the duplex pump type.

B. Unit to be of the integral mounted receiver and pump set type (Aurora 220 series).

C. Construct unit receiver of cast iron. Receiver to have the following features:
   1. Brass water level gauge glass assembly.
   2. Thermometer.
   3. Inlet 3-way strainer valve assembly with On-Off-Bypass adjustments.

D. Pump to be of the bronze fitted centrifugal type with high temperature mechanical seals, dynamically balanced impellar, bronze wear ring, stainless steel shaft, and back pull-out case design. Unit to be rated for temperatures up to 220 degrees F. Fit pumps with coupling guards and discharge pressure gauges.

E. Furnish Additional Electrical Accessories As Follows:
   1. Pre-wired electric alternator.
   2. NEMA 1 enclosure.
   3. Factory-wired motor starter with overload and under voltage protection for each pump.
   4. Disconnect switch for each pump.
   5. Receiver mounted float switch.
   6. On single phase units alternator switch contacts to be rated above maximum motor current if starters are not used.
   7. Hand-Off-Auto switch and pilot light for each pump.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install unit level and bolted to concrete pads.

B. Check all units for proper pump alignment and operation of all components.

C. Pipe receiver vents full connection size to outside.

END OF SECTION

SECTION 232513

WATER TREATMENT FOR CLOSED HYDRONIC SYSTEMS

PART 1 GENERAL

1.01 WORK INCLUDED

A. Provide a complete water treatment system for the closed chilled and hot water systems as specified herein. Provide system start-up and adjustment.

B. Provide one years supply of water treatment chemicals and systems pre-cleaning chemicals.

C. Submit complete water treatment systems for approval.

D. All chilled, and hot water piping and related equipment shall be thoroughly flushed out with pre-cleaning chemicals designed to remove deposition such as pipe dope, oils, loose rust, mill scale and other extraneous materials. Recommended dosages of pre-cleaner chemical products shall be furnished by water treatment supplier and added and circulated throughout the water systems. The water systems shall then be drained, refilled and flushed thoroughly until no foreign matter is observed and total alkalinity of the rinse water is equal to that of the make-up water.

PART 2 PRODUCTS

2.01 CLOSED CHILLED AND HOT WATER TREATMENT SYSTEMS

A. Provide a one-shot chemical feeder of 5-gallon capacity and minimum 125 PSI working pressure for each closed water system. Feeder to be complete with funnel with fill valve, and inlet, outlet and drain connections.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install and place complete water treatment systems in proper operating condition in accordance with drawings, specifications, and manufacturer's published installation instructions. Provide communication link between water treatment microprocessor and Building Automation System PC.

B. Permanent facility pumps should not be used for circulating the cleaning water. However if it is impractical to use temporary pumps, the permanent facility pump may be used provided that the pump is unconditionally warranted for two years, parts and labor, after the date of substantial completion by the mechanical contractor.

C. Water treatment equipment manufacturers’ representative to supervise systems pre-cleaning, water treatment systems installation and start-up, and train owners’ representatives a minimum of 8 hours concerning proper feeding and control techniques. Provide two copies of water treatment systems operating and maintenance manuals to Designer.

D. Cleanness of the system shall be determined by water sampling performed by the water management chemical engineer and witnessed and approved in writing by the General Contractor’s quality control representative.

END OF SECTION

SECTION 233110

SHEET METAL DUCTWORK - LOW PRESSURE

PART 1 GENERAL

1.01 WORK INCLUDED

A. Low pressure ductwork refers to systems operating at 2.00" w.g. total static pressure with velocities up to 2000 FPM. It is the intent of this specification to provide an installed duct system which will supply the air quantities indicated by the plans and have the lowest possible friction loss with the least possible leakage loss. Friction loss for each system shall not exceed that which is indicated in the A.C. unit schedule as external static pressure or in the fan schedule as static pressure and shall include the losses of all accessories. Friction losses shall be minimized by reduction in the number of offsets and elbows by pre-planning the duct system installation and coordination with other trades to prevent interferences. Access to all accessories requiring maintenance, service and inspection shall be maintained. Radius elbows are preferred for all turns to minimize friction, noise and vibration; and, especially, for sections having large volume or higher velocities and sections which may have turbulences.

B. The contractor shall provide and/or construct all materials, ductwork, joints, transitions, splitters, dampers, access doors, etc., as set forth in these specifications necessary to install the Low Pressure Sheet Metal Ductwork required by the Mechanical Drawings.

C. Low pressure ductwork shall be constructed to meet the following pressure class:
   1. Supply ductwork downstream of terminal units: 1.0" pressure class.
   2. Exhaust and return ductwork (Fan ESP ≤2.0"): 2.0" pressure class.
   3. Return duct within 100 feet of a fan: 3.0" pressure class.

1.02 QUALITY CONTROL AND REGULATORY STANDARDS

A. SMACNA Manual: Sheet Metal Tradesman is to have access on the construction site to the Latest Edition of SMACNA "HVAC Duct Construction Standards”, (Metal and Flexible). The Manual is referred to in specifications for required construction methods and details. Contractor shall comply with provisions of the SMACNA Manual and more stringent requirements of this specification.

B. Quality control involves not only the general performance requirements for all air ducts, but also quality workmanship which includes layout preplanning so that offsets, rises, falls, elbows, fittings, etc., are minimized or eliminated. General performance requirements for all ducts include:
   1. Dimensional stability (shape deformation and strength).
   2. Containment of the air being conveyed (leakage control).
   3. Vibration (fatigue and appearance).
   4. Noise (generation, transmission or attenuation).
   5. Exposure (to damage, weather, temperature extremes, flexure cycles, wind, corrosive atmospheres, biological contamination, flow interruption or reversal, underground or other encasement conditions, combustion, or other in-service conditions).
   6. Support (alignment and position retention).
   7. Seismic restraint is applicable. Refer to specification section 230547.
   8. Thermal conductivity (heat gain or loss and condensation control).

C. Provide galvanized duct materials which meet applicable requirements of SMACNA manual and local and state codes, whichever is the most stringent.

D. Support ductwork in accordance with applicable requirements of SMACNA manual, local and state codes, and details on plans, whichever is the most stringent.

E. Emboss fittings with material gauge, manufacturer, and type material.

F. Ductwork shall be installed to comply with the roof ceiling assembly for this project shown on Architectural Drawings, in accordance with the UL Fire Resistance Index Catalog.

G. Materials used as sealers, pre-insulated jackets and flexible ducts shall comply with a flame spread rating of 25 or less and a smoke developed rating of not over 50.

H. Joint sealer shall meet the requirements of UL181A or UL181B as applicable.

I. Duct sealant classification: Seal all transverse joints, longitudinal joints and duct wall penetrations in accordance with SMACNA Class A. The sealant used to seal the longitudinal joints of low pressure ductwork must be visible or the joints shall require resealing in the field.

1.03 SUBMITTALS AND SHOP DRAWINGS

A. Submit material/product data to designer for approval ONLY when it deviates from products specified in Part 2 herein.

B. Shop Drawings: Contractor to submit to owner for approval complete sheet metal shop drawings of all ductwork, including equipment rooms, shafts, and especially congested areas and areas with possible conflicts. No installation shall proceed without owner stamped approval of shop drawings. Submittal to reflect space requirements coordinated with other trades such as Electrical, Plumbing, Mechanical and Structural. Prior to submission to owner, shop drawings to have stamped approval of all major trades which occupy ceiling space (HVAC, plumbing, piping, sprinkler, and electrical), to substantiate adequate coordination as to space, accessibility and to ensure no conflict exists between contractors.

C. The General Contractor shall be responsible for coordination between trades and shall stamp and sign the duct drawings to substantiate that the coordination has been accomplished. Non-critical piping and conduit shall give way to ducts.

PART 2 PRODUCTS

2.01 MATERIAL

A. Sheet Metal, Angles, Bar Slips, Hangers, and Straps: Galvanized steel.

B. Screws: Cadmium plated.

C. Joint Sealer: Hardcast Iron Grip 601 or equal, Single Stage Sealant Process.

2.02 FABRICATION

A. Provide a rectangular or round duct where required on drawings of prime quality galvanized steel sheets, thickness and reinforcement as required by latest edition of SMACNA, or local and state codes, whichever is more stringent. When fabricating low pressure ductwork, largest duct dimension governs the entire duct and complete joint. **Ductwork to be no lighter than 24 gauge**. Contractor may substitute heavier gauge at no additional cost.

B. Duct dimensions shown on drawings indicate inside clear dimensions.

C. In addition to the requirements above, add supplemental bracing as necessary to prevent sagging, drumming, and vibration.

D. Round prefabricated slip joint duct may be used on exhaust and return duct 12" and smaller and for runout duct to boxes, diffusers, registers, and grilles.
   1. Secure duct sections and fittings with sheet metal screws.
   2. Make connections of round duct to rectangular duct using "spin-in" collars with manual volume damper.
   3. Transverse and longitudinal slip joints shall be sealed with approved sealer.

E. Provide transverse joints of "s" and drive construction at least every eight feet on duct whose larger side is less than 18". Seal all transverse joints with joint sealant material.

F. Provide transverse joints, or equivalent supplemental angle reinforcing on 4 foot centers on duct whose larger side is greater than 18". At the contractor's option, duct mate or equal joint system may be substituted for "s" and drive construction. Seal all transverse joints with joint sealant material.

G. Longitudinal seams shall be Pittsburg Lock or grooved seams closed tightly and evenly. Button punch snap lock longitudinal seam construction shall not be allowed. Seal longitudinal joints which prove to leak with joint sealant material.

H. Cross break ductwork over 10" dimension, either side.

I. Do not exceed 20 degree angle of slope for increase-in-area transitions.

J. Do not exceed 20 degree angle of slope for decrease-in-area transitions.

K. Do not exceed 30 degrees on the entering side or 45 degrees on the leaving side for angle of transitions at connections to equipment without the use of approved vanes. 20 degree angle is preferred and should be used space permitting.

L. Provide Ells fabricated to one of the following specifications in order of preference (SMACNA Figures 4-2 through 4-4 and Figure 4-9 and Chart 4-1):
   1. Unvaned elbow with the throat radius equal to 3/4 of the width of the duct and with a full heel radius.
   2. Six inch throat radius with full radius, single thickness vanes and full heel radius. Maximum unsupported length of vanes shall be 36". Vanes shall be securely fastened to runners. All vanes shall be secure and stable in installed operating position. Construct vane edges to project tangents parallel to duct sides.
   3. Square elbows with single thickness turning vanes. Maximum unsupported length of vanes shall be 36". Vanes shall be securely fastened to runners. All vanes shall be secure and stable in installed operating position. Construct vane edges to project tangents parallel to duct sides.
   4. Radius elbows are the preferred fitting. Square elbows are to be used only when available space prevents the use of radius elbows.

M. Provide offsets as necessary in accordance with SMACNA Figure 4-7.

N. Make branch connections and tees in one of the following manners:
   1. Converging radius elbow with MVD. (SMACNA Figure 4-5).
   2. 45-degree entry with MVD. (SMACNA Figure 4-6).
   3. Round spin-in fitting with MVD.

O. Space duct joints to avoid cutting them for branch take offs and outlet collars.

2.03 SPECIAL DUCTWORK

A. Central Sterile and Receiving (CSR): Stainless steel with welded, continuous, liquid tight seams and joints, ground smooth.
   1. Pitch duct to drain to low points.
   2. Provide trapped drain connections at low points.
   3. Pipe liquid away to floor drains.

B. Apparatus Casing:
   1. Comply with SMACNA Manual Chapter 9 and requirements herein, whichever is the most stringent.
   2. Construct of 18-gauge galvanized sheet metal formed in 1-1/2" high standing seam panels.
   3. Form casing in a rectangular shape, with slope of air stream between system components limited to a maximum of 45 degrees.
   4. Provide supplemental interior angle iron reinforcing before fan inlet, and exterior reinforcing after fan discharge, to avoid buckling and collapse during fan start-up and under extreme filter loading conditions.
   5. Reinforce casing spans and walls in medium or high pressure casing, as outlined in SMACNA manual.
   6. Provide access doors, minimum size 20" wide by 54" high where possible, as specified in Section 233300.
   7. Install access door in a 16-gauge (minimum) channel or zee-section frame provided in the casing.
   8. Extend side members of access door frame from floor to roof line.

PART 3 EXECUTION

3.01 INSTALLATION, APPLICATION, ERECTION

A. Support ductwork on each side of the duct with suitable sheared strips of galvanized metal or 1" x 1/8" galvanized steel band iron hangers.

B. Attach hangers to the ductwork using sheet metal screws.

C. Secure hangers to concrete structure with approved anchor shields and to steel structure by means of C-clamps.

D. Space hangers approximately eight feet along the duct except as noted below.

E. Obstructions shall not be located within ducts.

F. Do not exceed 45 degrees for easement transition angle.

G. All ductwork, including supply, return and exhaust shall have circumferential joints, longitudinal joints, and duct wall penetrations externally sealed in accordance to SMACNA Class A. The sealant used to seal the longitudinal joints of low pressure ductwork must be visible or the joints shall require resealing in the field.

H. Insulation: Where drawings and insulating specifications indicate that ducts are to be insulated make provisions for neat insulation finish around damper operating quadrants, splitter adjusting clamps, access doors, and similar operating devices. Metal collar equivalent in depth to insulation thickness and of suitable size to which insulation may be finished to be mounted on duct.

I. Counterflashing: Counterflash all ducts where they pierce the roof.

J. Pitot Ports: Pitot ports for measuring airflow to be located in each main duct at the downstream end of the straightest run of the main and before the first branch take-off. Pitot ports to be formed by drilling 7/16" holes in the duct, lined up perpendicular to airflow on maximum 8" centers and at least three to a duct, evenly spaced. Holes to be plugged with plastic plugs. Provide access to these for future rebalancing.

K. Supply ductwork from the final filters to the operating room, to be installed as follows:
   1. Wipe duct clean before installation. (Take care to assure the duct arrives at the job clean and stays clean.)
   2. Seal taps and other openings during construction, to prevent entrance of dust and dirt.
   3. Make up joints with a coating of Hardcast or approved equal sealer as specified in Section 233110, to assure these joints are leak-tight.
   4. Apply a brush coat of duct sealer externally to joints after erection.

L. Apparatus Casing:
   1. Rivet or bolt casing panels at floor line to a continuous 2"x2"x1/4" galvanized angle attached on 18" centers by expansion shields and bolts to concrete pad.
   2. Join casing to walls and roof similarly or by flanging casing and attaching to masonry by bolts and expansion shields on 24" centers.
   3. Seal standing seam joints and attachment joints with duct sealant, mastic, or caulking compound applied so that pressure differential drives sealant into joint.
   4. Seal piping and conduit penetrations with sealant plates and gaskets.

3.02 CLEANING

A. Clean ductwork thoroughly to assure all foreign matter, dirt, etc. is removed.

3.03 LEAKAGE TESTING OF INSTALLED SYSTEMS

A. Test Low Pressure Ductwork as follows:
   1. Follow procedure published by United Sheet Metal Division of United McGill Corporation entitled “System Pressure Testing for Leaks” using prescribed test kit containing test blower, two U-tube manometers, and calibrated orifice tube.
   2. Leak test all duct that is enclosed in a chase or above a drywall ceiling.

3. Installed low pressure duct system to be pressurized to maximum amount for the appropriate pressure class. Air leakage at test pressure to be measured by a calibrated orifice type flow meter. Ductwork shall be tested in accordance with the 2012 Second Edition of SMACNA HVAC Air Duct Leakage Test Manual. Low pressure duct shall be considered a Seal Class "A" with a leakage class of 8 for rectangular duct and 4 for round duct. Allowable leakage rate shall be in accordance with the Figure 5-1L.
4. Leakage concentrated at one point may result in objectionable noise even if system passes leakage rate criteria; correct to satisfaction of Designer.
5. Orifice flow measurement device to be individually calibrated against a primary standard and calibrated curve permanently attached to orifice tube assembly.
6. Leak testing shall be observed by the General Contractor's on-site quality control representative. The contractor shall have on site at all times the duct leak test training video distributed by the Owner. Maintain on site a set of prints to identify, in different colors, the duct sections isolated for each test, as well as the date of the leak test and final leakage rate recorded for each duct section.
7. For low pressure ductwork where both longitudinal and transverse seams are fully sealed, leakage test described herein may be omitted.

END OF SECTION

SECTION 233111

SHEET METAL DUCTWORK - MEDIUM PRESSURE

PART 1 GENERAL

1.01 WORK INCLUDED

A. The contractor shall provide and/or construct all materials, ductwork, joints, transformations, fittings, access doors, etc., as set forth in these specifications necessary to install the medium pressure sheet metal ductwork required by the drawings.

B. Medium pressure - sheet metal ductwork with air velocity greater than 2000 feet per minute and static pressure 6" or less, but greater than 2".

C. It is the intent of this specification to provide an installed duct system which will supply the air quantities indicated by the plans and have the lowest possible friction loss with the least possible leakage loss. Friction loss for each system shall not exceed that which is indicated in the A.C. unit schedule as external static pressure or in the fan schedule as static pressure and shall include the losses of all accessories. Friction losses shall be minimized by reduction in the number of offsets and elbows by pre-planning the duct system installation and coordination with other trades to prevent interferences. Access to all accessories requiring maintenance, service, and inspection shall be maintained. Radius elbows are preferred for all turns to minimize friction, noise and vibration; and, especially, for sections having large volume or higher velocities, and sections which may have turbulences.

D. Medium pressure ductwork is required from the outlet of AHU to each variable volume terminal box and shall be constructed to meet a 6" pressure class minimum or higher as required to meet air handling unit design external static pressure.

1.02 QUALITY CONTROL AND REGULATORY STANDARDS

A. SMACNA Manual: Sheet metal tradesman to have access, on the construction site, to "HVAC Duct Construction Standards, Metal and Flexible, Latest Edition. The Manual is referred to in the specifications for required construction methods and details. The Contractor shall comply with applicable provisions of the SMACNA Manual and the more stringent requirements of this specification.

B. Quality control involves not only the general performance requirements for all air ducts; but also, quality workmanship, which includes layout preplanning so that offsets, rises, falls, elbows, fittings, etc., are minimized or eliminated. General performance requirements for all ducts include:
   1. Dimensional stability (shape deformation and strength).
   2. Containment of the air being conveyed (leakage control). (See Part 3 of this specification for leakage testing.)
   3. Vibration (fatigue and appearance).
   4. Noise (generation, transmission or attenuation).
   5. Exposure (to damage, weather, temperature extremes, flexure cycles, wind, corrosive atmospheres, biological contamination, flow interruption or reversal, underground or other encasement conditions, combustion, or other in-service conditions).
   6. Support (alignment and position retention).
   7. Seismic restraint, if applicable. Refer to Specification Section 230547.
   8. Thermal conductivity (heat gain or loss and condensation control).

C. Provide galvanized duct materials which meet requirements of SMACNA manual and local and state codes, whichever is the most stringent. Ductwork to be no lighter than 24 ga.

D. Support duct in accordance with SMACNA manual, local and state codes, and details on plans, whichever is the most stringent.

E. Emboss fittings and duct sections with material gauge, manufacturer, and type material.

F. Materials used as sealers, liners, pre-insulated jackets and flexible ducts shall comply with a flame spread rating of 25 or less and a smoke developed rating of 50 or less.

G. Joint sealer shall meet the requirements of UL181A or UL181B as applicable.

H. Duct sealant classification: Seal all transverse joints, longitudinal joints and duct wall penetrations in accordance with SMACNA Class A.

1.03 SUBMITTALS AND SHOP DRAWINGS

A. Submit material/product data to owner for approval.

B. Shop Drawings: The Contractor is to submit to Owner for approval complete sheet metal shop drawings of all ductwork, including equipment rooms, shafts, and especially, congested areas and areas with possible conflicts. No installation shall proceed without owner stamped approval of shop drawings. Submittal to reflect space requirements coordinated with other trades such as Electrical, Plumbing, Mechanical, and Structural. Prior to submission to Owner, shop drawings to have stamped approval of major trades which occupy ceiling space (HVAC, plumbing, piping, sprinkler, and electrical), to substantiate adequate coordination as to space and accessibility and to ensure no conflict exists between contractors.

C. The General Contractor shall be responsible for coordination between trades and shall stamp and sign the duct drawings to substantiate that the coordination has been accomplished. Noncritical piping, low pressure ducts, and conduit shall give way to medium pressure ducts.

PART 2 PRODUCTS

2.01 MATERIAL

A. Sheet Metal, Angles, Bar Slips, Hangers and Straps: Galvanized steel.

B. Screws: Cadmium plated.

C. Joint Sealer: Hardcast Iron Grip 601 or Equal Single-Stage Sealant Process.

2.02 GENERAL FABRICATION REQUIREMENTS

A. Medium-pressure duct and fittings to be manufactured by a company who has had as its principal business the manufacture of spiral duct and welded fittings for at least five years.

B. Medium-pressure fittings to be manufactured by same manufacturer of ductwork to assure tight fit of all ductwork and components.

C. Supplier of medium-pressure ductwork to provide to Designer certified copies of test data made by independent United States laboratory covering all duct and fittings as manufactured by supplier.

D. Duct test data to cover leakage rate, bursting strength, collapsing strength, seam strength, and friction loss. Friction loss test data to cover both duct and assembled coupling joints. Fitting test data to cover friction loss tests of all fittings shown on drawings.

E. Installation manuals to be included by the Contractor with submittals. Manuals to provide detailed instructions on assembly, joint sealing, erection, reinforcement of flat-oval duct, and system pressure testing for leaks.

2.03 SPECIFIC FABRICATION REQUIREMENTS

A. Round Duct and Fittings:
   1. Round duct to be manufactured using galvanized steel meeting ASTM A-525. Construction shall be in accordance with SMACNA manual and manufacturer's standards.
   2. Round duct is to have appropriate seams made to eliminate leakage based on pressures for which the system has been designed. Longitudinal seam duct to have fusion welded butt seam.
   3. Fittings and couplings shall have the minimum gauges specified by SMACNA Manual. Fittings to have continuous welds along all seams.

4. Divided flow fittings (90 degree and 45 degree branches, wyes, crosses, etc.) to be manufactured as a separate fitting, not as a tap collar or saddle tap welded into spiral duct sections. Entrances to be free of weld buildup, burrs, or irregularities.
5. Elbows in diameters 3" thru 8" to be stamped elbows. Other elbows to be gored construction with all seams continuously welded. Elbows to be fabricated to center line radius of 1.5 times the cross-sectional diameter. Two-piece mitered elbows shall not be used unless specifically shown on plans.
6. Spun bellmouth connections to be used at each round take-off from medium pressure plenum.
7. Galvanized areas damaged by welding to be coated with corrosion resistant aluminum paint.

2.04 COUPLINGS FOR ROUND MEDIUM-PRESSURE DUCT

A. Diameters up to 60":
   1. Duct-to-Duct joints to be sleeve couplings, reinforced by rolled beads.
   2. Duct-to-fitting joints to be slip-fit of projecting collar fitting into duct.
   3. Insertion length of sleeve coupling and fitting collar to be 2" minimum.

B. Rectangular Ductwork:
   1. Reinforce rectangular duct with angles or internal tie rods. Joints to be double "S" slip up to 60" in width and companion angle flanged joint above 60" in width. Sheet metal gauges for medium pressure duct shall be as required by SMACNA 2005 manual.
   2. Fabricate elbows using one of the following methods:
      a. Radius elbows are the preferred fitting. Square elbows are to be used only when available space prevents the use of radius elbows.
      b. Six inch throat radius with full radius, single thickness vanes and full heel radius. Maximum unsupported length of vanes shall be 36". Vanes shall be secure and stable in installed operating position. Construct vane edges to project tangents parallel to duct sides.
      c. Unvaned elbow with the throat radius equal to 3/4 of the width of the duct and a full heel radius.
      d. Square elbows with H-E-P: High Efficiency Profile turning vanes as manufactured by Aero/Dyne Company. Turning vanes shall be double thickness airfoil design with smoothly-rounded entry nose and extended trailing edge. Turning vane assemblies shall be fabricated with side rails and installed on design centers across the full diagonal dimension of the elbow. Vanes are to be installed in strict accordance with manufacturers' recommendations.
   3. Contractor may request round or oval duct be substituted for any rectangular duct shown. Size substitutions to be based on equivalent airflow resistance.

PART 3 EXECUTION

3.01 INSTALLATION

A. Support round ducts from building structure with galvanized steel hangers as recommended in SMACNA manual. Secure hangers to masonry portion of building by means of inserts or other acceptable anchors. Secure hangers to steel structure members by means of C-clamps. Vertical risers and other duct runs where methods of support specified above are not applicable, to be supported by angle brackets as shown in SMACNA manual.

B. Support rectangular ducts by 1" x 1/8" galvanized band iron or 3/8" galvanized rod hangers attached to reinforcing angles and spaced same as reinforcing angles. Secure hangers to concrete beam or slab by inserts, anchor shield and bolt, toggle bolt, or expansion bolt.

C. Attach hangers to ductwork using sheet metal screws.

D. Space hangers approximately 8' along the duct for ducts under 60". For ducts 60" and larger and heavier sections, such as welded duct, space hangers at approximately 4' intervals.

E. Hangers and bracing used with ductwork to be galvanized.

F. Obstructions shall not be located within ducts.

G. Provide smooth insulation finish around dampers, access doors, and similar operating devices. Provide metal collar equivalent in depth to insulation thickness.

H. Provide pitot ports for measuring airflows in each main supply duct downstream of straightest run of main and before first branch takeoff. Form pitot ports by drilling 7/16" holes in the duct, lined up perpendicular to airflow on maximum of 8" centers. Provide minimum of 3 per duct evenly spaced. Plug holes with plastic plugs. Provide access to pitot ports for future re-balancing.

I. Seal duct joints as follows:
   1. Apply sealer to male end of couplings and fittings. After joint is slipped together, place sheet metal screws 3" on center, 1/2" from joint bead. Apply sealer to the outside of the joint extending 1" on each side of the joint bead and covering screw heads.
   2. Duct sealer to be specifically formulated for the sealing of high-pressure duct systems. Submit sealer specifications for approval. Flame spread rating of sealer to be less than 25, smoke development rating of sealer to be less than 50. Apply joint material in strict accordance with manufacturers' published installation instructions.
   3. Flanged joints to be sealed with neoprene rubber gaskets.
   4. The sealant on longitudinal seams of field fabricated duct and fittings shall be visible on the exterior of the duct or the joints shall require resealing in the field.

3.02 LEAKAGE TESTING OF INSTALLED SYSTEMS

A. Test medium pressure ductwork as follows:
   1. Follow procedure published by United Sheet Metal Division of United McGill Corporation entitled "System Pressure Testing for Leaks" using prescribed test kit containing test blower, two U-tube manometer, and calibrated orifice tube.
   2. Medium pressure duct to be pressure tested from the AHU to the terminal boxes.
   3. Installed medium-pressure duct system to be pressurized to 50% over design operating pressure to 6" w.g. maximum. Air leakage at test pressure to be measured by a calibrated orifice type flow meter. Ductwork shall be tested in accordance with the SMACNA HVAC Air Duct Leakage Test Manual. Medium pressure duct shall be sealed to a Seal Class "A" with a leakage class of 4 for rectangular duct and 2 for round or flat oval ductwork. Allowable leakage rate shall be determined in accordance with the SMANA Figure 5-1L.
   4. Leakage concentrated at one point may result in objectionable noise even if system passes leakage rate criteria; correct to satisfaction of Designer.
   5. Orifice flow measurement device to be individually calibrated against a primary standard and calibrated curve permanently attached to orifice tube assembly.
   6. Leak testing shall be observed by the General Contractor's on-site quality control representative. The contractor shall have on site at all times the duct leak test training video distributed by the Owner. Maintain on site a set of prints to identify, in different colors, the duct sections isolated for each test, as well as the date of the leak test and final leakage rate recorded for each duct section.

END OF SECTION

SECTION 233248

ACOUSTICAL AIR PLENUMS

PART 1 GENERAL

1.01 RELATED WORK

A. Section 237313: Air Handling Units

1.02 QUALITY CONTROL/STANDARDS

A. Plenum design to meet combustion requirements established by ASTM E84. Panels not to exceed the following limits:
   1. Flame Spread: 10-20
   2. Smoke Developed: 0-20
   3. Fuel Contributed: 10-15

B. All lining material to meet erosion test method as described in UL Publication No. 181.

C. Manufacturer to supply certified test data in accordance with the following: Minimum allowable transmission loss (TL) of panel including all components, when tested in accordance with ASTM E90-61T, to be as follows:

MINIMUM ALLOWABLE TRANSMISSION LOSS						
OCTAVE BAND CENTER						
FREQUENCIES, Hz:	125	250	500	1000	4000	8000
DECIBELS:	23	35	45	53	58	58
Note: Ratings apply to panels in “regular” and “hard” construction.						

D. Composite panel assembly when tested in accordance with ASTM C423-65T, to have minimum absorption coefficients as follows:

MINIMUM ALLOWABLE ABSORPTION CHARACTERISTICS						
OCTAVE BAND CENTER						
FREQUENCIES, Hz:	125	250	500	1000	4000	8000
COEFFICIENTS:	0.63	1.09	1.17	1.01	0.97	0.93

1.03 SUBMITTALS

A. Submit items under provisions of Section 237313.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Titus products.

B. Rink Corporation.

2.02 ACOUSTICAL AIR PLENUMS

A. Air plenums to be 4" thick with interior perforated panel of #22 U.S. gauge galvanized steel with 3/32" diameter holes spaced on 3/16" staggered centers. Support panel walls and partitions directly on concrete floor slab.

B. Exterior solid panels sheets to be #18 U.S. gauge galvanized steel.

C. Sound retarding and absorbing fill to be incombustible, inert, mildew resistant, and vermin-proof.

D. Internal panel reinforcement to be a minimum of #18 U.S. gauge galvanized steel and spaced so that span does not exceed 2'. Perimeter and internal reinforcement and panel sheets to be welded and riveted to form a rugged metal-sheathed acoustical panel. Spot welds not to exceed 3" on centers.

E. Prior to attaching face sheet, panel to be filled with sound retardant and absorbing fill as specified above. Fill to be slightly larger and thicker than inside dimension of the panel. No voids will be tolerated.

F. Face sheet to be welded and riveted to panel assembly to compress and hold fill materials in place under severe conditions of vibration such as encountered in shipment, installation, and operation.

G. Door panels to be constructed of solid #18 U.S. gauge galvanized metal sides. Doors to be supplied 24" wide by 60" high or 36" by 72" high as specified on the drawings. Doors to be 4" thick of the overlapping seal type. Each door to be supplied with single continuous air/acoustical seals around the sill, jambs, and head. Doors to have 3 hinges and 2 latches with an inside release handle. Each door to be assembled with hinge hardware attached and adjusted, and latches installed in the field. Door latches to be wedge type with inside handle. Hinges to be heavy duty type designed for door size and weight. Doors to be installed to open against air pressure.

H. Windows to be furnished for doors where shown on drawings and consist of two layers of 1/4" safety glass separated by air space and sealed acoustically and air tight with rubber seals. Air space to contain a desiccant material to prevent misting.

I. Roof channels, aprons and corner joiners to be made of #16 U.S. gauge galvanized steel formed to prevent a direct path for sound and/or air leakage. Floor channels to be made of #18 U.S. gauge galvanized steel. Panel joiners to be made of #20 U.S. gauge galvanized steel and roll formed for greater strength than standard 16 gauge joiners. Where roll formed joiner sections are not utilized standard 16 gauge to be utilized. All panel accessories to be furnished in standard lengths to be field cut to required dimensions. Where panel walls and partitions join concrete floor, secure panels to 2" x 2" x 3/16" galvanized structural steel angle framing. Secure angle framing to concrete floor on not over 24" centers, and caulk airtight with "Dow Corning #780" building sealant or "General Electric PTV" silicone rubber. All panel joiners and connectors requiring felted surfaces to have the felt field applied.

J. Openings for fan and duct connections where required to be provided by plenum manufacturer. Pipe and conduit penetrations to be located and cut in the field and sealed in accordance with the manufacturer's recommendations.

K. Plenum structure to be normally self-supporting. Where roof spans and wall loadings require additional structural strength, provide either by heavier roof and wall joiners, or additional structural members and/or pipe columns.

L. Metal surfaces to be galvanized except 5" wide flange beams. Prime paint all such structural members.

M. Panels to have Heat Transfer Factor of 0.07 BTUH/Sq. Ft./F. temperature difference at standard air.

N. Plenum installation to be capable of withstanding positive internal static air pressure of 8".

O. Plenum installation to be capable of withstanding negative internal static air pressure of 4".

P. All lining material to meet erosion test method as described in UL Publication No. 181.

Q. Plenum manufacturer to warrant that when plenums are installed in workmanlike manner in accordance with specifications and manufacturers' instructions, that plenums will meet acoustical, thermal, and air pressure performance specified.

R. Plenums to be furnished clean, well made, and free of any defects that adversely affect appearance, serviceability, or performance.

2.03 ACCESS DOORS

A. Access doors to be provided for access to all heaters, fire dampers, automatic dampers, smoke dampers, air monitor stations, if installed, and other equipment installed in ducts and at other points indicated on drawings.

B. Where required, access doors in masonry walls to be furnished and installed under Section 230100.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with manufacturers' instruction at locations shown on drawings.

B. Install access door and dampers as required by other sections of specifications.

END OF SECTION

SECTION 233300

AIR DUCT ACCESSORIES

PART 1 GENERAL

1.01 WORK INCLUDED

A. Specialties to be submitted and approved before starting installation.

B. Items to be installed approximately as shown on drawings taking into account differences in mechanical equipment submitted and that shown on contract documents. Each item to be installed so that it is readily accessible for maintenance, repair, and/or setting and balancing.

C. Diffusers, registers, and grilles to have ratings certified by Air Diffusion Council and tested per ADC Equipment Test Code 1062R2 and ASHRAE Standard 36B-63.

D. Refer to drawings for diffuser, register, and grille sizes and number of airflow directions.

PART 2 PRODUCTS

2.01 FIRE DAMPERS

A. Fire dampers to be U.L. listed in accordance with UL-555. Fire dampers to be held in an open position with a 165 degree F fusible link and arranged to lock in position on closure.

B. Fire dampers for rectangular duct to be type "B" and for round duct to be Type "C". Fire dampers located behind sidewall registers and grilles and others specifically indicated on drawings to be Type "A". Fire dampers to be multi-leaf type with spring closing for horizontal mounting and weighted-gravity closing for vertical mounting. Dampers to be steel construction with rust resistant finish and provided with a factory-installed mounting sleeve suitable for structure. Mount per manufacturer's published U.L. approved installation instructions.

C. See Architectural drawings for hour-rating of walls and/or floors. Dampers to be compatible with hour ratings.

2.02 COMBINATION SMOKE/FIRE DAMPERS

A. Combination smoke/fire dampers to be U.L. listed both as 1-1/2 hour fire damper under UL-555 and as smoke damper under UL-555S as Minimum Leakage Category II and Elevated Temperature Category B (350 degrees F).

B. Dampers to be steel construction with rust resistant finish and provided with 165 degree F electronic resettable fuse link (EFL) and factory-installed mounting sleeve suitable for structure. Mount damper per manufacturer's published U.L. approved installation instructions.

C. Damper operator to be electric type compatible with electrical characteristics used for smoke detection and/or fire alarm system.

D. Dampers to be Ruskin Model FSD36 with crimped type blades for low-pressure duct systems and Ruskin Model FSD60 with airfoil blades for medium- and high-pressure duct systems.

2.03 DAMPERS

A. Manual Volume Dampers (MVD): Manual volume dampers to be hand-operated type dampers constructed of galvanized steel, minimum 22-gauge for duct widths 18" and less, minimum 16-gauge for duct widths greater than 18". Dampers for ducts to 12" height and 12" diameter to be single blade carried on a 3/8" round steel rod mounted inside of duct without frame and fitted with locking type quadrant and brass end bearing plate accurately drilled and secured to duct. Dampers for ducts greater than 12" height to be multi-blade type, 12" maximum blade width up to 30" blade length and 10" maximum blade width over 30" blade length. Blades to be mounted on frame with brass

sleeve bearings interconnected for operation from one locking type hand quadrant. Round pivot rods to have section faced flat to receive locking setscrew in locking quadrant. Refer to SMACNA manual Figures 2-14 and 2-15.

1. For manual damper locations above a rigid or non-accessible ceiling or where damper access is limited, a remote damper operator shall be used. Damper operator to be self-locking worm gear designed for 3/8" damper shaft. Shaft extension to be 3/8" square rod with coupler. Remote operator to be provided with wrench operated shaft adjustment, position indication and lock nut. Where straight shaft extension cannot be used due to accessibility, a flexible cable operator with compatible damper operator and regulator may be utilized. Damper operator, shaft and regulator shall be designed for minimum 35 in-lb torque. Remote operator in non-sterile areas to be ceiling mounted with removable cover plate or mounted above access door. Sterile area installations such as surgery rooms or elsewhere as indicated on drawings shall use bracket mount installation above access door. Where multiple operators are routed to single or multiple access locations, provide markings to identify the associated air device for future use. The damper operator, shaft extension and ceiling termination/regulator shall be manufactured by Young Regulator, Inc. or approved equal.
2. Ductwork manual volume damper (MVD) handles in externally wrapped ductwork shall be supplied with a stand-off bracket and locking quadrant to ensure that the handle can be adjusted without disturbing the insulation vapor barrier.

B. Backdraft Dampers (BDD): Backdraft dampers to be Ruskin Model CBD6 or approved equal low-leak counterbalanced backdraft dampers. Dampers to be heavy-duty type suitable for air velocities to 2500 fpm with all extruded aluminum construction, minimum 0.81" thick frame, and minimum .050" thick blades on maximum 4" centers. Provide blades with vinyl edge seals. Provide dampers with aluminum linkage and corrosion resistant type bearings. Provide dampers with adjustable counterbalances on blades to assist closing.

2.04 SQUARE CEILING DIFFUSERS

A. Provide Titus TMS or approved equal round neck, cone faced ceiling diffusers at all locations designated by schedule on drawings. Diffusers to be all aluminum construction. Frame to be flush mount for diffusers in "hard" ceilings and lay-in T-bar mount for diffusers in lay-in ceilings. Finish to be baked-on, off-white enamel.

2.05 LINEAR BAR DIFFUSERS

A. Provide Titus CT-540 or approved equal linear bar diffuser at all locations designated by "LSD" on drawings. Linear bar diffuser to be extruded aluminum construction with 0 degree deflection, 1/4" wide fixed bars spaced 1/2" apart. Diffuser to be complete with maximum 3/4" flanged border, and concealed fastening. Finish to be anodized with color selected by Designer.

2.06 LAMINAR FLOW DIFFUSERS

A. Provide Titus TLF-AA or approved equal laminar flow, aluminum, perforated face ceiling diffuser at all locations designated by schedule on drawings. Diffuser to have round neck, deflector ring, 3/32" diameter holes on 1/4" centers in a 60 degree staggered pattern, retainer cable and suitable for either surface-mounted or laid-in T-bar ceiling system. Finish to be baked-on, off-white enamel.

2.07 SIDEWALL SUPPLY REGISTERS

A. Provide Titus 272-FL or approved equal at locations designated on drawings. Registers to be all aluminum construction complete with individually adjustable, double deflection airfoil blades spaced 3/4" with front set of blades horizontal. Finish to be baked-on, off-white enamel.

2.08 SIDEWALL RETURN REGISTERS

A. Provide Titus 33-RL heavy duty registers at all locations designated on drawings. Registers to be minimum 16-gauge steel construction complete with minimum 38 degree deflection fixed blades spaced 1/2". Finish to be baked-on, off-white enamel.

2.09 CEILING RETURN & EXHAUST REGISTERS

A. Provide Titus Model 50-F or approved equal at locations designated by schedule on drawings. Registers to be complete with 1/2" cube egg-crate aluminum grid. Finish to be baked-on, off-white enamel. Border to be flush mounted frame style.

2.10 AIR LOUVERS

A. Air louvers shall be stationary horizontal, wind driven rain, extruded aluminum blades equal to Greenheck model EHH-601. The louvers shall be AMCA Certified. Louvers to be have minimum 0.081" thick aluminum frame and blades. Louver depth to be 6" with blades on approximate 2" spacing. Blade construction to be horizontal rain resistant style. Finish shall be (color selected by Architect). Manufacturer will submit metal color chip to Architect as part of the submittal approval. Louver shall be rated at: the beginning point of water penetration (0.01 oz. of water (penetration) per sq. ft. of louver free area is above 1,250 fpm, minimum 46% free area, 0.21" S.P. resistance at 1,000 fpm. Provided 1/2" mesh expanded aluminum screen with removable frame mounted on inside face of louver. Provide minimum 10 year finish warranty.

2.11 FLEXIBLE CONNECTORS

A. Install UL listed flexible duct connectors between duct and fan/equipment connections. Flexible duct connectors to be made of 28-ounce, heavy glass fabric double coated with neoprene.

2.12 FLEXIBLE DUCT

A. Flexmaster Type 1M Acoustical Attenuating or Approved equal. Submit acoustical performance of any alternate product for prior approval.
   1. Characteristics of flexible duct:
      a. Approved as UL-181 Class 1 air duct.
      b. Flame spread rating less than 25 and smoke developed rating less than 50.
      c. Rated for 6" w.g. positive pressure, 4" w.g. negative pressure, and 5000 fpm air velocity.
      d. Tear and puncture resistant reinforced CPE inner liner mechanically locked together with a corrosive resistant galvanized steel helix.
      e. Insulated with minimum 1/2" thick fiberglass insulation with vapor barrier jacket.

B. Seal off the insulation jacket at its ends and at joints with mastic, Hardcast, or similar material. Replace flexible duct if jacket is punctured.

C. Flexible duct is NOT to be used for runouts where it must pass through walls or through smoke or fire partitions. Flexible duct is not to be used in exposed application. Flexible duct lengths shall not exceed 6 feet at each connection.

D. No bends shall be made in flexible duct with the center line radius less than one and one-half duct diameter and only one bend may occur per 6 foot length of duct material.

2.13 DUCT ACCESS DOORS

A. Duct access doors to be provided for access to all coils, fire, fire/smoke, and smoke dampers, automatic and backdraft dampers, duct smoke detectors, static pressure and air volume sensing devices, and other equipment installed in ducts and at other points indicated on drawings.

B. Access door construction and airtightness must be suitable for the duct pressure class used (low, medium, or high).

C. Access doors to be double-panel, galvanized steel construction with minimum 1" rigid insulation between panels. Access doors in exhaust duct and unlined return duct may be uninsulated single panel, galvanized steel construction. Doors to mount in rigid frame constructed of formed galvanized steel. Angle iron bracing to be used as required to provide rigid assembly. Doors to hinge on one side with door latch on opposite side.

D. Access doors in ductwork shall fully comply with Figure 7-2, 7-3 and 7-2M of SMACNA manual. Casing access doors shall fully comply with Figure 9-15 and 9-16 of SMACNA manual. Minimum size shall be 12" x 12" per NFPA 80.

E. Doors to close against gasket seal.

F. Ductwork and/or equipment access doors shall be required at all motorized dampers, fire/smoke dampers, smoke detectors, airflow monitoring stations, duct-mounted temperature/pressure sensors and/or transmitters, vaned elbows, duct-mounted heat transfer coils, sound attenuators and any other mechanical and/or control device requiring inspection, maintenance or test access. In addition, 24" x 24" access doors should be utilized wherever possible to facilitate adequate access for maintenance and/or testing.

G. Access doors for fire dampers, fire/smoke dampers, and smoke dampers shall be permanently identified on the exterior by a label having letters not less than 0.5 inches in height reading: “Fire Damper” “Fire/Smoke Damper” or “Smoke Damper” as required by 2012 International Mechanical Code.

2.14 DUCT MOUNTED SMOKE DETECTOR

A. Duct mounted smoke detectors shall be furnished by Division 26. Coordinate power and control wiring. Installation of smoke detector shall by Division 23.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation to be in accordance with manufacturers’ published installation instructions as well as applicable sections of SMACNA manual.

B. Provide all screws, bolts, nuts, and inserts required for attaching sheet metal specialty items to ducts, walls, floors and ceilings.

END OF SECTION

SECTION 233320

ACOUSTICAL BARRIER WRAP

PART 1 GENERAL

1.01 WORK INCLUDED

A. Provide barrier wrap equal to Kinetics Model KNM-100ALQ materials at locations indicated on the drawings or as otherwise directed.

PART 2 PRODUCTS

2.01 BARRIER WRAP

A. Barrier wrap to be a single composite material consisting of a mass loaded limp, flexible, vinyl sheet noise barrier bonded to reinforced aluminum foil on exterior and 1” quilted fiberglass decoupling layer on interior.

B. The barrier wrap to be nominal 1 lb/sq ft density and to have a minimum 28 STC rating as a free hanging barrier when tested according to ASTM E-90-90.

OCTAVE BAND TRANSMISSION LOSS (dB)					
125	250	500	1K	2K	4K
13	16	24	33	43	49

C. The barrier wrap to have maximum flame spread rating of 10 and smoke developed index of 40 when tested in accordance with ASTM E-84.

D. The composite material to have the following minimum insertion loss when adhered to 20 gauge sheet metal duct when tested according to ASTM E-222-90.

OCTAVE BAND INSERTION LOSS (dB)					
125	250	500	1K	2K	4K
6	7	18	24	27	28

PART 3 EXECUTION

3.01 INSTALLATION

A. Wrap barrier around sheet metal completely covering the area indicated. Quilted fiberglass is to be placed against the sheet metal to decouple the outer limp barrier material from the metal. Securely fasten wrap with proper adhesive, kinetics acrylic based tape and/or bands.

B. All joints are to be sealed with a 6" minimum overlap of limp barrier material similar to that used in the composite to form a continuous air tight barrier around the duct. This to be adhered with 100% coverage of adhesive.

C. Seal all joints where the barrier wrap abuts the building construction with non-setting acoustical sealant such as DAP Acoustical Sealant or approved equal.

END OF SECTION

SECTION 233400

CENTRIFUGAL FANS

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section includes requirements for all centrifugal fans. Refer to drawings and schedules for style of fan and accessories to be provided.

B. Provide fan type, capacity, direction of rotation, discharge direction, and arrangement as shown on drawings.

1.02 PERFORMANCE

A. Certify fan performance in accordance with AMCA Certified Air and Sound Rating Criteria Standard 210, 300, and 301.

B. Fans shall be UL or ETL listed.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. ACME, Greenheck, Barry Blower, Twin City, Cook, or approved equal.

2.02 CENTRIFUGAL EXHAUST FANS

A. Non-overloading, backward inclined, aluminum centrifugal fan wheel.

B. Variable pitch V-belt drive or direct drive as scheduled.

C. Roof as scheduled.

D. Removable heavy gauge aluminum fan housing enclosing motor outside airstream.

E. Permanently lubricated, ball bearing fan motor.

F. Isolate fan motor, wheel, and drive from base with rubber vibration isolators.

G. Electrical junction box.

H. Gravity backdraft damper.

I. Birdscreen around fan discharge.

J. Disconnect switch on single-phase fans.

K. Prefabricated, 1" thick fiberglass insulated, minimum 18-gauge aluminum or galvanized steel construction, minimum 12" high roof curb. Coordinate required curb base type with roof construction, pitch, and flashing requirements. See architectural drawings.

L. Upblast housing when scheduled on drawings.

M. UL-762 listing for kitchen hood grease exhaust. Provide fan with upblast housing, hinged fan base, minimum 18" high roof curb, minimum 40" overall fan discharge height above roof surface, grease drain and external grease container.

N. Solid state variable speed controller when scheduled on drawings.

O. Sparkproof construction with explosionproof motor when scheduled on drawings.

P. Epoxy coating for dishwasher exhaust fans and other fans when scheduled on drawings.

Q. See fan schedule on drawings for other required accessories.

2.03 BELTED VENT SETS

A. Belted vent sets shall be a completely packaged unit including fan assembly, motor, adjustable belt drive, and adjustable motor base.

B. Wheels and Housings: Wheel diameters and discharge areas shall be sized in accordance with AMCA Standards.

C. Housing Construction: Heavy gage continuously welded steel. Housings shall be suitably braced to prevent vibration and pulsation. Housings shall be field rotatable to different discharge positions. Inlets shall be fully streamlined. Provide inlet and discharge flanges.

D. Painting: Factory applied, corrosion-resistant paint.

E. Shaft: Solid hot rolled steel, ground accurately for a smooth bearing fit.

F. Provide heavy duty, anti-friction, self-aligning ball or roller type bearings. Position bearing supports to directly oppose drive belt tensions and transmit loads to the fan base. Bearings to have a minimum L10 life of 40,000 hours.

G. Mount motor on an adjustable slide rail base.

H. Provide steel fan base.

I. Motor horsepowers and outlet velocities shall not exceed that scheduled on drawings.

J. Fans shall be statically and dynamically balanced at the factory.

K. Provide fans with OSHA approved expanded metal beltguards with tach hole for checking fan shaft speed.

L. Provide fans which all use same type grease.

M. Provide fan housing drain.

N. Provide housing access door.

O. Fans for outdoor mounting to be completely weatherproofed, with a fan motor and drive weather cover, and complete epoxy coating.

P. Exhaust fans serving airborne infection isolation (AII), bronchoscopy rooms, emergency department waiting rooms, nuclear medicine laboratories, radiology waiting, and laboratory chemical fume hoods, shall discharge a minimum of 10’-0” above the finished roof. Refer to details on the drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install fans in locations shown on drawings in accordance with manufacturers’ published installation instructions.

B. Connect fans to ductwork by means of flexible connections.

3.02 TEST AND ACCEPTANCE

A. Start-up and checkout fan for proper motor phasing, alignment, and vibration free operation. Correct improperly aligned fans. Change unmatched belts.

B. Demonstrate system operation to Owner's maintenance personnel and instruct them in operational and maintenance requirements.

C. Verify that, where applicable, fans are interlocked with other fans as required by control drawings.

END OF SECTION

SECTION 233600

AIR TERMINAL UNITS

PART 1 GENERAL

1.01 WORK INCLUDED

A. Variable volume air terminal units to be pressure independent, single duct, DDC control type with hot water reheat coil pre-assembled unit with factory installed piping and controls and shall be pre-commissioned.

B. Air terminal unit airflow and sound performance ratings to be certified in accordance with AHRI Standard 880. Unit maximum NC level shall not exceed NC 26 at 3.0" of static pressure at the inlet.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

A. Subject to compliance with requirements, provide products by the following:
   1. Johnson Controls, Inc.
      VAV Box Model VRU
      Contact: Kevin P. Tolbert
      email: BE-HCA@jci.com
      478-952-8740

2.02 EQUIPMENT REQUIREMENTS

A. Provide terminal units with minimum 22-gauge welded galvanized steel housing, slip and drive duct connection, hanger holes or brackets, and 1/2 inch thick internal glass fiber insulation with minimum 22-gauge inner sheet metal liner. Insulation to be UL listed and meet NFPA-90A and UL-181 requirements. Device to be double wall construction.

B. For terminals units with a 6" inlet or greater, airflow to be monitored by an integral, multiple point, averaging airflow sensing ring or cross to maintain constant airflow within 5 percent of rated cfm down to 25 percent of nominal cfm, independent of changes in system static pressure. Sampling points to be evenly spaced across the air terminal box inlet for better readings. Factory set, field adjustable settings for terminal unit maximum and minimum airflows to be provided in accordance with schedule on drawings. Integral flow taps and calibration chart to be provided for each terminal unit.

C. On terminal units with inlets less than 6", a single point flow measuring device is acceptable.

D. Internal resistance of terminal unit shall not exceed that scheduled on drawings when handling maximum scheduled air volumes.

E. Terminal unit leakage rate to be maximum 2 percent of nominal catalog rated cfm at 3.00" w.g. inlet static pressure when tested according to ASHRAE 130.

F. Maximum room N.C. due to discharge or radiated sound shall not exceed NC-35 when terminals are either in throttled or full open position with inlet static pressure ranging from 0.5 to 2" w.g. Correction of noise excesses not to constitute additional charges.

G. Terminal units to be complete with factory installed, direct digital control actuator for connection to DDC controls provided by controls contractor.

H. Provide factory mounted hot water reheat coils for terminal units scheduled on drawings in accordance with Section 238213 Heating Coils. Minimum tube thickness of 0.016".

I. Provide a discharge air temperature on each terminal unit. Temperature measurement to be 1000 Ohm RTD, 2-wire sensing element with +/- 0.3°F accuracy and a stability of less than 0.1°F in five years.

J. Where box supplier has an offering for a constant volume box or a variable volume box controlled to a constant volume, provide the latter to obtain the most data points and for flexibility.

K. An 8 inch diameter or 7.75 inch by 7.75 inch gasketed hinged access door shall be provided on the terminal unit. Door frame may be bolted, sealed or flanged to the casing. The door shall be double wall construction, gasketed and insulated. The Door shall be held in place with a cam lock latch allowing quick access without the use of tools.

L. Shipping: All components to be adequately protected during shipping, pipes to be plugged to keep debris from getting into the pipe and fittings, pipe ends to be prevented from damage during shipping.

M. Warranty: 1-year parts and labor warranty for all the parts of the pre-assembled air terminal box unit, with the exception of the controls contractor's scope of work.

2.03 PRE-PIPED VAV TERMINAL ASSEMBLY REQUIREMENTS

A. Terminal box assembly shall consist of factory fabricated terminal unit, integral controls, coil, piping of the sizes, capacities and configurations shown on the drawings with catalogued part numbers. All controls and hydronics piping shall be accessible from the same side of the unit. All hydronics piping packages shall be piped in the opposite direction of the control panel, downstream of the VAV terminal unit. Controls Contractor shall be responsible for proper selection/sizing of the VAV based on scheduled performance parameters and the supplying of the VAV.

B. The entire VAV assembly (terminal unit, coil, hydronics piping packages, controls hardware, electrical components and wiring) shall be seismically certified per IBC 2010 code with a 2.5 allowance factor and carry the OSHPD (OSP) certification.

C. If required for single-side access, single duct terminal units with hot water coils shall be shipped with a factory supplied 16 inch duct extension attached downstream of the coil. The construction of the duct extension shall be equal to the quality of materials and workmanship to that of the terminal unit. All connections to be sealed with silver foil tape rated at 6" of total pressure. The insulation shall match the insulation of the VAV box.

D. A control panel manufactured with a minimum 20 gauge sheet metal shall be supplied. The enclosure cover design shall allow for the following motions with a single universal design: a 180 degree hinged motion, a sliding motion from left to right and right to left including full removal of the enclosure cover without tools. The controls cover shall reside in a set position without the use of mechanical fasteners or screws. "Quick Release" sheet metal tabs/guide stops shall be supplied to allow the cover from slipping off when in the fully open position. The "Quick Release" tabs/guide stops shall be designed in such a way to allow the complete removal of the cover. A handle shall be supplied on the controls cover for opening and closing the controls cover. The control enclosure shall have factory installed knock outs for mounting all the electrical and controls components required. All electrical and electronic components including both line voltage and low voltage shall be mounted in the metal controls enclosure per applicable codes. The control panel shall include stand-offs to allow mounting of the controls and electrical items without penetrating the VAV terminal box casing.

E. A single point power connection shall be provided to the VAV unit. Low voltage wire from the ATC control valve actuator to the DDC controller shall be wired in 3/8 inch flexible conduit in accordance with UL-1995 and the National Electric Code. An electrical junction box with a disconnect switch, 24 volt transformer with low voltage wiring shall be provided and mounted on the VAV by the VAV manufacturer. All relays required shall be installed and wired in the electrical enclosure.

F. Hot water coils shall be factory installed with a maximum of ten (10) aluminum fins per inch and rated in accordance with ARI 410.The coil circuiting shall be a multi circuited header with corrosion free brass manual air vent piped in at the highest and lowest point of the piping header to ensure efficient drainage and air removal from the coil. A metal coil-u-bend cover shall to be factory installed on the coil u-bends to protect the coil u-bends during shipment and installation. Upstream and downstream coil casing connections to terminal unit and duct extension to be sealed with silver foil tape rated at 6" TSP. Tube thickness shall be a minimum of 0.016"

G. Braided stainless steel hose kits are acceptable for terminal boxes. Hoses to be a minimum of ¾" diameter and 24" long and to have operating temperature range from -40° to 250° Fahrenheit, a working pressure of 400 psi, and a minimum burst pressure of 1600 psi. . Hose kits to ship with one end attached to the VRU piping valve assembly and

the other end with a minimum 3/4" diameter 8 " long sealed copper air chamber. The sealed end of the copper air chamber should be cut, prepped and connected to the loop piping. Do not twist the hose kit during installation and keep all flux and other chemicals off the braided hoses. Pay close attention during construction to allowable hose bend radius.

H. VAV boxes serving operating rooms and C-section rooms shall have a minimum of two-rows for rapid room warm-up. Two-row coils are preferred in all applications to reduce fan power requirements and sound transmission.

I. Two (2) 90 degree copper pipes formed on a tube bender shall be sweated directly to the header of the coil with a minimum distance of 6 inches from the coil inlet and to the coil outlet regardless of the coil size. Sweated copper elbows and fittings are not acceptable to achieve the same result.

J. A minimum of two adjustable Universal Handle Brackets with built in handles shall be supplied for every VAV furnished. Handles shall be constructed with a minimum of 14 gauge metal shall be painted to avoid corrosion and stress fractures of hydronics. Handle opening shall be able to accept a minimum of the following lifting devices through the handle portion of the bracket without damaging the product: human hand, forklift, Unistrut, pipe or other lifting devices. The handle shall have a 180 degree – "rolled up edge" to prevent injury to the human hand: raw edges or non-rolled edges shall not be accepted.

K. The shipping handle brackets shall use 4 military grade rubber grommets for elimination of galvanic corrosion and isolation between copper piping and support handles. The rubber grommets shall be made of Buna-N and be resistant to petroleum-based oils and fuels, water and alcohols.

L. The piping assembly and coil shall be field reversible. The hydronics piping structure and 2 handle shipping brackets shall be attached to the coil inlet and outlet connections as one assembly integral to the VAV. All piping assemblies for the VAVs supplied shall be identical and interchangeable for inlet sizes of four (4) inch through 24 inch. The supply and return aspect ratios of the inlet and outlet piping shall be 6 inch on center of the coils. The piping aspect ratio is identical for all VAVs supplied regardless of VAV box/coil size.

M. The following minimum factory installed piping components shall be supplied; a valve package consisting of a stainless steel ball valve with a #20 stainless steel screen to act as a strainer, a union, P/T (pressure temperature) port, drain or blow-down with integrated stainless ball valve and removable brass end cap to seal the drain connection. Union with P/T port. All P/T ports require an extension of a minimum of 1.5 inches. Stainless steel isolation valve, union, and P/T readout ports. Pressure gauge to confirm 100% leak free product delivery. Type "L" ¾ inch copper pipe. Two (2) 24 inch long stainless steel hose kits tested to meet UL94 with a VO rating and a washer-less design with a 6" long 3/4:" sealed copper air chamber attached to each end of the hose.

N. Memory stops shall not be provided with VAV boxes, but shall be available from the manufacturer for field retrofit without the need to replace the entire valve, should the need arise.

O. A ½ inch control valve with stainless steel ball and stem shall be provided and factory installed in the piping trim at the factory. A 24 volt electric non-spring return modulating valve actuator shall be provided. The actuator wires shall be terminated to the VMA controller. Both the actuator and control valve shall be tested before leaving the factory.

P. Four aircraft cables shall be factory installed on the VAV with the job specific platform fastening mechanism at the end of the aircraft cables. Cables shall be a minimum of 10 feet long. Cables shall be rated for a minimum of 100 lbs each with a 5:1 safe working load allowance.

Q. A transformer with primary and secondary transformer fusing with a toggle disconnect switch shall be provided and installed at the factory. All secondary wiring from the toggle switch and transformer to the VMA vav controller shall be factory installed and tested before shipment.

R. A platinum 1k ohm DAT (Discharge Air Temperature) Sensor shall be provided. The DAT sensor shall have a stainless steel mounting flange with two hex-head self-drilling mounting screws and come equipped with a 10 ft plenum rated cable with ¼" female insulated quick-connect terminator leads. Cable must meet UL 1995 requirements for installation within an air plenum. The DAT sensor shall be factory installed in the duct extension at the farthest point downstream of the coil. The DAT sensor shall be factory checked for proper resistance range and factory-wired to the VMA- 1630 controller.

S. A VAV box controller shall be provided and factory installed. All wiring from the DAT, transformer and control valve shall be connected and tested at the factory. The pneumatic tubes from the air flow sensor shall be connected to the controller transducer at the factory

2.04 QUALITY ASSURANCE

A. The hydronics piping structure and coil shall be charged with nitrogen or other appropriate dry gas at the factory before shipment at greater than sea level pressure at the assembly area; seal the gas in the piping structure: Test the sealed piping structure and coil for a minimum of 12 hours to determine whether the gas stays within the hydronics Piping Structure and coil through the use of a pressure gauge. If the gas leaks from the hydronics piping structure per the pressure gauge identify the leak, fix it and re-test upon verification of the piping structure having zero leakage of the gas prior to shipment.

B. Transport the sealed and pressurized piping structure with coil from the factory to the construction site; determining a pressure of the gas at the construction site. If hydronics structure and coil arrives without holding pressure, then Contractor to trouble shoot and fix leak.

C. Inside of terminal unit and duct extension to be cleaned and wiped down. Inlet and discharge shall be wrapped with a protective cover. All VAVs shall be individually tagged, strapped down, palletized, enclosed in cardboard boxes and shrink wrapped with a pallet stretch machine. Labels with bar codes shall be adhered to the to each unit with the following information: Tag numbers, Model no, Serial no., Date of manufacture, Manufacturer, Inlet size, MFG, ID # and Job Name. Electrical wiring schematic shall be adhered to the outside of each control enclosure. Additional tagging to be placed on the outside of the cardboard box shrink wrapping. Shipping boxes shall list all relative shipping information including reference ID no., telephone number and name of person/entity receiving the product(s), and tags of individual VAV units on the pallets

D. Inlet of terminal unit and outlet of duct extension to be sealed with a plastic wrap to keep air borne particles out of the inlet and outlet of the VAV. In addition, the entire assembly shall be wrapped and secured to the shipping pallet.

E. Factory Commissioning of Controls and Software
   1. Load appropriate VAV program into the DDC controller and program all the performance parameters commensurate for each zone/VAV unit per schedule supplied by the controls contractor
   2. Properly address each controller with the correct address in order for the BAS system to identify each DDC controller.
   3. Power up the VAV and run the program through full cycle operation. Stroke the damper actuator to full open and then to closed position. Stroke the temperature control valve to full open and full closed.
   4. Set and Ship all actuators in the open position

F. Digital Data Retrieval System – VAV manufacturer shall provide the following as part of the Operational and maintenance manuals in digital form:
   1. Digital images of each individual VAV shipped including the hydronic piping packages, controls hardware, electrical, coil and terminal unit taken before shipment.
   2. Controller software and individual VAV performance files specific for each VAV by tag number.
   3. Approved Submittals
   4. Operational and maintenance instructions
   5. Drawings
   6. Part numbers

PART 3 EXECUTION

3.01 INSTALLATION

A. Install terminal units in strict accordance with manufacturers' published installation instructions.

B. Terminal units to be supported directly from unit to structure with appropriate supports.

C. Refer to section 019113 for terminal box commissioning requirements and methodologies.

D. The HCA standard is that heating coils on VAV boxes are not provided with individual balancing valves. Balancing valves are instead to be provided at every floor, wing, and at every branch serving a minimum of 3 VAV boxes. Confirm balancing of individual terminal box is not included in the base scope of work of the Test and Balancing agent.

E. Provide shutoff valves as required for maintenance and replacement without a large-scale shutdown of equipment.

F. The mechanical contractor is to provide and install a set of isolation valves at the connection of the hot water distribution piping and the braided steel hoses so the boxes can be isolated from the rest of the system in the event of a hose failure.

END OF SECTION

SECTION 234000

HVAC AIR CLEANING DEVICES

PART 1 GENERAL

1.01 WORK INCLUDED

A. Furnish and install filters and factory-fabricated filter housings as scheduled on drawings with appropriate draft gauge(s).

1.02 QUALITY ASSURANCE

A. All filters to meet NFPA 90A requirements for flammability.

B. Filters with a 90% efficiency and less shall be tested in accordance with ASHRAE Standard 52.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. American Air Filter, Flanders, CamFilFarr, TriDim, and 3M.

2.02 MANOMETER

A. Provide a Dwyer magnehelic gauge across each filter bank.

B. Mark gauge to indicate design clean and dirty loading conditions.

2.03 MEDIUM-EFFICIENCY DISPOSABLE FILTERS

A. Provide medium efficiency, disposable, pleated media filters at locations shown on drawings.

B. Each filter shall consist of a non-woven cotton media, media support grid, and enclosing frame.

C. Filter shall be listed by UL as Class II.

D. Provide MERV 11 (60% efficiency) per ASHRAE Test Standard 52.

E. 4-Inch Thick Media: Effective filter media area shall not be less than 4.6 square feet of media per square foot of face area.

2.04 HIGH-EFFICIENCY CARTRIDGE FILTERS

A. Provide MERV 14 (90% efficiency) per ASHRAE Standard 52 to locations shown on drawings.

B. 12-Inch Thick high-efficiency cartridge type filter.

C. Filters to have average velocity through media of not more than 25 fpm.

D. Filters to be selected in accordance with schedule for face velocity in order to produce efficiency and not exceed initial and final resistance as indicated on drawings.

2.05 HEPA FILTERS

A. Filters to be Class I High Efficiency Particulate Air Filters (HEPA), 99.99% efficient on thermally generated, 0.3 micrometer smoke particles of dioctyl-phthalate.

B. All filters shall be factory scan tested and certified for no pinhole leaks.

C. Ultra fine fiberglass media formed into a high density paper and pleated.

D. Media to be waterproof and fire retardant.

E. Pleats to be separated by corrugated aluminum separators.

F. Filter cell to be constructed of fire retardant plywood sides.

G. Neoprene expanded rubber SCE-43 grade 15-30 durometer gasketing.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide filters and housings of size and capacities scheduled on drawings.

B. Mount filters and housings at locations shown on drawings.

C. Provide one complete change of filter media for each air handling unit, delivered to job site and turned over to Owner at final inspection.

D. Install filters in accordance with manufacturers' published installation instructions.

E. Install draft gauge(s) outside of air stream for each bank of filters.

F. Protect heating coils, cooling coils, and ductwork with filter media during construction.

G. Upon completion of ductwork and fan system, thoroughly clean systems and install specified filter media prior to placing system in operation.

H. The installing contractor shall be responsible for providing a new set of clean filters during initial system startup and at the start of TAB fieldwork for all air handling units. In addition, temporary filter media shall be removed and final unit filters shall be installed prior to final unit setup by the TAB agency (i.e., prior to final unit traverse).

END OF SECTION

SECTION 235700

HEAT EXCHANGERS FOR HVAC

PART 1 GENERAL

1.01 WORK INCLUDED

A. Provide where shown on floor plans heat-exchangers of size and type as scheduled on drawings.

PART 2 PRODUCTS

2.01 SHELL AND TUBE HEAT EXCHANGER

A. Tube Bundle - Removable, U-bend Type.

B. Shell - Steel.

C. Tubes - 3/4" O.D. Copper.

D. Heads - Cast Iron or Steel.

E. Tube Sheets - Steel.

F. Baffles, Tie-Rods, Spacers - Steel.

G. Construction
   1. Provide manufacturers' data report for pressure vessels, form No. U-1 as required by provisions of ASME Code Rules along with submittal data. Form to be signed by qualified inspector holding National Board commission certifying construction conforms to latest ASME Code for pressure vessels for 150 psig work pressure and 200 degrees F temperature. ASME "U" symbol to be stamped on each heat exchanger.
   2. Tubes, shell, and tube sheets to be designed for expansion stresses of fluids used.

2.02 PLATE AND FRAME HEAT EXCHANGER

A. Heat exchanger to be designed, tested, and stamped in accordance with ASME Code for Unfired Pressure Vessels for 150 psig working pressure at 100 degree F design temperature.

B. Frame, side bolts, and shroud to be corrosion resistant epoxy painted carbon steel.

C. Corrugated channel plates, carrying bars, and all materials in contact with fluid to be Type 304 stainless steel. Plates and frame shall be designed so an individual plate may be removed without having to remove any other plates.

D. Channel plate ports to be gasketed with nitrile rubber to prevent mixing or cross-contamination and cause any leaks to flow to outside heat exchanger. Gaskets shall not be glued.

E. Connections
   1. Provide piping connections suitable for welding or with 300-pound rated flanges.
   2. Finished unit to be provided with OSHA required, formed aluminum splash guard to enclose exterior channel plate and gasket surfaces.

PART 3 EXECUTION

3.01 INSTALLATION

A. Heat exchanger to be mounted as shown on drawings. Install in strict accordance with manufacturer's published installation instructions.

B. Balance waterflows as specified in other sections.

END OF SECTION

SECTION 236423

PACKAGED AIR COOLED CHILLER SCROLL

PART 1 GENERAL

1.01 WORK INCLUDED

A. Contractor shall provide and install a packaged air cooled chiller as specified herein and scheduled on the drawings. Rate chiller performance according to requirements in AHRI 550/590.

B. Factory Run Test: Chiller shall be pressure-tested, evacuated and fully charged with refrigerant and oil, and shall be factory operational run tested with water flowing through the vessel.

1.02 WARRANTY

A. Unit Warranty: Manufacturer shall include parts and labor warranty on all equipment and material of its manufacture against defects in workmanship and material for a period of twelve (12) months from date of substantial completion.

B. Compressor Warranty: Manufacturer shall warrant all compressors against defects in workmanship and material for a period of sixty-six (66) months from date of shipment

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. York/JCI. For pricing contact:
   1. Johnson Controls, Inc.
      Contact: Kevin P. Tolbert
      email: BE-HCA@jci.com
      478-952-8740

2.02 EQUIPMENT REQUIREMENTS

A. Chiller Materials And Components
   1. General: Install and commission, as shown on the schedules and plans, factory assembled, charged, and tested air cooled scroll compressor chiller(s) as specified herein.
   2. Chiller shall be designed, selected, and constructed using a refrigerant with Flammability rating of "1", as defined by ANSI/ASHRAE STANDARD 34 Number Designation and Safety Classification of Refrigerants.
   3. Chiller shall include not less than two refrigerant circuits above 30 tons, scroll compressors, direct-expansion type evaporator, air-cooled or water-cooled condenser, refrigerant, lubrication system, interconnecting wiring, safety and operating controls including capacity controller, control center, motor starting components and special features as specified herein or required for safe, automatic operation.
   4. Cabinet: For equipment installed outside, external structural members shall be constructed of heavy gauge, galvanized steel coated with baked on powder paint which, when subject to ASTM B117, 1000 hour, 5% salt spray test, yields minimum ASTM 1654 rating of "6".
   5. Operating Characteristics: Provide low and high ambient temperature control options as required to ensure unit is capable of operation from 0°F to 125°F ambient temperature.
   6. Service Isolation valves: Discharge (ball type) isolation valves factory installed per refrigerant circuit. Includes a system high-pressure relief valve in compliance with ASHRAE15.
   7. Pressure Transducers and Readout Capability
   8. Discharge Pressure Transducers: Permits unit to sense and display discharge pressure.
   9. Suction Pressure Transducers: Permits unit to sense and display suction pressure.
   10. High Ambient Control: Allows units to operate when the ambient temperature is above 115°F.
   11. Low Ambient Control: Allows units to operate when the ambient temperature is below 30°F.

B. Compressors: Shall be hermetic, scroll-type, including:
   1. Compliant design for axial and radial sealing.

2. Refrigerant flow through the compressor with 100% suction cooled motor.
3. Large suction side free volume and oil sump to provide liquid handling capability.
4. Compressor crankcase heaters to provide extra liquid migration protection.
5. Annular discharge check valve and reverse vent assembly to provide low-pressure drop, silent shutdown and reverse rotation protection.
6. Initial oil charge.
7. Oil level sight glass.
8. Vibration isolator mounts for compressors.
9. Brazed-type connections for fully hermetic refrigerant circuits.
10. Compressor Motor overloads capable of monitoring compressor motor current. Provides extra protection against compressor reverse rotation, phase-loss and phase-imbalance.

C. Refrigerant Circuit Components: Each refrigerant circuit shall include: a discharge service ball type isolation valve, high side pressure relief, liquid line shutoff valve with charging port, low side pressure relief device, filter-drier, solenoid valve, sight glass with moisture indicator, thermostatic expansion valves, and flexible, closed-cell foam insulated suction line and suction pressure transducer.

D. Heat Exchangers
1. Evaporator:
   a. Evaporator shall be stainless steel construction capable of refrigerant working pressure of 650 psig and liquid side pressure of 150 psig.
   b. Heat exchangers shall be UL listed.
   c. Water nozzles shall be provided with grooves for field provided ANSI/AWWA C-606 mechanical couplings.
   d. Evaporator shall include vent and drain fittings and thermostatically controlled heaters to protect to -20°F ambient in off-cycle.
   e. A 20-mesh, serviceable wye-strainer and mechanical couplings shall be provided for field installation on evaporator inlet prior to startup.
   f. Liquid connection from evaporator shall be at edge of unit. Thermal dispersion type flow switch shall be factory installed in the evaporator outlet pipe extension and wired to the unit control panel. Insulation and heat trace on piping shall be responsibility of installing contractor. Nozzle connections shall be ANSI/AWWA C-606 (grooved).
   g. Where specified, the evaporator shall be freeze-resistant design for cold water production below 40˚F without additives.
2. Air-cooled Condenser:
   a. Coils: Condenser coils shall resist galvanic corrosion due to dissimilar metals. Sub cooling is included. Coils shall be designed for a design working pressure of 650 PSIG (45 bar). Condenser coil shall be washable with potable water under 100 psi (7 bar) pressure.
   b. Low Sound Fans with Variable Speed Drives: All fans shall be powered by VSDs. Fans shall provide vertical air discharge. Fans shall be corrosion resistant. Fan impeller shall be dynamically balanced for vibration-free operation. Fan guards of heavy gauge, PVC (polyvinyl chloride) coated or galvanized steel.
   c. Fan Motors: High efficiency, direct drive, 6 pole, 3 phase, insulation class “F”, current protected, Totally Enclosed Air-Over (TEAO) , rigid mounted, with double sealed, permanently lubricated, ball bearings.

E. Insulation
1. Material: Closed-cell, flexible, UV protected, thermal insulation complying with ASTM C 534 Type 2 (Sheet) for preformed flexible elastomeric cellular thermal insulation in sheet and tubular form.
2. Thickness: minimum 1-1/2” (38mm) and in accordance with applicable energy code.
3. Thermal conductivity: 0.26 (BTU/HR-Ft2-°F/in) maximum at 75°F mean temperature.
4. Factory-applied insulation over cold surfaces of liquid chiller components including evaporator shell, water boxes, and suction line. Liquid nozzles shall be insulated by Contractor after pipe installation.
5. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface including all seams and joints.

F. Acoustical Data
1. Provide acoustical sound power or sound pressure level data in decibels (dB) at the scheduled eight (8) octave band center frequencies. A-weighted sound data alone is not acceptable.
2. Provide all sound power or sound pressure level data at 100%, 75%, 50%, and 25% load.

3. Supplied equipment shall not exceed scheduled sound power or sound pressure level data at any load point. The mechanical Contractor shall be responsible for any additional costs associated with equipment deviation.
4. Acoustical performance ratings shall be in accordance with AHRI Standard 370.

G. Controls
1. General: Automatic start, stop, operating, and protection sequences across the range of scheduled conditions and transients.
2. Power/Control Enclosure: Rain and dust tight NEMA 3R powder painted steel cabinet with hinged, latched, and gasket sealed door.
3. Microprocessor Control Center:
   a. Automatic control of compressor start/stop, anti-coincidence and anti-recycle timers, automatic pump down at system shutdown, condenser fans, evaporator pump, evaporator heater, unit alarm contacts, and chiller operation from 0°F to 125°F ambient. Automatic reset to normal chiller operation after power failure.
   b. Software stored in non-volatile memory, with programmed set points retained in lithium battery backed real-time-clock (RTC) memory for minimum 5 years.
   c. Forty character liquid crystal display viewable in direct sunlight and LED backlit for nighttime viewing, descriptions in English (or Spanish), numeric data in English (or Metric) units. Sealed keypad with sections for Set points, Display/Print, Entry, Unit Options & clock, and On/Off Switch.
   d. Programmable Set points: display language; chilled liquid temperature set point and range, remote reset temperature range, daily schedule/holiday for start/stop, manual override for servicing, low and high ambient cutouts, low liquid temperature cutout, low suction pressure cutout, high discharge pressure cutout, anti-recycle timer (compressor start cycle time), and anti-coincident timer (delay compressor starts).
   e. Display Data: Return and leaving liquid temperatures, low leaving liquid temperature cutout setting, low ambient temperature cutout setting, outdoor air temperature, English or metric data, suction pressure cutout setting, each system suction pressure, liquid temperature reset via a 4-20milliamp or 0-10 VDC input, anti-recycle timer status for each compressor, anti-coincident system start timer condition, compressor run status, no cooling load condition, day, date and time, daily start/stop times, holiday status, automatic or manual system lead/lag control, lead system definition, compressor starts/operating hours (each), status of hot gas valves, evaporator heater and fan operation, run permissive status, number of compressors running, liquid solenoid valve status, load & unload timer status, water pump status.
   f. System Safeties: Shall cause individual compressor systems to perform auto shut down; manual reset required after the third trip in 90 minutes. System Safeties include: high discharge pressure, low suction pressure, high pressure switch, and motor protector. Compressor motor protector shall protect against damage due to high input current or thermal overload of windings.
   g. Unit Safeties: Shall be automatic reset and cause compressors to shut down if low ambient, low leaving chilled liquid temperature, under voltage, and flow switch operation.
   h. Alarm Contacts: Low ambient, low leaving chilled liquid temperature, low voltage, low battery, and (per compressor circuit): high discharge pressure, and low suction pressure.
   i. BAS Communications: BACnet MS/TP
   j. Remote Monitoring: All on-board control points shall be discoverable on the BAS for remote monitoring, trending, and alarms.
4. Manufacturer shall provide any controls not listed above necessary for automatic chiller operation. Mechanical Contractor shall provide field control wiring necessary to interface sensors to the chiller control system.

H. Power Connection And Distribution
1. Power Panels:
   a. NEMA 3R rain/dust tight, powder painted steel cabinets with hinged, latched, and gasket sealed outer doors. Provide main power connection(s), control power connections, compressor and fan motor start contactors, current overloads, and factory wiring.
   b. Power supply shall enter unit at a single location in bottom of panel, be 3 phase of scheduled voltage, and connect to individual terminal blocks per compressor.
   c. Single Point Circuit Breaker: Single point Terminal Block with Circuit Breaker and lockable external handle (in compliance with Article 440-14 of N.E.C.) to be supplied to isolate power voltage for servicing. Incoming power wiring must comply with the National Electric Code and/or local codes.
2. Compressor, control and fan motor power wiring shall be located in an enclosed panel or routed through liquid tight conduit.

I. Accessories And Options
   1. Control Power Transformer: Converts unit power voltage to 120-1-60 (500 VA capacity). Factory-mounting includes primary and secondary wiring between the transformer and the control panel.
   2. Condenser Coil Environmental Protection (if installed outside within 60 miles of coastal environment): Post-Coated Dipped: Dipped-cured coating on condenser coils for seashore and other corrosive applications (with the exception of strong alkalis, oxidizers, and wet bromine, chlorine and fluorine in concentrations greater than 100 ppm).
   3. Protective Chiller Panels (Factory Mounted): Louvered Panels (full unit): Painted steel as per remainder of unit cabinet, to protect condenser coils from incidental damage, visually screen internal components, and prevent unauthorized access to internal components.
   4. Thermal Dispersion Flow Switch (Factory installed and wired in piping extension kit): Normally open, 30bar pressure rating, stainless steel 316L construction, IP67, -4°F to 158°F ambient rating.
   5. Hot Gas By-Pass: Permits continuous, stable operation at capacities below the minimum step of unloading to as low as 5% capacity (depending on both the unit & operating conditions) by introducing an artificial load on the evaporator. Hot gas by-pass is installed on only one refrigerant circuit.
   6. Low Temperature Process Glycol: Leaving chilled liquid set point range 10°F to 50°F.
   7. Sound Reduction (Factory installed): Compressor Acoustic Sound Blankets
   8. Vibration Isolation (Field installed): 2" Deflection Restrained Spring Isolators: Level adjustable, restrained mounts in rugged welded steel housing with vertical and horizontal limit stops. Housings shall be designed to withstand a minimum 1.0g accelerated force in all directions to 2 inches (50.8 mm)

J. Modular Chiller Requirements
   1. Each circuit shall be constructed to be independent of other circuits from a refrigeration and electrical stand-point. The multi-circuit chiller must be able to produce chilled water even in the event of a failure of one or more refrigerant circuits.
   2. Compressors, heat exchangers, piping and controls shall be mounted on a heavy gauge coated steel frame. Electrical controls, contactors, and relays for each module shall be mounted within that module.
   3. The compressors shall be enclosed in sound attenuating blankets. An easily-removable, internally-lined enclosure shall be provided to further attenuate sound transmission.
   4. Chilled and Condenser Water Mains: Each module shall include supply and return mains for both chilled and condenser water. Cut grooved end connections shall be provided for interconnection to piping with grooved type couplings. Rolled grooved shall be unacceptable. Water Mains shall be installed such that they are beneath any power or control wiring so as to ensure for safe operation in the event of condensation or minor piping leaks.
   5. Evaporators and Condensers: Evaporator and condenser shall be brazed plate heat exchangers constructed of 316 stainless steel; designed, tested, and stamped in accordance with UL 1995 code for 650 psig working pressure on the evaporator and 650 psig working pressure on the condenser. Both the condenser and evaporator heat exchanger shall be mounted below the compressor, to eliminate the effect of migration of refrigerant to the cold evaporator with consequent liquid slugging on start-up.
   6. Variable Flow Operation (Chilled and/or Condenser Water): Automatic butterfly type isolation valves shall incorporate appropriate accessories and controls to allow the chiller to operate efficiently in a variable primary flow system. Each valve shall modulate via a motorized actuator for return water temperature control, chiller minimum flow bypass, chiller no load bypass, or head pressure control.
   7. Total Access Design: Manual isolation valves shall be installed between the heat exchangers and water supply mains for heat exchanger isolation and removal without the requirement to shut down the entire chiller allowing for total access to all serviceable components.
   8. Compressor: Each module shall contain two hermetic scroll compressors independently circuited and with internal spring isolation mounted to the module with rubber-in-shear isolators. Each system shall also include high discharge pressure and low suction pressure manual reset safety cut-outs.
   9. Central Control System: Scheduling of the various compressors shall be performed by a microprocessor based control system (Master Controller). A new lead compressor is selected every 24 hours to assure even distribution of compressor run time.
   10. Automatic Module Partitioning: Where required by engineering design for variable heat recovery applications, automatic butterfly valves shall be provided between each chiller module. Valves shall be actuated open or closed by the chiller controller based on signal from BAS in response to heating or cooling loads.
   11. The Master Controller shall monitor and report the following on each refrigeration system:
       a. Discharge Pressure Fault
       b. Suction Pressure Fault

c. Compressor Winding Temperature
d. Suction Temperature
e. Evaporator Leaving Chilled Water Temperature

12. The Master Controller shall be powered by the single point power connection and shall monitor and report the following system parameters:
    a. Chilled Water Entering and Leaving Temperature
    b. Condenser Water Entering and Leaving Temperature
    c. Chilled Water and Condenser Water Flow
13. An out of tolerance indication from these controls or sensors shall cause a "fault" indication at the Master Controller and shutdown of that compressor with the transfer of load requirements to the next available compressor. In the case of a System Fault the entire chiller will be shut down. When a fault occurs, the Master Controller shall record conditions at the time of the fault and store the data for recall. This information shall be capable of being recalled through the keypad of the Master Controller and displayed on the Master Controller's 2 line by 40 character back-lit LCD. A history of faults shall be maintained including date and time of day of each fault (up to the last 20 occurrences).
14. Individual monitoring of leaving chilled water temperatures from each refrigeration system shall be programmed to protect against freeze-up.
15. The control system shall monitor entering and leaving chilled water temperatures to determine system load and select the number of compressor circuits required to operate. Response times and set points shall be adjustable. The system shall provide for variable time between compressor sequencing and temperature sensing, so as to fine tune the chiller to different existing building conditions.
16. Interoperability: The Chiller shall be capable of interfacing to the building automation system. Interface shall be accomplished using an Interoperability Web Portal and shall be capable of communication over BACNet.
17. The chiller array shall have a single or double point power connection based on engineer requirements. Single external inputs and outputs are to be compatible with the building automation system. Inputs/Outputs required include:
    a. Remote Start/Stop
    b. Customer Alarm Relay
    c. Customer Chilled/Load Limit Reset Signal
    d. ECW to Mechanical Cooling Module
    e. LCW from Mechanical Cooling Module
    f. ECHW to Mechanical Cooling Module
    g. LCHW from Mechanical Cooling Module
    h. Power Phase Monitor
    i. Chilled Water Flow Switch Input
    j. Condenser Water Flow Switch Input
    k. Full Load Indicator Relay
    l. Condenser Pump Relay
    m. Chilled Water Pump Relay
18. Single Point Power: Chiller shall be equipped with a pre-engineered genuine buss bar electrical system for single point power. Where the equipment size exceeds the amp rating of the buss bar, multiple power connections may be applied. Pre-engineered system shall also incorporate individual module isolation circuit breakers for full redundancy and ability of a module to be taken off-line for repair while the rest of the modules continue to operate. Individual power feeds to each module shall be unacceptable.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Rig and Install in full accordance with Manufacturer’s requirements, Project drawings, and Contract documents.

B. Location: Locate chiller as indicated on drawings, including cleaning and service maintenance clearance per Manufacturer instructions. Adjust and level chiller on support structure.

C. Components: Installing Contractor shall provide and install all auxiliary devices and accessories for fully operational chiller.

D. Electrical: Coordinate electrical requirements and connections for all power feeds with Electrical Contractor (Division 26).

E. Controls: Coordinate all control requirements and connections with Controls Contractor.

F. Finish: Installing Contractor shall paint damaged and abraded factory finish with touch-up paint matching factory finish.

END OF SECTION

SECTION 237313

AHU MODULAR INDOOR CENTRAL STATION

PART 1 GENERAL

1.01 DESCRIPTION

A. Provide air-handling units of the single-zone draw-thru, double wall central station type and size as scheduled on drawings.

1.02 PERFORMANCE

A. Certify unit components in accordance with AHRI Standard 430 as applicable.

B. Certify coils in accordance with AHRI Standard 410. Substantiate performance by AHRI computer-generated output.

C. Furnish coils with minimum rows and fins as scheduled even though performance can be achieved with fewer rows or fins.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. York/JCI. For pricing contact:
   1. Johnson Controls, Inc.
      Contact: Kevin P. Tolbert
      email: BE-HCA@jci.com
      478-952-8740

B. Manufacturers to review the allowable space for the units considering supply and return airflow, service and maintenance access, coil pull clearance, and piping connections to insure adequate clearance exists for their units prior to submitting bid. Contractor shall not be allowed extra payment should the low bidder prove to have unacceptable clearance.

2.02 UNIT CONSTRUCTION

A. Unit sections shall be 2" double wall construction. Exterior wall shall be minimum 18-gage solid galvanized steel. Interior wall shall be minimum 20-gage solid galvanized steel. Unit to be completely insulated with 1-1/2 pound density fiberglass insulation to meet R value of 13 hr-ft^2-°F/Btu. Insulation shall meet NFPA-90A standards. All connecting channels shall be insulated to prevent sweating.

B. Provide view windows in access doors at pre-filter section and fan sections and humidifier section.

C. The unit manufacturer shall provide a factory leak test on all units at 8" wg. static pressure. Cabinet leakage is not to exceed 1% of specified air flow on the operating side of the unit. Manufacturer shall furnish a written report to the engineer. If the unit manufacturer has a ETL listing, previous test data on similar units may be used as a substitution for the actual leak test.

D. Perforated panels shall be provided on intake, discharge, and fan sections.

E. Provide wall panels and access doors that deflect no more than L/240 when subjected to 1.5 times design static pressure up to a maximum of +8 inches w.g. in positive pressure sections and -8 inches w.g. in negative pressure sections. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint.

F. Provide floors and roofs that deflect no more than L/240 when subjected to a 300 lb static load at mid-span. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint.

G. All exterior (minimum 18 gauge) and interior (minimum 20 gauge) casing panels (roof, wall, access door) shall be made of G90 galvanized steel. Interior casing panels (walls and floor) shall be made of 304 stainless steel within wet sections

from cooling coil humidifier up to supply fan bulkhead sections. Units installed within 60 miles of the coast shall also include 304 stainless steel walls in outdoor air sections up to the cooling coil.

H. Floors shall be provided with 0.125" aluminum diamond treads plate liner for units 48" and greater in height. Units below 48" in height shall have 14 gauge G90 galvanized steel floors in dry sections and 14 gauge 304 stainless steel floors from cooling coil or humidifier to fan bulkhead. Units shorter than 48" installed within 60 miles of the coast shall also have 14 gauge 304 stainless steel floors in outdoor air sections up to the cooling coil.

2.03 FAN SECTION

A. Fan Array Systems:
   1. The fan array systems shall include multiple, direct driven, arrangement 4 plenum fans constructed per AMCA requirements for class III duty. The fan array shall be selected to operate at a system Total Static Pressure that does not exceed 90% of the specified fan's peak static pressure producing capability at the specified fan/motor speed. Motors shall be manufactured for use in multiple fan arrays that operate at varying synchronous speeds as driven by an approved VFD. All motors shall include permanently sealed (L10-300,000 hr) bearings and shaft grounding to protect the motor bearings from electrical discharge machining due to stray shaft currents. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, exceeding category BV-5, to meet or exceed an equivalent Grade G.55, producing a maximum rotational imbalance of .022" per second peak, filter in.
   2. The fan array shall consist of multiple fans and motors, spaced in the air way tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein. There shall be no blank off plates or "spacers" between adjacent fan columns or rows to position the fans across the air way tunnel.
   3. Each Fan Array section to be provided with fan blank-off panels to enable manual isolation of fan for servicing. Quantity of panels shall equal number of fans on a single VFD. Backdraft dampers (barometric or controlled) shall not be permitted. The system effects for the back flow prevention device(s) shall be included in the criteria for TSP determination for fan selection purposes, and shall be indicated as a separate line item SP loss in the submittals.
   4. All motors in the fan array system shall be provided with individual motor protection for thermal overload protection. All motor circuit protectors can be located in starting device enclosure or in a separate enclosure. Motor circuit protector enclosure must be located and mounted at a minimal distance from motors in the fan array. Provide remote indication by means of aux contacts wired in series.
   5. Each individual fan in the fan array shall be equipped with a Piezometer ring air flow measuring sensor mounted in the factory. Sensor to be accurate to +/- 1.5% measurement accuracy. There shall be no portions of device protruding into the inlet cone. All sensors shall be wired to a single monitoring panel with user interface. The system shall be capable of detecting failed fans and correcting the total output signal for any air that backflows through the failed fan. Refer to Section 230923 for specification of airflow transmitters.
   6. Provide fan section with full sized, hinged, latched, double wall access doors for access to fan, motor, and bearings.
   7. Mount each fan and motor assembly on minimum 1" deflection spring isolators. Fan assembly to be completely isolated from unit bulkhead with flexible neoprene connections.
   8. For units with dual fans or fan arrays, provide two Variable Frequency Drives (VFD) with half the number of fans on one VFD and the other half of the fans on a separate VFD.
   9. Eighty hertz is the maximum allowed at design conditions unless approved by FacilitiGroup Engineer.
   10. Airfoil fans shall comply with AMCA standard 99 2408 69 and 99 2401 82. Provide an AMCA seal on airfoil fans. Airfoil fan performance shall be based on tests made in accordance with AMCA standards 210 and comply with the requirements of the AMCA certified ratings program for air performance.
   11. Provide fans with the following accessories:
       a. Fan inlet screens
       b. OSHA-compliant belt guard enclosing the fan motor and drive (if belt driven)
   12. Provide fans with polished steel shafts with first critical shaft speed at least 125% of the maximum operating speed for the fan pressure class. Shaft shall have an anti-corrosion coating.
   13. Provide horizontal thrust restraints between AHU casing and fan housings.

2.04 COIL SECTION

A. Coil Section:
   1. Provide insulated, double wall, stainless steel construction drain pan extending under the coil and fan sections. Pan shall be sloped to provide positive drainage of condensate. Drain connection(s) are to be provided on the water piping connection side of unit. Coil sections with stacked coils to have an intermediate drain pan with condensate drop tubes to main drain pan.
   2. Completely enclose coil headers within the insulated casing with piping connections extended through cabinet. Piping connections to be on same end of unit.
   3. Provide coil section with removable access panel or access door to remove coil.

B. Cooling Coils - Chilled Water.
   1. Coil to be constructed of 5/8" outside diameter copper tubing minimum 0.025" thick with aluminum fins and copper headers. Bond fins by mechanical expansion shall be 0.0075 inch thick. Casing shall be 16 gauge 304 stainless steel.
   2. Provide coils with a maximum working pressure of 175 psig at 200 degrees F.
   3. Provide circuited drainable coils with vent connection at highest point and drain connection at lowest point.

C. Heating Coils - Hot Water:
   1. Coil to be constructed of 5/8" outside diameter copper tubing minimum 0.025" thick with aluminum fins and copper headers. Bond fins by mechanical expansion shall be 0.0075 inch thick. Casing shall be 16 gauge 304 stainless steel.
   2. Provide coils with a maximum working pressure of 175 psig at 200 degrees F.
   3. Provide circuited drainable coils with vent connection at highest point and drain connection at lowest point.

D. Condensate Pan: Condensate drain pan shall be 16 gauge stainless steel. All pans are to be insulated “Double Bottom” construction with welded corners. Drain pans are to be sloped for complete drainage with no standing water in the unit. Drain connections shall be standard 1 ¼" MPT connection. Drain pans shall be provided under all cooling coil sections and humidifier section.

E. Provide drain connection made of same material as drain pan. Do not use dissimilar metals because of the risk of galvanic corrosion. Weld connection to the drain pan.

F. Cooling coil drain pan shall be double wall construction with an insulation R- value of 13 hr-ft2-°F/ (BTU-in). Low temp glycol coils shall be provided with additional 2” insulated drain pan subfloor. Drain pans shall be extended as much as possible without making the section longer.

G. Provide drain pan under the complete width and length of cooling coil and humidifier sections. Drain pan shall be full width, and completely extend to next section downstream of cooling coil and humidifier within AHU without growing section length. Pan shall extend a minimum of 12” downstream of cooling coil except where the length is limited due to the installation of UV lighting.

H. Drain pan shall allow visual inspection and physical cleaning on 100% of the pan surface without removal of the coil or humidifier.

I. Provide a minimum of 1” clearance between the drain pan and any coil casing, coil support or any other obstruction.

J. Provide drain pan that allows the design rate of condensate drainage regardless of fan status.

K. Provide drain pan sloped in at least two planes by at least 1/8” per foot toward a single drain. Locate drain connection at the lowest point of the pan. Pan shall have no horizontal surfaces.

2.05 FILTER SECTION:

A. Refer to Section 234000 HVAC Air Cleaning Devices.

B. Provide factory-built flat filter section complete with filters as specified herein. Minimum filter area to be as specified on unit schedule but not to exceed 500 fpm filter face velocity. Filter sections to have full sized, hinged, latched, double wall access doors for filter service.

C. All filter racks shall be front loading type and shall have metal support on the entire perimeter of the filter cartridge.

D. Provide integral hold down clips for holding filter cartridge against filter rack.

E. Install frames to provide service and installation from the dirty side.

F. The Cx authority shall inspect the filter arrangement for tight fit and absolute minimal bypass leakage around frame assembly and it shall be the responsibility of the contractor to correct any deficiencies prior to acceptance by the Owner.

G. Provide 4" thick, MERV 11 (60% efficiency) disposable pre-filters.

H. Provide 12" thick MERV 14 (90% efficiency) cartridge final filters.

I. Provide a factory mounted magnahelic gage across each filter section and mark gage to indicate design clean and dirty loading conditions.

J. In addition to the set of filters provided with the air handler, provide one clean set for balancing, and one additional set for final turnover to owner, for a total of 3 sets of filters provided.

2.06 ADDITIONAL SECTIONS

A. Mixing box to have interconnected low-leak type outside and return air dampers with parallel blades. Arrange dampers so outside and return air merge when entering mixing box. Damper rods to rotate in nylon bushings.

B. Humidifier Section: Manufacturer shall provide factory-packaged steam injection type humidifier when scheduled on the drawings. Arrange and install so that condensation does not occur upstream or downstream of the humidifier. Refer to section 238413.

C. Air Blender: Provide factory installed air blenders in all units to insure a maximum of one degree Fahrenheit differential at any given points across the cooling coil at all airflows and ambient conditions.

2.07 FACTORY INSTALLED ELECTRICAL ACCESSORIES

A. In addition to motor power terminals, provide an independent power terminal for convenience receptacles and lights. Provide switches as shown on drawings.

B. Provide LED (light emitting diode) lights in segments as scheduled or shown on drawings. Provide light switches as scheduled or shown on drawings. Lights shall be constructed of safety glass and suitable for wet locations.

C. Provide a 1-hour timer on external light switches.

D. Provide a 20A 120V convenience receptacle on supply fan segment. Receptacle shall be powered separately from fan VFD so it remains energized when fan disconnect is open.

2.08 UVC FIXTURES

A. Provide surface decontamination UV fixtures within cooling coil sections for air handlers serving emergency departments, operating rooms, bone marrow areas, and all ICUs.

B. UV system shall be tied to a switch to kill power to the lighting system when the access door is opened. A second manual kill switch shall be provided inside the unit for safety.

C. UVC products shall be from an ISO 9001 manufacturer or the supplier shall provide proof of 100% inbound and outbound testing of equipment and have at least 10 years' experience as a manufacturer of UVC products for air handling equipment.

D. Fixtures shall be tested, listed and labeled as UL/C-UL under Category Code ABQK (Accessories, Air Duct Mounted), UL Standards: 153, 1598 & 1995 respectively.

E. Fixtures shall meet the "UL" drip proof design and each fixture is equipped with an electrical interlock.

F. Useful lamp life shall be 9000 hours with no more than a 20% output loss at the end of one year of continuous use. They are constructed with UVC proof metal bases and shall not produce ozone.

G. Each lamp shall contain no more than 8 milligrams of mercury, consistent with current environmental practices, while producing the specified output at 500 fpm in temperatures of 55-135° F.

H. Lamps and fixtures shall be installed in sufficient quantity and in such a manner so as to provide even distribution of UVC energy on designated surface area (Coil, filter rack, etc.). When installed, the minimum intensity striking any point on a plane representing the surface of the coil or component shall not be less than 50 microwatts per square centimeter. Average radiation shall be 150 microwatts minimum per square centimeter.

I. The minimal UVC energy striking a surface shall be sufficient to continuously destroy a mono-layer of mold and bacteria as typically found in HVAC systems in less than six hours.

J. Lamp fixtures shall be constructed of type 304 stainless steel to preclude corrosion. Support components shall be constructed of type 304 stainless or galvanized cold rolled steel.

K. Power supply shall be of a high efficiency, high frequency electronic type, matched to the lamp and designed to maximize UVC radiance and reliability. They shall be capable of four wire lamp operation rapid start. They shall be UL Listed and labeled, and comply with FCC 47, Part 18, non-consumer limits requirements. The ballast shall be protected from failure in the event of End of Lamp life lamp failure. The ballast shall be capable of operation indefinitely when powered with no lamp or a failed or broken lamp. Track mounted fixture ballasts shall have 120VAC or 240 VAC input. Strut mounted ballasts shall have universal input (100VAC to 277VAC). Track mounted fixtures shall be capable of producing the output as specified under Irradiation and Intensity at no more than 13Watts of power consumption for each square foot of treated, cross sectional plane.

L. Ballast system shall not proprietary to the manufacturer of the UV bulb.

M. Provide and install a UV radiometer for monitoring bulb intensity near center of coil - tie to BAS. Set BAS to alarm operator when bulb intensity drops below manufacturer-recommended threshold.

N. Original purchase of equipment has to include a separate price for a service contract to replace bulbs once per year for five years after startup. Contract must include materials and labor to install new and dispose of old bulbs. Contract must be signed by the facility prior to submittal approval.

2.09 APPURTENANCES

A. For motors 7.5HP and larger in the stacked position, provide internal structural I-Beam motor removal rail with structural frame to distribute motor weight to unit base. Rail shall be perpendicular to centerline of access door for ease of removal.

2.10 FINISHES

A. Provide steel base rails suitable for rigging and lifting, as shown on product drawings.

B. Provide safety grates over bottom openings, as shown on drawings. Safety grates shall be capable of supporting a 300 lb. center load.

C. Provide lifting lugs where required.

D. Manufacturer shall clean the exterior surfaces of units prior to finishing, painting, or shipment.

E. Unpainted air-handling units constructed of galvanized steel shall pass the ASTM B-117 test for 220-hour salt spray solution (5%) without any sign of red rust. (confirm).

PART 3 EXECUTION

3.01 SUBMITTALS

A. At the time of submission to Engineer, Contractor shall submit an information only copy of the complete air handling unit submittal to HCA Corporate Engineering FaciliGroup, 6100 Tower Circle, Suite 400, Franklin, TN 37067.

3.02 COORDINATION

A. Prior to purchasing units, refer to drawings and coordinate the required side of unit for motor, access panels and doors, and duct and piping connections to provide proper access clearance.

3.03 DELIVERY, STORAGE AND HANDLING

A. Comply with ASHRAE 62, Section 5 (mold and corrosion resistant casings, filters upstream of wetted surfaces, and drain pan design).

B. Comply with ASHRAE 62, Section 7 (practices to be followed during construction and startup). Protect equipment from moisture by appropriate in-transit and on-site procedures.

C. Follow manufacturer's recommendations for handling, unloading and storage.

D. Protect, pack, and secure loose-shipped items within the air-handling units. Include detailed packing list of loose-shipped items, including illustrations and instructions for application.

E. Protect, pack and secure controls devices, motor control devices and other electronic equipment. Do not store electronic equipment in wet or damp areas even when they are sealed and secured.

F. Enclose and protect control panels, electronic or pneumatic devices, and variable frequency drives. Do not store equipment in wet or damp areas even when they are sealed and secured.

G. Seal openings to protect against damage during shipping, handling and storage.

H. Wrap indoor and outdoor units with a tight sealing membrane. Wrapping membrane shall cover entire AHU during shipping and storage. Cover equipment, regardless of size or shape. Alternatively AHU must be tarped for shipment and storage.

I. Wrap equipment, including electrical components, for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion. Keep equipment clean and dry.

J. Clearly mark AHU sections with unit tag number, segment sequence number, and direction of airflow. Securely affix safety-warning labels.

3.04 WARRANTY

A. Provide entire unit parts and labor warranty for 12 months from date of substantial completion. Warranty shall cover manufacturer defects. Warranty work shall be performed by manufacturer's factory-trained and factory-employed technician.

B. For air handlers provided with UV lights, include service contract to replace bulbs once per year for five years after startup. Contract must include materials and labor to install new and dispose of old bulbs.

C. Parts associated with other routine maintenance, such as belts and air filter replacement shall be excluded.

3.05 SYSTEM STARTUP

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

B. Comply with manufacturer's start-up requirements to ensure safe and correct operation and integrity of warranty.

3.06 INSTALLATION

A. Install each unit on a minimum 4" high, level, rigid, and heavy concrete base.

B. Provide proper clearance at each unit for routine service including the changing of filters, removal of coils, bearing greasing, opening of access doors, and pulling of fan shaft.

C. Ductwork: Duct connections at each unit to allow for straight and smooth airflow. No turns are to be installed at the fan discharge which are in the opposite direction to fan wheel rotation. Provide flexible connections at duct connections to unit.

D. Piping:
   1. Support piping independently of coils and with adequate flexibility to prevent undue stress at coil header connections.
   2. Install full size drain lines from the drain pan connection to nearest floor drain and include trap to permit condensate to drain freely. The cooling coil condensate drain piping should be suitably configured and trapped to allow the condensate to drain while the air handling unit is in operation.
   3. Install service valves on both supply and return lines to coils and install so valves can be shut off, a small section of pipe removed, and coil allowed to slide out. This condition applies to water and steam coils only.

E. Do not use AHUs for temporary heating, cooling or ventilation prior to complete inspection and startup performed per this specification.

F. AHU Inspection:
   1. Installing Contractor to perform an inspection of unit and installation prior to startup. Start-up report submitted to general contractor shall verify the following as a minimum:
      a. Damage of any kind
      b. Level installation of unit
      c. Proper reassembly and sealing of unit segments at shipping splits.
      d. Tight seal around perimeter of unit at the roof curb
      e. Installation of shipped-loose parts, including filters, air hoods, bird screens and mist eliminators.
      f. Completion and tightness of electrical, ductwork and piping
      g. Tight seals around wiring, conduit and piping penetrations through AHU casing.
      h. Supply of electricity from the building's permanent source
      i. Integrity of condensate trap for positive or negative pressure operation
      j. Condensate traps charged with water
      k. Removal of shipping bolts and shipping restraints
      l. Sealing of pipe chase floor(s) at penetration locations.
      m. Tightness and full motion range of damper linkages (operate manually)
      n. Complete installation of control system including end devices and wiring
      o. Cleanliness of AHU interior and connecting ductwork
      p. Proper service and access clearances
      q. Proper installation of filters
      r. Filter gauge set to zero
   2. Resolve any non-compliant items prior to unit start-up.

END OF SECTION

SECTION 237513

PACKAGED DX OUTDOOR ROOFTOP UNIT

PART 1 GENERAL

1.01 WORK INCLUDED

A. Provide packaged VAV air conditioning units as manufactured by AAON.

1.02 QUALITY ASSURANCE

A. Unit cooling capacity shall be in accordance with and tested to AHRI Standard 210/240 or 360.

B. Units up to 20 tons capacity shall carry the AHRI compliance label.

C. Units shall be safety certified in accordance with UL Standard UL465 and ANSI Standard Z21.47.

D. Unit shall be safety certified by an accredited testing laboratory. Unit nameplate shall carry the label of the certification agency.

E. Unit shall be shipped completely assembled by the manufacturer including all standard items and accessory items.

F. Unit shall be 100 percent run tested by the manufacturer with a copy of the run test report shipped with the unit.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Unit Construction:
   1. Unit shall be completely factory assembled, piped, wired and shipped in one piece.
   2. Unit shall be specifically designed for outdoor application with a fully weatherproof cabinet.
   3. Unit shall be designed for mounting on a roof curb.
   4. Cabinet shall be constructed entirely of G90 galvanized steel with the exterior constructed of 18 gauge or heavier material.
   5. The unit roof shall be cross broken and/or sloped to assure drainage.
   6. Access to compressor(s), controls, filters, fan(s), heating section, and other items needing periodic checking or maintenance shall be through hinged access doors with a quarter turn latch (door fastening screws are not acceptable).
   7. Air side service access doors shall be fully gasketed with rain break overhangs. Air side access doors shall have an internal metal liner to protect the door insulation.
   8. Unit exterior shall be painted with 2-part polyurethane paint over a wash primer and a paint grip type galvanized steel.
   9. The interior side of all exterior panels shall be entirely insulated with 1" thick, one pound density, neoprene coated, fiberglass insulation.
   10. Unit shall be provided with interior insulation liners to provide double wall construction.
   11. Insulate base on units not mounted on a curb.
   12. All openings through the base pan of the unit shall have upturned flanges of at least 1/2" in height around the opening through the base pan.
   13. Unit shall have decals and tags to indicate unit lifting rigging, service areas, and caution areas.
   14. Wiring diagrams shall be both "point-to-point" and "ladder" diagrams. Wiring diagrams shall also be laminated in plastic and permanently fixed to the control compartment door.
   15. Wiring shall be color coded and marked with identification on each end.

B. Fans:
   1. Fan(s) shall be entirely self-contained on a slide deck for service and removal from the cabinet.
   2. All motors 1 horsepower and larger shall have belt-driven fans. All motors less than 1 horsepower shall have direct-driven fans. Belt-driven fan(s) shall have backward inclined airfoil blades. Adjustable v-belt drive shall be

provided with a minimum rating of 140 percent of the motor nameplate brake horsepower when the adjustable pulley is at the minimum RPM. Direct-driven fan(s) shall have forward curved blades.
3. Fans, drives, and motors shall be dynamically balanced.
4. Provide high-efficiency fan motors and variable frequency drive. Mount VFD inside electrical section.

C. Condensing Section:
1. The condensing section shall be equipped with direct-drive, vertical discharge condenser fan(s).
2. The condenser coil shall be sloped at least 30 degrees from horizontal to protect the coil from damage. If condenser coil is not sloped for protection, louvered coil guards shall be provided.
3. Condenser coil(s) shall be copper tubes with aluminum fins mechanically bonded to the tubes.
4. Condenser coil(s) to be sized for a minimum of 10 degrees sub-cooling.

D. Evaporator Coil:
1. Evaporator coil shall be minimum 6 rows.
2. Evaporator coil(s) shall be copper tubes with aluminum fins mechanically bonded to the tubes.
3. Evaporator coil(s) shall have galvanized steel end casings.
4. Evaporator coil(s) shall have equalizing type vertical tube distributors with a top suction connection.
5. Evaporator coil(s) for multi-compressor units shall be circuited with one circuit and expansion valve per compressor.
6. Unit shall be provided with stainless steel drain pan.

E. Refrigeration System:
1. Compressor(s) shall be of the hermetic scroll type with internal thermal overload protection.
2. All units over 7-ton capacity shall be multiple stage and shall have a minimum of two stages of capacity control.
3. Compressor(s) shall be mounted in an isolated compartment to permit operation of the unit without affecting airflow when the compressor compartment is open.
4. Compressor(s) shall be isolated from the base pan and supply air to avoid any transmission of noise from the compressor into the building area.
5. System shall be equipped with thermostatic expansion valve type refrigerant flow control.
6. System shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant controls.
7. Unit shall be equipped with Schrader type service fittings on both the high side and low pressure sides of the system.
8. Unit shall be equipped with refrigerant liquid line filter driers.
9. Unit shall be fully factory charged with refrigerant R-410.
10. 5-year compressor warranty shall be provided.
11. Unit shall be provided with 0 degree F low ambient control.
12. Unit shall be provided with hot gas bypass on each refrigerant circuit.
13. All circuits shall be equipped with liquid line sight glass.
14. Unit shall be provided with 5-minute anti-short cycle time delay relay for each compressor unless thermostat or microprocessor control provides this feature.
15. Multi-compressor unit shall be provided with 20-second time delay relay to prevent both compressors from starting simultaneously unless thermostat or microprocessor control provides this feature.

F. Electric Heating: Unit shall be provided with an electric heating section complete with fuses and manual reset high temperature limit switch. Provide modulating SCR control.

G. Outside Air:
1. Outside air shall be 0-50 percent with an adjustable motor-operated outside air damper constructed of extruded aluminum blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 25 cfm of leakage per square foot of damper area when subjected to 2" w.g. air pressure differential across the damper. Damper motor shall be spring return to ensure closing of outside air damper during periods of unit shutdown or power failure.

H. Filters:
1. Unit shall be provided with 4" thick, 65 percent high-efficiency pleated, throwaway supply air filters.
2. Provide clogged filter switch.
3. Provide filter gauge.

I. Electrical:
   1. Unit shall be provided with a factory installed and wired internal non-fused disconnect switch.
   2. Unit shall be provided with a factory installed and factory wired 115-volt, 13-amp ground fault service receptacle.

J. Controls:
   1. Provide terminals for connection to controls provided under separate controls section.
   2. Provide unit mounted variable air volume programmable microprocessor controller to control discharge air temperature and supply duct static pressure. Provide with discharge air temperature sensor, return air temperature sensor, outside air temperature sensor, zone temperature sensor and supply air duct static probe.
   3. Provide one hand-held service tool with keypad and LCD display to communicate with unit programmable controller and allow user to view any temperature or output condition and change any setpoint for any unit. Turn service tool over to Owner at project completion. Start up and verify unit controls and system manager are operating properly.

K. Roof Curb: Roof curbs shall be constructed of galvanized steel. Roof curbs shall be minimum 14" high. Curbs shall be fully gasketed between the curb top and unit bottom. Curbs shall provide full perimeter support, cross structure support and air and water tight seal for the unit.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install unit in accordance with manufacturers' published installation instructions.

B. Manufacturers' representative service technician to provide start-up supervision for each unit.

C. Duct connections to units to allow for straight and smooth airflow. Connections to unit to be made with flexible duct connections. Sleeve duct penetrations through roof. Provide three 2" layers of neoprene coated fiberglass duct liner to completely fill inside of roof curb.

D. Drain lines to be trapped and run full size from drain pan connection to discharge into nearest roof drain.

END OF SECTION