

PROJECT MANUAL

for



HOWSER STADIUM UPGRADE HVAC

FSU Project No. 2601490

(Bid number)

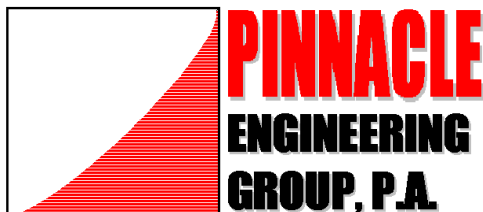
by

FLORIDA STATE UNIVERSITY

Set No. _____

100% CONSTRUCTION DOCUMENTS

Date Issued: October 22, 2026



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**FLORIDA STATE UNIVERSITY
HOWSER STADIUM UPGRADE HVAC
[FSU # 2601490 / PEG #226-106]**

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SECTION 01 91 13 - GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes general requirements that apply to implementation of commissioning without regard to specific systems, assemblies, or components.
- B. The commissioning for this project will be "construction level" only. This is not an enhanced commissioning project whereby design will be reviewed by the CxA. The intent is that the final product be commissioned to ensure it operates in accordance with the EOR's requirements.

1.3 DEFINITIONS

- A. BoD: Basis of Design. A document that records concepts and product selections used to meet the OPR and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.
 - 1. This document is to be provided by the Owner/Design Professional.
- B. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
 - 1. This document will be abbreviated to suit the project as required for construction level commissioning.
- C. CxA: Commissioning Authority.
- D. OPR: Owner's Project Requirements. A document that details the functional requirements of a project and the expectations of how it will be used and operated. These include Project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.
 - 1. This document is to be provided by the Owner/Design Professional.
- E. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 COMMISSIONING TEAM

- A. Members Appointed by Contractor(s): Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, representatives of the Contractor, including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.
- B. Members Appointed by Owner:
 - 1. CxA: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process. Owner will engage the CxA under a separate contract.
 - 2. Representatives of the facility user and operation and maintenance personnel.

3. Architect and engineering design professionals.

1.5 OWNER'S RESPONSIBILITIES

- A. Provide the OPR documentation to the CxA for information and use.
- B. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities.
- C. Provide the BoD documentation, prepared by Architect and approved by Owner, to the CxA and Contractor for use in developing the commissioning plan, systems manual, and operation and maintenance training plan.

1.6 CONTRACTOR'S RESPONSIBILITIES

- A. Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
 1. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
 2. Cooperate with the CxA for resolution of issues recorded in the Issues Log.
 3. Attend commissioning team meetings.
 - a. For the purpose of this project, assume one kickoff meeting to review commissioning requirements.
 4. Integrate and coordinate commissioning process activities with construction schedule.
 5. Review and accept construction checklists provided by the CxA.
 6. Review and accept commissioning process test procedures provided by the Commissioning Authority.
 7. Complete commissioning process test procedures.

1.7 CxA'S RESPONSIBILITIES

- A. Organize and lead the commissioning team.
- B. Provide commissioning plan.
- C. Convene commissioning team meetings, where applicable.
- D. Provide Project-specific functional performance checklists and commissioning process test procedures.
- E. Verify the execution of commissioning process activities using random sampling. The sampling rate may vary from 1 to 100 percent. Verification will include, but is not limited to, equipment submittals, construction checklists, training, operating and maintenance data, tests, and test reports to verify compliance with the OPR. When a random sample does not meet the requirement, the CxA will report the failure in the Issues Log.
- F. Prepare and maintain the Issues Log.
- G. Prepare and maintain completed construction checklist log.
- H. Witness systems, assemblies, equipment, and component startup.
- I. Compile test data, inspection reports, and certificates; include them in the systems manual and commissioning process report.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 91 13

SECTION 23 05 10 – MECHANICAL REQUIREMENTS

PART 1 – GENERAL

This section applies to all Division 23 specifications and trades.

Cooperate with all other trades and install work as fast as the progress of the job will permit.

Use only mechanics skilled in the work they are to perform and have a competent representative on the job when any work is being done.

No work shall be done unless the Superintendent of the Contractor is on the job site. Work shall be properly protected, all rubbish removed promptly, and exposed work shall be carefully cleaned prior to final acceptance.

In decisions arising from discrepancies, interpretation of Drawings, and Specifications, substitutes, and other pertinent matters, the decision of the Owner's representative shall be final unless the Contractor seeks relief per the General Conditions.

1.1 QUALITY ASSURANCE

- A. Applicable welding certifications, procedures, and testing shall comply with ANSI Standard B31.9 - Standard Code for Building Services Piping, and The American Welding Society, Welding Handbook.
- B. Soldering and Brazing procedures for refrigerant piping shall conform to ASME/ANSI B31.5 Refrigeration Piping.
- C. Installation of refrigeration systems shall conform to ANSI/ASHRAE 15 Safety Code for Mechanical Refrigeration.

1.2 WARRANTY

- A. Contractor shall provide a one-year parts and labor warranty on all equipment provided on this project. Warranty shall start on the date of substantial completion. Contractor shall purchase manufacturer's warranty for all refrigeration equipment. Refer to individual Sections for additional warranty requirements.

1.3 RELATED DOCUMENTS

- A. Work herein shall conform to all applicable laws, ordinances, codes, regulations, and local utility companies' rules. The general conditions and all requirements of the contract documents shall apply to all work of this section. Work shall be in accordance with the latest requirements and addendums as of the date of this specification unless otherwise noted:

NFPA 13 – 2019 Standard for the Installation of Sprinkler Systems.

NFPA 14 – 2019 Standard for the Installation of Standpipe and Hose Systems, except 4-4.3 shall be omitted.

NFPA 25 – 2020 Standard for Inspection, Testing and Maintenance of Water-Bases Fire Protection System.

NFPA 70 – 2020 National Electrical Code

NFPA 90A – 2021 Standard for the Installation of Air Conditioning and Ventilating Systems.

NFPA 90B – 2021 Standard for the Installation of Warm Air Heating and Air Conditioning Systems.

NFPA 92 – 2018 Standard for Smoke Control Systems

NFPA 101 – 2021 Life Safety Code (Florida Edition)

NFPA 105 – 2019 Recommended practice for the Installation of Air Conditioning and Ventilating Systems

NFPA 170 – 2012 Fire Safety Symbols

NFPA 241 – 2019 Standard for Safeguarding Building Construction and Demolition Operations.
NFPA 251 -2006 Standard Methods of Fire Testing of Building Construction and Materials Tests
of Door Assemblies
NFPA 252 – 2012 Standard Methods of Fire Test of Door Assemblies
NFPA 257 - 2012, Standard for Fire Tests of Window & Glass Block Assemblies
ANSI-A 17.1 - Elevator Code
2023 Florida Fire Prevention Code, 8th Edition
Local Government Growth Management
Local Permit Authority Requirements
2023 Florida Building Code, 8th Edition
State of Florida, Department of Environmental Protection Rules
State of Florida, State Fire Marshal, Rules and Regulations (Rule 69A-3.012, FAC)
SMACNA, HVAC Duct Construction Standards
Americans with Disabilities Act
Florida Accessibility Code for Building Construction
Department of Management Services Guidelines & Standards

1.4 DEFINITIONS

- A. Furnish: Supply and deliver to project site, ready for unloading, unpacking, assembly, installation, and similar subsequent requirements.
- B. Install: Operations at project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, start-up and similar requirements.
- C. Provide: Furnish and install, complete and ready for intended use.
- D. Installer: Entity (firm or person) engaged to install work by Contractor, subcontractor, or sub-subcontractor. Installers are required to be skilled experts in work they are engaged to install.
- E. Specification Text Format: Any underscoring facilitates scan reading, no other meaning. Imperative language is directed at Contractor, unless otherwise noted.

1.5 SPECIFICATIONS AND DRAWINGS

- A. Plans show locations of equipment and are intended to depict the general intent of the work in scope, layout, and quality of workmanship. They are not intended to show in minute detail every or all accessories intended for the purpose of executing the work, but it is understood that such details are a part of this work.
- B. Where Drawings and Specifications conflict, it shall be the responsibility of this Contractor to bring such conflict to the attention of the Architect/Engineer for clarification. If the contractor fails to bring the conflict to the Engineer's attention, the most stringent (most costly) requirements apply. All changes from the Drawings necessary to make the work conform with the building as constructed and to fit the work of other trades or to conform to the rules of authorities having jurisdiction, shall be made by the Contractor at his own expense.
- C. Keep a record of the locations of concealed work and of any field changes in Contract Drawings and Specifications for each trade and, upon completion of the job, supply "As-Built" Drawings and Specifications showing, in pencil on sepia reproductions, any deviations from the original Drawings indicating in the Specifications each manufacturer's name underlined or inserted whose product was used on the job. These Drawings shall indicate dimensions of buried utility lines from building walls. One set of sepia reproductions of the original tracings will be furnished upon request for this purpose. Provide record documents in accordance with the General Conditions.
- D. Where equipment is used other than manufacturers specified, the Contractor shall request approval to substitute materials and/or products in accordance with the General Conditions.

- E. The Contractor shall lay out all the work as required by the drawings and be held responsible for damage, if any is incurred, due to incorrect layout of work. The Contractor shall establish all building lines, benchmarks, and levels from which all trades can work, and take necessary measures to keep the marks in visible evidence throughout all stages of the work.
- F. The Contractor shall comply with all rules and regulations of the Florida Industrial Commission, the State and Federal Departments of Commerce and Labor, EPA regulations, and the OSHA Laws, as they may apply to the work. The Contractor shall also comply with all Owner policies while on-site.
- G. By submitting a bid for equipment other than the "Design Basis Equipment" (i.e., that which is shown on the Contract Drawings), the Contractor:
 - 1. Represents that he has personally investigated the proposed substitute product and determined that it is equal or superior in all respects to that specified and complies with all the requirements set forth in the General Conditions;
 - 2. Certifies that the cost data presented is complete and includes all related costs under this Contract but excludes costs under separate contracts, and excludes the Engineer's redesign costs, and waives all claims for additional costs related to the substitution which subsequently become apparent;
 - 3. Will coordinate the installation of the accepted substitute, making such changes as may be required for the work to be complete in all respects; and,
 - 4. Certifies that the proposed equipment meets the requirements of the Contract Documents.

1.6 PERMITS, FEES, AND INSPECTIONS

- A. The Contractor shall give all necessary notices, obtain all permits, and pay all government fees, and other costs, and file all permit applications required by all governmental departments having jurisdiction.
- B. Obtain all required certificates of inspection for work and deliver them to the Owner before requesting acceptance and final payment for the work.
- C. The Contractor shall include in the work, without extra cost to the Owner, any labor, materials, services, apparatus, and drawings required to comply with all applicable laws, ordinances, rules and regulations.
- D. The Contractor shall inform the Owner of any work or materials which conflict with any of the applicable codes, standards, laws and regulations before submitting his bid.

1.7 GENERAL

- A. Materials or products specified herein and/or indicated on drawings by trade name, manufacturer's name and/or catalog number shall be provided as specified. Substitutions will not be permitted except as described herein and in the General Conditions.
- B. All materials shall be new and of quality as specified, and when required, be clearly labeled and/or stamped as manufactured in the United States.
- C. A list of all materials and equipment which the Contractor proposes to furnish shall be submitted for approval within ten (10) days after the contract has been awarded. Data shall be complete in all respects.

1.8 RENOVATION WORK

- A. Areas under renovation which are adjacent to occupied areas shall be sealed off and maintained under a negative pressure during construction. If existing exhaust fans are used, then the ducts shall be cleaned after construction is complete but before final test and balance.

1.9 SHOP AND ERECTION DRAWINGS

- A. Submit shop drawings for all components in the proposed system for review by Owner's representative before ordering or installing any equipment or material. Equipment or material ordered or installed before Owner's representative review may not be accepted and will have to be removed from the project.
- B. Shop drawings shall consist of manufacturer's scale drawings, cuts or catalogs, including descriptive literature which shall clearly indicate the construction, material, physical dimensions, wiring diagrams and complete operating data clearly marked for each item. Data of general nature will not be accepted.
- C. Submit shop drawings in accordance with the General Conditions.

1.10 COORDINATION DRAWINGS

- A. Prepare coordination drawings when alternate manufacturers are proposed of space containing air handling units, pumps, chillers, water heaters or similar large mechanical equipment detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Drawings shall be prepared at a scale of 1/4" - 1'0" or larger. Indicate locations of access and where sequencing and coordination of installations are of importance to the efficient flow of the Work.
- B. Indicate the proposed locations of piping, ductwork, equipment, and materials. Include the following:

Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance; Equipment connections and support details; Exterior wall and foundation penetrations; Fire-rated wall and floor penetrations; concrete pads and bases.
- C. Floor plans, elevations, and details shall indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

1.11 MECHANICAL EQUIPMENT CLEARANCES

- A. Maintain three (3) feet clearance in front of mechanical equipment requiring maintenance. Pay close attention to access doors of new and existing equipment.

1.12 ROOF MOUNTED EQUIPMENT

- A. All equipment installed on the roof shall be attached to the structure in a manner approved by the manufacturer and shall be capable of withstanding winds in excess of 130 mph.

1.13 ROUGH-IN

- A. For all piping and equipment field verify final locations for rough-ins with actual field measurements and with the requirements of the actual equipment to be connected.

1.14 UNDERGROUND PIPING

- A. Provide the Engineer with a seven (7) day notice prior to covering up any underground pipe to allow sufficient time for inspection.

1.15 EXPERIENCE

- A. The Contractor performing this work shall be a Florida licensed, reputable firm, regularly performing the type of work incorporated in this project and who also maintains, as part of the firm, a service department with qualified personnel who regularly perform this type of work. The Contractor shall, upon request, show evidence of at least two jobs of similar scope and size either completed or under contract within the preceding two years.

1.16 ELECTRICAL WORK FOR MECHANICAL SYSTEMS

- A. All electrical components shall be U.L. listed. All wiring components and devices shall conform to the National Electrical Code.

1.17 WIRING FOR MECHANICAL EQUIPMENT

- A. All power wiring for mechanical equipment shall be provided by Division 26.
- B. All control wiring for mechanical equipment shall be provided by Division 23. Control wiring shall be defined as all wiring not in the direct path of supplying power to the mechanical equipment.

1.18 MOTORS

- A. All motors shall be built in accordance with the current applicable IEEE, ASA, and NEMA standards. All general-purpose motors shall be open drip-proof machines for installation indoors and/or in protected locations. Totally enclosed fan cooled (TEFC) motors shall be used in all areas of exposure to weather or other environmental contamination. Motors shall be rated explosion proof when located in hazardous atmospheres.
- B. Unless indicated otherwise, motors shall be NEMA Design B with a service factor of 1.15 with total temperature rise of 50 degrees C. (resistance measured) in 40 degrees C. ambient when powered from the system voltage feeding the motor. TEFC motors shall have class F insulation and ODP motors shall have class B insulation. Motors located in areas exceeding 40 degrees C. ambient shall be factory rated for the ambient temperature of the motor environment. Single phase motors shall generally be NEMA Design N split phase induction motors with built-in thermal protectors. Unless otherwise noted, motors supplied on this project one (1) HP and larger shall have an efficiency which meets or exceeds the efficiency shown in Tables 1 and 2, below (per FBC Energy Conservation – C405.7), tested in accordance with IEEE Standard 112, Test Method B, and shall have a power factor not less than 85 percent under rated load conditions. Power factor of less than 85 percent shall be corrected to at least 90 percent under rated load conditions. Power factor corrective devices, installed to comply with this requirement, shall be switched with the utilization equipment.

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Table 1:
Minimum Nominal Full Load Efficiencies for 4 Pole (1800 RPM) Electric Motors at 60Hz

<u>Motor Horsepower</u>	<u>Open Motors</u>	<u>Enclosed Motors</u>
	<u>Minimum Nominal Efficiency (%)</u>	<u>Minimum Nominal Efficiency (%)</u>
1	85.5	85.5
1.5	86.5	86.5
2	86.5	86.5
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	94.1	94.1
50	94.5	94.5
60	95.0	95.0
75	95.0	94.4
100	95.4	95.4
125	95.4	95.4
150	95.8	95.8
200	95.8	96.2
250	95.8	96.2
300	95.8	96.2
350	95.8	96.2
400	95.8	96.2
450	96.2	96.2
500	96.2	96.2

Table 2:
Minimum Nominal Full Load Efficiencies for 2 Pole (3600 RPM) Electric Motors at 60Hz

<u>Motor Horsepower</u>	<u>Open Motors</u>	<u>Enclosed Motors</u>
	<u>Minimum Nominal Efficiency (%)</u>	<u>Minimum Nominal Efficiency (%)</u>
1	77.0	77.0
1.5	84.0	84.0
2	85.5	85.5
3	85.5	86.5
5	85.5	88.5
7.5	85.5	89.5
10	89.5	90.2
15	90.2	91.0
20	91.0	91.0
25	91.7	91.7
30	91.7	91.7
40	92.4	92.4
50	93.0	93.0
60	93.6	93.6
75	93.6	93.6
100	93.6	94.1
125	94.1	95.0
150	94.1	95.0
200	95.0	95.4
250	95.0	95.8
300	95.4	95.8
350	95.4	95.8
400	95.8	95.8
450	96.2	95.8
500	96.2	95.8

- C. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
 - 5. Shaft Grounding Ring: Microfiber type.
 - 6. Provide grounded discharge path for VFD induced voltage in the shaft to prevent arcing in the motor bearings.

1.19 REMOVAL OF RUBBISH

- A. Contractor shall keep premises free from accumulations of waste material or rubbish caused by his employees or work. At completion of work, he shall remove all his tools, scaffolding, surplus materials, and rubbish from building and site. He shall leave premises and his work in a clean orderly condition acceptable to the Owner's representative.

1.20 QUIET OPERATION AND VIBRATION

- A. All equipment provided under this section shall operate under all conditions of load free of abnormal sound and vibration. Sound and vibration conditions considered abnormal shall be corrected in an approved manner at no additional cost to the Owner.

1.21 EXAMINATION OF EXISTING CONDITIONS

- A. Visit and carefully examine those portions of the site and/or present buildings affected by this work to become familiar with existing conditions and difficulties that will affect the execution of the work before submitting proposals.
- B. Submission of a proposal will be construed as evidence that such examination has been made and later claims for labor, equipment, or materials required because of difficulties encountered, which could have been foreseen had such examination been made, will not be recognized.

1.22 CLEANING AND ADJUSTMENTS

- A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.
- B. Clean and flush hydronic piping systems; remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.
- C. Mark calibrated name plates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.
- D. Upon completion of work, Contractor shall clean and lubricate pumps, fans, motors, and other running equipment and apparatus which he has installed and make certain such apparatus and mechanisms are in proper working order and ready to test.
- E. Scratched or damaged painting shall be touched up as necessary to return the painting to "new" condition and appearance.
- F. All piping and equipment shall be thoroughly blown out under pressure and cleared of all foreign matter, wasting air, gas, or water through temporary connections as long as necessary to thoroughly clean system before system is placed in operation. Use every precaution to prevent pipe compound, scale, dirt, welding, and other objectionable matter from getting into the piping system and equipment.

- G. During blow out period, baskets from strainers shall be removed, traps and control valves, etc., shall be by-passed.
- H. All cleanings shall be done prior to any pressure testing, flow balancing or equipment adjustment procedures.

1.23 DEMOLITION

- A. Demolition shall be as shown on drawings or specified.
- B. Schedule all demolition work with Owner to cause minimum downtime of any building service or function. No extra cost to the contract will be allowed for overtime work unless specifically authorized in advance by representative or Owner in writing.
- C. During demolition and construction, protect from damage all existing equipment and services that are to remain. Repair or replace any damage to existing facilities at no extra cost to the contract.
- D. Remove with care and deliver to a location designated by representative of the Owner all items designated to remain the property of the Owner.
- E. Drawings are diagrammatic and show only major obstructions, coordinate with other trades for removal or relocation of pipes, conduits, hangers, etc., in path of work.
- F. No columns, beams, joists, building foundations, nor any other structural building component shall be cut, drilled, or disturbed in any way. Conflicts shall immediately be brought to the attention of the Owner's representative. Contractor shall not proceed until instructed in writing by the Owner's representative if conflicts between mechanical work and structural elements occur.
- G. Temporary Removal: Carefully remove, store, clean, reinstall, reconnect, and make operational equipment indicated to be reused. Prior to removal Contractor shall inspect existing equipment and note any deficiencies and repairs needed. Failure to note deficiencies will require the Contractor to repair the equipment for no additional cost.
- H. Demolish and remove inactive and obsolete piping, fittings, and specialties, equipment, ductwork, controls, fixtures, and insulation.
- I. Piping and ducts embedded in floors, walls, and ceilings may remain if such materials do not interfere with new installations.
- J. Demolish and remove obsolete and abandoned exposed piping and ducts to a point flush with floors and walls. Remove materials above accessible ceilings and below raised floors. Drain and cap piping and ducts allowed to remain.

1.24 CONNECTIONS TO EXISTING WORK

- A. Plan installation of new work and connections to existing work to insure minimum interference with regular operation of existing facilities.
- B. Submit to the Owner for approval, a schedule of necessary temporary shut-downs of existing services. All shutdowns shall be made at such times as will not interfere with regular operation of existing facilities and only after written approval of the Owner.
- C. To ensure continuous operation, make necessary temporary connections between new and existing work.
- D. Connect new work to existing work in neat and approved manner. Restore disturbed existing work to original condition.
- E. After completion of project clean the exterior surface of equipment included in this section, remove all concrete residues and touch up paint or completely repaint all damaged surfaces.

1.25 STORAGE OF MATERIALS

- A. All materials stored on site shall be in a Contractor supplied trailer or enclosure and shall be properly protected from injury or deterioration. Materials shall not be stored in contact with ground or floor.
- B. Do not remove manufacturer's packing materials until ready to install. Materials showing signs of corrosion, improper handling or storage shall be replaced at no cost to the Owner.
- C. During construction protect all piping and equipment from damage and dirt. Cap the open ends of all piping and equipment.
- D. Provide continuous protection for all equipment already installed.

1.26 WATERPROOFING

- A. Where any work pierces waterproofing including waterproof concrete, the method of installation shall be as approved by the Owner before the work is done.
- B. Provide all necessary sleeves, caulking and flashing required to make openings watertight. Waterproof flashing materials shall be compatible with base materials.

1.27 TESTS

- A. Contractor shall make all tests required to establish the adequacy, quality, safety, completed status, and satisfactory operation of all systems to the satisfaction of the Owner's representative. Provide all instruments, labor, and services necessary to conduct tests.

1.28 INSTRUCTIONS

- A. Fully instruct Owner's personnel in the care and operation of mechanical systems and furnish a letter to the Owner's representative advising the particular person who has received such instruction.

1.29 AUTOMATION CONTROLS

- A. Refer to Specification 23 09 23. Include all indicated Mechanical work scope. Fully coordinate and cooperate with Integrated Automation Contractor so that all work scope is included, and work proceeds as expedited as possible.

1.30 COORDINATE WITH OTHER DISCIPLINES

- A. Also, include work scope as required for the Controls Contractor and Test & Balance Contractor and associated work scopes.
- B. Coordinate with and cooperate with Div 26 Contractor and other disciplines as required to fully complete work for fully operational systems.

END OF SECTION 23 05 10

SECTION 23 05 11 – ELECTRICAL REQUIREMENTS FOR MECHANICAL SYSTEMS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections: Other separate electrical components and materials required for field installation and electrical connections are specified in Division 26. Refer to other sections of Division 23 specifications for related work or requirements.

1.2 SUMMARY

- A. This section specifies the basic requirements for electrical components which are an integral part of packaged mechanical equipment or are separate electrical components provided for mechanical equipment. These components include, but are not limited to motors, starters, disconnect switches and adjustable frequency drives furnished either as a separate or integral part of packaged mechanical equipment as specified.
- B. Specific electrical requirements (i.e., horsepower and electrical characteristics, etc.) for mechanical equipment are specified within the individual equipment specification sections.

1.3 REFERENCES

NEMA Standards MG 1: Motors and Generators.
NEMA Standards ICS 2: Industrial Controls Devices, Controllers, and Assemblies.
NEMA Standard 250: Enclosures for Electrical Equipment.
NEMA Standard KS 1: Enclosed Switches.
Comply with National Electrical Code (NFPA 70).

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each material described in this section as is applicable. These submittals and shop drawings shall be in no less detail than the product, material and installation descriptions provided herein and on the drawings. Submit product data for motors, starters, and other electrical components with submittal data required for the equipment for which it serves, as required by the individual equipment specification sections.

1.5 QUALITY ASSURANCE

- A. Electrical components and materials shall be UL labeled.

1.6 MOTOR STARTERS

Motor Starter Characteristics:

- A. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations, plenums and exterior locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have NEC proper class and division.
- B. Type and size of starter shall be as recommend by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.
- C. Manual Switches Shall Have: Pilot lights and extra positions for multi-speed motors.
- D. Overload Protection: Melting alloy type thermal overload relays.
- E. Magnetic Starters:

1. Maintained contact push buttons and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
2. Trip-free thermal overload relays, each phase.
3. Interlocks, switches, and similar devices as required for coordination with control requirements of Division 23 Controls sections.
4. Built-in 120 volts control circuit transformer, fused from line side, where service exceeds 240 volts.
5. Externally operated manual reset.
6. Under-voltage release or protection.

1.7 DISCONNECTS SWITCHES

- A. Fusible Switches: Fused, each phase; general duty; horsepower rated; non-teasible quick-make, quick-break mechanism; dead front line side shield; solderless lugs suitable for copper or aluminum conductors; spring reinforced fuse clips; electro silver plated current carrying parts; hinged doors; operating lever arranged for locking in the "Open" position; arc quenchers; capacity and characteristics as indicated.
- B. Non-fusible Switches: For equipment 2 horsepower and smaller, shall be horsepower rated; toggle switch type; quantity of poles and voltage rating is indicated. For equipment larger than 2 horsepower, switches shall be the same as fusible type.

PART 2 – EXECUTION (Not Applicable)

PART 3 – EXECUTION

3.1 GENERAL

- A. Division 23 contractor shall provide all starters, contactors, and disconnects required to operate mechanical equipment provided by this Division 23 contractor unless specifically stated otherwise on the plans or in these specifications, including Division 26 plans and specifications.

3.2 WIRING FOR MECHANICAL EQUIPMENT

- A. All power wiring for mechanical equipment shall be provided by Division 26 as required, unless stated otherwise in Division 23.
- B. Wiring that is required as a part of Division 23 shall conform to the requirements for wiring methods and materials as stated in Division 26.
- C. Provided detailed composite wiring diagrams for all control systems and equipment which may be required by Division 23. Verify electrical characteristics of equipment before ordering and finalize with Division 26. Reference electrical drawings for electrical characteristics of equipment specified herein and on the plans.
- D. Division 23 shall be responsible for the correct functioning of all the control systems and equipment.

END OF SECTION 23 05 11

SECTION 23 05 12 – BASIC MATERIALS AND METHODS

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section specifies mechanical components and installation methods common to more than one section of Division 23 and shall apply to all Division 23 work as is applicable.

1.2 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each material described in this section as is applicable. These submittals and shop drawings shall be in no less detail than the product, material and installation descriptions provided herein and on the drawings.

PART 2 – PRODUCTS

2.1 CEILING/WALL ACCESS DOORS

- A. Steel Access Doors & Frames: Factory-fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.
- B. Frames: 16-gage steel, with a 1-inch-wide exposed perimeter flange for units installed in unit masonry, precast, or cast-in-place concrete, ceramic tile, or wood paneling.
- C. For installation in masonry, concrete, ceramic tile, or wood paneling: 1 inch-wide-exposed perimeter flange and adjustable metal masonry anchors.
- D. For gypsum wallboard or plaster: perforated flanges with 22 gage wallboard bead.
- E. For full-bed plaster applications: galvanized expanded metal lath and exposed casing bead, welded to perimeter of frame.
- F. Flush Panel Doors: 14-gage sheet steel, with concealed continuous piano hinge set to open 175 degrees; factory applied baked on powder coat finish to match adjacent ceiling finish color.
- G. Fire-Rated Units: Insulated flush panel doors, with continuous piano hinge and self-closing mechanism.
- H. Locking Devices: Flush, screwdriver-operated cam locks.

2.2 AVAILABLE MANUFACTURERS

- A. Larsen's Manufacturing Company L-DWC series or approved equal.

2.3 FIRE STOPS

- A. General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.
- B. Fire-Resistant Joint Sealers: Two-part foamed-in-place silicone sealant, intumescent putty, or one-part silicone elastomeric sealant, formulated for use in through-penetration fire-stopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.
- C. Sealants and accessories shall provide fire-resistance ratings to three (3) hours protection, as established by testing identical assemblies in accordance with ASTM E 814, by Underwriters' Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

2.4 ACCEPTABLE MANUFACTURERS:

3-M Corporation
Dow-Corning Corp.
General Electric Co.
Nelson Flame Seal
Fire Stop V

Submit manufacturer's technical data for each produce used and include installation instructions, and material safety data sheets.

PART 3 – EXECUTION

EXAMINATION

3.1 DELIVERY, STORAGE, & HANDLING

- A. Deliver fire stop materials and similar type items in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.
- B. Store and handle all materials in compliance with the manufacturer's recommendations to prevent their deterioration and damage.

3.2 SEQUENCING & SCHEDULING

- A. Coordinate the size and location of concrete equipment pads. Cast anchor-bolt inserts into pad.
- B. Coordinate the installation of pipe sleeves for foundation wall penetrations, etc.
- C. Coordinate mechanical equipment locations and supports with roof work.

3.3 CONTROLS COORDINATION

- A. The mechanical contractor shall install control valves/actuators, control dampers, damper actuators, immersion wells, pressure sensor taps, flow meters, etc. which are to be furnished by the controls contractor.

3.4 MECHANICAL EQUIPMENT NAMEPLATE DATA

- A. Nameplate: For each piece of power operated mechanical equipment provide a permanent operational data nameplate indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliance, and similar essential data. Locate nameplates in an accessible location. Where equipment is insulated or otherwise concealed, nameplates shall be located so as to be visible with insulation installed.

3.5 IDENTIFICATION

- A. Provide a complete identification system for all systems. All equipment, valves, controls and piping shall be identified and marked as specified below. All numbers and letters shall be manufacturer's standard block lettering. Provide a typed index of all abbreviations and numbering systems used in the identification system. Coordinate names, abbreviations and number with those used on the drawings.
- B. Coordination: Where identification is to be applied to surfaces which require insulation, painting, or other covering of finish, including valve tags in finished mechanical spaces, install identification prior to installation of acoustical ceiling and similar removable concealment.

3.6 VALVE IDENTIFICATION

- A. General: Provide valve tag on every valve, cock, and control device in each piping system; exclude check valves within factory-fabricated equipment units, plumbing fixture faucets, convenience and lawn-watering hose bibs, and shut-off valves at plumbing fixtures, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.
- B. Mount valve schedule frames and schedules in machine rooms where indicated or, if not otherwise indicated, where directed by Architect/Engineer.
- C. Where more than one major machine room is shown for project, install mounted valve schedule in each major machine room, and repeat only main valves which are to be operated in conjunction with operations of more than one single machine room.

3.7 EQUIPMENT IDENTIFICATION

- A. Each unit furnished shall be identified by its system number and other appropriate designation as directed by the owner. Minimum requirements include engraved plastic laminate signs (1/8" thick) permanently attached to each piece of equipment. Equipment requiring identification shall include but not be limited to: pumps, chillers, cooling towers, DX equipment controls, and other equipment as may be directed by the Owner's representative. The contractor shall submit proposed equipment identification system with shop drawings.

3.8 PIPING IDENTIFICATION

- A. Provide plastic pipe markers for all new piping systems using plastic pipe markers specified below.

3.9 PLASTIC PIPE MARKERS

- A. General: Pipe Markers shall comply with ANSI/ASME A13.1 (latest edition) "Scheme for the Identification of Piping Systems" and be installed as required and indicated below using legends (pipe content) spelled out fully and few abbreviations and directional arrows to indicate flow. Arrows must have the same background color as the pipe marker legend or be incorporated into the pipe marker.
- B. Color: Pipe Markers shall conform to ANSI Z535.1 "Safety Color Code". For existing Plants & MER's, match existing color scheme as directed by owner.
- C. Small Pipes: For external diameters less than 6" (including insulation if any), provide semi-rigid plastic full band pipe markers, extending 360 degrees around pipe at each location. The marker shall include the legend (pipe content) and a direction flow arrow. The marker shall be supplied as a pre-tensioned device and be equipped with a 1/2" strip of adhesive on the inside to secure marker in place. The marker shall also be fastened to the pipe with two metal color coded bands (color selected by Owner).
- D. Large Pipes: For external diameters greater than 6" (including insulation, if any), provide a semi-rigid plastic strap-on pipe marker with a height no less than 3 times the letter height. The marker shall include a legend (pipe content) and a direction flow arrow. The Marker shall be supplied with no less than two metal color coded bands (color selected by Owner) to secure the marker in place.
- E. Insulation: Furnish 1" thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125 deg. F (52 deg. C) or greater. Cut length to extend 2" beyond each end of plastic pipe marker.

3.10 PIPING IDENTIFICATION INSTALLATION

- A. General: Install pipe markers on each system provided and include arrows to show normal direction of flow:
 - 1. Plastic pipe markers, with application system as indicated above. Install on pipe insulation segment where required for hot non-insulated pipes.
 - 2. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
 - a. Near each valve and control device.
 - b. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
 - c. Near locations where pipes pass through walls or floors/ceilings or enter non-accessible enclosures.
 - d. At access doors, manholes and similar access points which permit view of concealed piping.
 - e. Near major equipment items and other points of origination and termination.
 - f. Spaced intermediately at maximum spacing of 50' along each piping run, except reduce spacing to 25' in congested areas of piping and equipment.
 - g. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.11 VALVE TAGS

- A. Brass Valve Tags: Provide 19-gauge polished brass valve tags with stamp-engraved piping system abbreviation in 1/4" high letters and sequenced valve numbers 1/2" high, and 5/32" hole for fastener.
- B. Provide 1-1/2" diameter tags, except as otherwise indicated.
- C. Provide size and shape as specified or scheduled for each piping system.
- D. Fill tag engraving with black enamel.
- E. Valve Tag Fasteners: Provide manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves and manufactured specifically for that purpose.
- F. Access Panel Markers: Provide manufacturer's standard 1/16" thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve. Include 1/8" center hold to allow attachment.
- G. Fire Resistance Ratings: Where a fire-resistance classification is indicated, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in the UL "Building Materials Directory" for rating shown.
- H. Provide UL label on each fire-rated access door.

3.12 VALVE SCHEDULE FRAMES

- A. General: For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.

3.13 PLASTICIZED TAGS

- A. General: Manufacturer's standard pre-printed or partially pre-printed accident prevention tags, of plasticized card stock with matt finish suitable for writing, approximately 3-1/4" x 5-5/8", with

brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

3.14 LETTERING AND GRAPHICS

- A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified, or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers, or as required for proper identification and operation/maintenance of mechanical systems and equipment.
- B. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (as examples; Boiler No. 3, Air Supply No. 1H, Standpipe F12).

3.15 DUCT SYSTEM IDENTIFICATION

- A. General: Identify air supply, return, exhaust, intake, outside air, and relief ducts with duct markers or stenciled signs and arrows, showing duct system service and direction of flow. Locate in each space where ducts are exposed and where ducts are located above accessible ceiling systems. Locate near points where duct enter the space and at maximum 50-foot intervals.
- B. Identify the location of all fire and fire/smoke dampers. Identification tags shall be affixed to the ceiling/wall and shall be visible from the occupied space.

3.16 EQUIPMENT SUPPORTS

- A. Fabricate structural steel stands to suspend equipment from structure above or support equipment above floor.
- B. Grouting: Place grout under supports for piping and equipment.

3.17 CUTTING, PATCHING, AND LAYOUT

- A. Provide openings required for the installation of the work. Patch work as required. Finished work shall match the existing adjoining work.
- B. Verify all conditions affecting the work to be performed under this contract.
- C. Carefully verify measurements at the site, determine the exact location of chases and openings required. Provide sleeves, inserts, and hangers as required. Neither columns, beams, joists, building foundations nor any other structural building component shall be cut, drilled or disturbed in any way. Conflicts shall immediately be brought to the attention of the Owner's representative.
- D. Any damage incurred by the Contractor shall be repaired by the Contractor in a manner approved by the Owner's representative at no cost to the Owner and with no extension of time limitation.

3.18 APPLICATION OF JOINT SEALERS

- A. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
- B. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
- C. Comply with recommendations of ASTM C 790 for use of acrylic-emulsion joint sealants.
- D. Surface Cleaning for Joint Sealers: Clean surfaces of joints immediately before applying joint sealers to comply with recommendations of joint sealer manufacturer.

- E. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.
- F. Tooling: Immediately after sealant application and prior to time skinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.
- G. Installation of Fire-Stopping Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around mechanical services penetrating floors and walls, to provide fire stops with fire resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

3.19 INSTALLATION OF ACCESS DOORS

- A. Provide metal framing as required for rough opening. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
- B. Adjust hardware and panels after installation for proper operation.

3.20 SMOKE DETECTORS

- A. Install smoke detectors as indicated on drawings and comply with these specifications and the manufacturer's instructions. Install in an accessible area or provide access door if installed above a hard ceiling. Smoke detectors installed prior to the air handler shall be installed in the return air duct prior to mixing with outside air. Install level so sampling tube openings are directly exposed to air flow. Coordinate the following application considerations with the Division 26 contractor who will furnish smoke detectors.
- B. Application Considerations: Only one detector is required per location, regardless of volume of air, if:
 - 1. The sampling tube extends at least 3/4 of the total width of the duct and is located approximately at the center of the vertical dimension of the duct, and
 - 2. There is no air inlet to the duct upstream.
- C. If, however, there is an inlet within a distance of six duct widths upstream:
 - 1. Use one detector for each four feet of vertical height (lower sampling tube located two feet above the bottom of the duct and additional sampling tubes mounted four feet on center of vertical height).
 - 2. For ducts wider than 12 feet use two detectors for each position, mounted on opposite sides of the duct.
- D. The above recommended detector limits apply to both the return air and supply air locations as required.

3.21 PAINTING/PROTECTIVE COATINGS

- A. Prime and paint (2 coats) all ducts (except stainless steel) in Mechanical Equipment Rooms (or otherwise exposed to view), piping, insulation, unpainted equipment or steel, structural bases and supports provided in Division 23 and existing in the limits of construction. Paint shall be industrial grade enamel; match existing color scheme or as directed by the Owner.
- B. Uninsulated piping, bases, supports and other unfinished steel shall be thoroughly cleaned of all rust and dirt. Apply one coat of rust inhibiting primer and two finishing coats.

- C. Insulated piping and equipment shall receive one coat of primer and two finishing coats.
- D. Pipe hangers, saddles and accessories shall be painted to match the piping (or existing color scheme).
- E. Colors for piping systems shall conform to ANSI A13.1 and ASHRAE Fundamentals, Chapter 38. Color for equipment supports and bases shall be gray.

3.22 IDENTIFICATION ADJUSTING AND CLEANING

- A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.
- B. Cleaning: Clean face of identification devices and glass frames of valve charts.

3.23 COMMISSIONING

- A. Coordinate all work with Owner's Commissioning Agent prior to Bid.
- B. Install Strainers with Start-Up Screens: Install permanent screens after flushing and start-up is complete.
- C. Fill the System: Check compression tanks to determine that they are not air bound and that the system is completely full of water. Sanitize domestic water systems. Perform initial chemical treatment of hydronic and systems.
- D. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
- E. After operating system to remove solids, remove start-up screens and provide standard screen.
- F. Before operating the system perform these steps:
- G. Open valves to full-open position. Close coil bypass valves.
- H. Remove and clean strainers.
- I. Check pump for proper direction of correct improper wiring.
- J. Set automatic fill valves for required system pressure.
- K. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
- L. Set temperature controls so all coils are calling for full flow.
- M. Check operation of automatic bypass valves.
- N. Install minimum 30% efficient ASHRAE filters for start-up and install all new pre and final filters prior to test and balance.
- O. Check and set operating temperatures of chillers to design requirements.
- P. Lubricate motors and bearings.
- Q. Close drain valve, hydrants, and hose bibbs.
- R. Charge refrigerant systems using the following procedure:

- S. Install core in filter dryer after leak test but before evacuation.
- T. Evacuate refrigerant system with vacuum pump; until temperature of 35°F. is indicated on vacuum dehydration indicator.
- U. During evacuation, apply heat to pockets, elbows, and low spots in piping.
- V. Maintain vacuum on system for minimum of 5 hours after closing valve between vacuum pump and system.
- W. Break vacuum with refrigerant gas; allow pressure to build up to 2 psi.
- X. Complete charging of system using new filter dryer core in charging line. Provide full operating charge.
- Y. Train Owner's Maintenance Personnel on procedures and schedules related to start-up and shut-down, troubleshooting, servicing, and preventative maintenance of refrigerant piping valves and refrigerant piping specialties.
- Z. Review data in Operating and Maintenance Manuals. Refer to Division 1 section "Project Closeout."
- AA. Schedule training with Owner through the Architect, with at least 7 days advance notice.

END OF SECTION 23 05 12

SECTION 23 05 19 – METERS & GAGES

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section includes meters and gages used in mechanical systems.

1.2 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for each type of meter, gage, and fitting specified. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit a meter and gage schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gage.
- C. Product certificates signed by manufacturers of meters and gages certifying accuracies under specified operating conditions and compliance with specified requirements.
- D. Maintenance data shall be included in the "Operating and Maintenance Manuals" specified in Division 1 Section "Project Closeout."

1.3 QUALITY ASSURANCE

- A. Comply with applicable portions of American Society of Mechanical Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gages.
- B. Design Criteria: The Drawings and specifications indicate types, sizes, capacities, ranges, profiles, connections, and dimensional requirements of meters and gages and are based on the specific manufacturer types and models indicated.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mercury-in-Glass Thermometers:
Marshalltown Instruments, Inc.
H.O. Trerice Co.
Weiss Instruments, Inc.
Weksler Instruments Corp.
Marsh Instrument Company
 - 2. Pressure Gages:
Ametek, U.S. Gauge Div.
Marsh Instrument Co.
Marshalltown Instruments, Inc.
H.O. Trerice Co.
Weiss Instruments, Inc.
Weksler Instruments Corp.
 - 3. Test Plugs:
Flow Design, Inc.
MG Piping Products Co.
Peterson Equipment Co., Inc.
Sisco Co., Spedco, Inc.
H.O. Trerice Co.

Watts Regulator Co.

2.2 THERMOMETERS, GENERAL

- A. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.
- B. Scale Range: Temperature ranges for services listed as follows:
 - Domestic Hot Water: 30 to 240 deg F with 2-degree scale divisions.
 - Domestic Cold Water: 0 to 100 deg F with 2-degree scale divisions.
 - Hot Water: 30 to 240 deg F with 2-degree scale divisions.
 - Condenser Water: 0 to 160 deg F with 2-degree scale divisions.
 - Chilled Water: 0 to 100 deg F with 2-degree scale divisions.
 - Steam and Condensate: 50 to 400 deg F with 2-degree scale divisions.

2.3 MERCURY-IN-GLASS THERMOMETERS

- A. Case: Weather resistant, die cast, aluminum finished, in baked epoxy enamel, glass front, spring secured, 9" long.
- B. Adjustable Joint: Finished to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.
- C. Tube: Red reading, mercury filled, magnifying lens.
- D. Scale: Satin-faced, non-reflective aluminum, with permanently etched markings.
- E. Stem: Copper-plated steel, aluminum or brass, for separable socket, length to suit installation.

2.4 APPROVED MANUFACTURERS

Marshalltown Instruments
H.O. Trevice
Weiss Instruments
Weksler Instruments

2.5 THERMOMETER WELLS

- A. Thermometer Wells: Brass or stainless steel, pressure rated to match piping system design pressure; with 2" extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap. Thermometer well shall be as provided with the thermometer from the manufacturer.

2.6 PRESSURE GAGES

- A. Type: Industrial Grade, ASME B40.1, Grade A, 316 S.S. bourdon- tube type, bottom connection.
- B. Case: Poly propylene safety case, solid front with blow out back, 4-1/2" diameter.
- C. Connector: 316 S.S., 1/4" NPS, provide brass snubber.
- D. Scale: White coated aluminum, with permanently etched markings, slotted adjustable micrometer pointer.
- E. Accuracy: 1/2 of 1 percent of range span.
- F. Range: Conform to the following:
- G. Vacuum: 30 inches Hg to 15 psi.

H. All Fluids: 1.5 times operating pressure.

2.7 PRESSURE GAGE ACCESSORIES

A. Snubber: 1/4" NPS brass bushing with corrosion-resistant porous metal disc. Disc material shall be suitable for fluid served and rated pressure.

B. Siphon: 1/4" NPS straight coil constructed of brass tubing with threads on each end.

2.8 APPROVED MANUFACTURERS

Ametek
U.S. Gauge Division
Marshalltown Instruments, Inc.
H.O. Trerice Co.
Weiss Instruments Co.
Weksler Instruments Corp.

2.9 PHOTOHELIC PRESSURE GAUGES

A. Differential pressure indicating transmitter shall be diaphragm operated with sensing element motion restrained by a calibrated spring affixed with a strain gauge transducer. Electrical signal shall be internally conditioned to a two-wire standard 4-20 mA control loop output. Transmitter shall have local pointer dial indication of sensed pressure with white dial, black figures, and graduations and pointer zero adjustment. Transmitter shall be Dwyer Instruments, Inc., Catalog No. 605 or approved equal.

2.1 TEST PLUGS

A. Test Plugs shall be nickel-plated brass body, with 1/2" NPS fitting and 2 self-sealing valve-type core inserts, suitable for inserting a 1/8" O.D. probe assembly from a dial-type thermometer or pressure gage. Test plug shall have gasketed and threaded cap with retention chain and body of length to extend beyond insulation. Pressure rating shall be 500 psig.

B. Core Material: Conform to the following for fluid and temperature range:

1. Air, Water, Oil, and Gas, 20 to 200°F: Neoprene.
2. Air and Water, minus 30 deg to 275°F: EPDM.
3. Steam: Provide as recommended by manufacturer for specific application.

C. Test Kit: Provide test kit consisting of one (1) pressure gage adapter with probe, two (2) bimetal dial thermometers, and carrying case.

D. Ranges of pressure gage and thermometers shall be approximately two (2) times systems operating conditions.

2.11 APPROVED MANUFACTURERS:

MG Piping Products
Peterson Equipment
H.O. Trerice
Watts Regulator

PART 3 - EXECUTION

3.1 METER AND GAGE APPLICATIONS

A. General: Where indicated, install meters and gages of types, sizes, and capacities.

3.2 METER AND GAGE INSTALLATION, GENERAL

- A. Install meters, gages, and accessories according to manufacturers' written instructions for applications where used.

3.3 THERMOMETER INSTALLATION

- A. Install thermometers and adjust vertical and tilted positions.
- B. Thermometer Wells: Install in vertical position in piping tees where thermometers are indicated.
 - 1. Fill wells with oil or graphite and secure caps.

3.4 PRESSURE GAGE INSTALLATION

- A. Install pressure gages in piping tee with pressure gage valve located on pipe at most readable position.
- B. Pressure Gage Needle Valves: Install in piping tee with snubber. Install siphon instead of snubber for steam pressure gages.

3.5 TEST PLUG INSTALLATION

- A. Install test plugs in piping tees where indicated, located on pipe at most readable position, secure cap.

3.6 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. The Drawings indicate the general arrangement of piping, fittings, and specialties.
- B. Install meters and gages adjacent to machines and equipment to allow servicing and maintenance.
- C. Make electrical connections to power supply and electrically operated meters and devices.

3.7 ADJUSTING & CLEANING

- A. Calibrate meters according to manufacturer's written instructions, after installation.
- B. Adjusting: Adjust faces of meters and gages to proper angle for best visibility.
- C. Cleaning: Clean windows of meters and gages and factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION 23 05 19

SECTION 23 05 23 – VALVES

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes general duty valves common to most mechanical piping systems.

1. Special purpose valves are specified in individual piping system specifications.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data, including body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.

1.3 QUALITY ASSURANCE

A. Single Source Responsibility: Valves of same type shall be provided by the same manufacturer.

B. American Society of Mechanical Engineers (ASME) Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

C. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

1.4 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products from one of the manufacturers listed below:

Armstrong
Crane
Grinnell
Hammond
Jenkins
Lunkenheimer
Milwaukee
Powell
Stockham
Jomar
Tour and Andersson

1.5 DELIVERY, STORAGE, & HANDLING

A. Preparation For Transport: Prepare valves for shipping as follows:

1. Ensure valves are dry and internally protected against rust and corrosion.
2. Protect valve ends against damage to threads, flange faces, and weld-end preps.
3. Set valves in best position for handling. Set globe and gate valves closed to prevent rattling; set ball and plug valves open to minimize exposure of functional surfaces; set butterfly valves closed or slightly open; and block swing check valves in either closed or open position.

B. Storage: Use the following precautions during storage:

1. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.
 2. Protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.
- C. Handling: Use a sling to handle valves whose size requires handling by crane or lift; rig valves to avoid damage to exposed valve parts. Do not use hand wheels and stems as lifting or rigging points.

PART 2 – PRODUCTS

2.1 VALVE FEATURES; GENERAL

- A. Valve Design: Rising stem or rising outside screw and yoke stems.
- B. Non-rising Stem Valves may be used where headroom prevents full extension of rising stems.
- C. Pressure and Temperature Ratings: As scheduled and required to suit system pressures and temperatures.
- D. Sizes: Same size as upstream pipe, unless otherwise indicated.
- E. Operators: Provide the following special operator features:
 1. Hand wheels, fastened to valve stem, for valves other than quarter turn.
 2. Lever handles, on quarter-turn valves 6" and smaller, except for plug valves. Provide memory stops on valves used for balancing. Provide plug valves with square heads; provide one wrench for every 10 plug valves.
 3. Chain wheel operators, for valves 2-1/2" and larger, installed 72" or higher above finished floor elevation. Extend chains to an elevation of 5'-0" above finished floor elevation.
 4. Gear drive operators, valves 8" and larger.
- F. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.
- G. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.
- H. End Connections: As indicated in the valve specifications.
- I. Threads: Comply with ANSI B1.20.1.
- J. Flanges: Comply with ANSI B16.1 for cast iron, ANSI B16.5 for steel, and ANSI B16.24 for bronze valves.
- K. Solder-Joint: Comply with ANSI B16.18.
 1. Caution: Where soldered end connections are used, use solder having a melting point below 840°F for gate, globe, and check valves; below 421°F for ball valves.

2.2 GATE VALVES

- A. Cast bronze 2 Inch and Smaller: MSS-SP-80
 - Class 125 and 150 - ASTM B-62 cast bronze body and union bonnet.
 - Class 250 - ASTM B-61 cast bronze body and union bonnet.

Threaded or solder ends, solid disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, malleable iron handwheel. Do not use solder end valves for hot water

heating or steam piping applications; use where system temperature and pressure is applicable.

B. Iron 2-1/2 Inch and Larger: MSS-SP-70

- Class 125 and 250 - ASTM A-126 Class B body and bolted bonnet.
- Class 150 - ASTM A-395 Ductile iron body.

Iron body bronze mount, with raised face flanged ends, "Teflon" impregnated packing or Aramid fibers with graphite, and two-piece backing gland assembly.

2.3 GLOBE VALVES

A. Case Bronze 2" and Smaller: MSS-SP-80

- Class 125 and 150 – ASTM B-62 cast bronze body and union bonnet.
- Class 250 – ASTM B-61 cast bronze body and union bonnet.

Threaded or solder ends, brace or replaceable composition disc, copper-silicon alloy stem, brass packing gland, Aramid fibers with graphite, and malleable iron handwheel.

B. Iron 2-1/2 Inch and Larger: MSS-SP-85

- Class 125 and 250 – ASTM A-126 Class B cast iron body and bolted bonnet.
- Class 150 – ASTM A-395 ductile iron body bolted bonnet.

Iron body bronze mount, raised face flanged ends, "Teflon" impregnated or Aramid fibers with graphite, and two-piece backing gland assembly.

2.4 CHECK VALVES

A. Swing Check Valves

1. Cast Bronze 2" and Smaller: MSS-SP-80

- Class 125 and 150 – ASTM B-62 cast bronze body and bonnet.
- Class 250 – ASTM B-61 cast bronze body and bonnet.

Threaded or solder ends, horizontal swing, bronze disc, and Y-pattern; provided valves capable of being reground while the valve remains in line.

2. Iron 2-1/2 Inch and Larger: MSS-SP-71

- Class 125 and 250 – ASTM A-126 Class B cast iron body and bolted bonnet.
- Class 150 – ASTM A-395 ductile iron body and bolted bonnet.

Raised face flanged ends and horizontal swing. Provided valves are capable of being reground while the valve remains in line.

3. Wafer Check Valves 2-1/2" and Larger:

Should be of non-slam design lapped and balanced twin flappers or lift type design as specified on the drawings, stainless steel trim and torsion spring. Provided valves designed to open and close at approximately one foot differential pressure.

2.5 BALL VALVES

A. 1 Inch and Smaller: WW-V-35B

1. Bronze body conforming to ASTM B-62:

- a. Rated for 150 saturated steam pressure, 400 psi WOG pressure; 2 or 3 piece

construction; full port, chrome plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout-proof stem, and vinyl-covered oval stainless steel handle.

B. 1-1/4 Inch to 2 Inch: WW-V-35

1. Bronze body conforming to ASTM B-62:

- a. Same as 1" and smaller bronze body.

C. 2-1/2 Inch and Larger: MSS-SP-72

1. Carbon steel body conforming to ASTM A216:

- a. Same as 1-1/4" to 2" carbon steel body except end are flanged.
- b. All ball valves provide IPS ends for condenser water, chilled water, and domestic hot and cold water service; threaded ends for heating hot water and low pressure steam.

D. Select valves with the following ends or types of pipe/tube connections:

- 1. Copper Tube Size, 2" and Smaller: Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
- 2. Steel Pipe Sizes, 2" and Smaller: Threaded or grooved end.
- 3. Steel Pipe Sizes 2-1/2" and Larger: Flanged.

2.6 PLUG VALVES

A. Plug Valves, 2" and Smaller: Rated at 150 psi WOG; bronze body, with straightaway pattern, square head, and threaded ends.

B. Plug Valves – 2" and Smaller:

- 1. Lunkenheimer 454

C. Plug Valves, 2-1/2" and Larger: MSS SP-78; rated at 175 psi WOG; lubricated plug type, with semisteel body, single gland, wrench operated, and flanged ends.

D. Plug Valves – 2-1/2" and Larger:

E. Powell: 2201

2.7 BUTTERFLY VALVES

A. Provide butterfly valves with an end cap for dead end service. Drill and tap valves on dead end service or requiring additional body strength.

B. 2-1/2" and Larger: MSS-SP-67

C. ASTM A-536 Ductile iron body or A126 Class B iron.

- 1. Provide valves with field replaceable EPDM sleeves nickel-plated ductile iron discs, stainless steel stem, and EPDM O-ring stem seals. Provide lug-type body. Provide lever operator with position indicator for sizes 2 through 6" and gear operators with position indicators for size 8 through 30". All valves in manholes and vaults shall have working pressure of 250#.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine valve interior through the end ports for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks used to prevent disc movement during shipping and handling.
- B. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides, and seats made accessible by such actuation. Following examination, return the valve closure member to the shipping position.
- C. Examine threads on both the valve and the mating pipe for form (i.e., out-of-round or local indentation) and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.
- E. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.
- F. Replace defective valves with new valves.

3.2 VALVE ENDS SELECTION

- A. Select valves with the following ends or types of pipe/tube connections:
 - 1. Copper Tube Size, 2" and Smaller: Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
 - 2. Steel Pipe Sizes, 2" and Smaller: threaded end.
 - 3. Steel Pipe Sizes 2-1/2" and Larger: flanged.

3.3 VALVE INSTALLATIONS

- A. General Application: Use gate, ball, and butterfly valves for shut-off duty; globe, ball, and butterfly for throttling duty. Refer to piping system specification sections for specific valve applications and arrangements.
- B. Install valves where indicated by and in accordance with equipment manufacturer's recommendations.
- C. Install shut-off duty valves at each branch connection to supply mains, and elsewhere as indicated.
- D. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, elsewhere as indicated.
- E. Install calibrated plug valves on the outlet of each heating or cooling element and elsewhere as required to facilitate system balancing.
- F. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required to facilitate system balancing.
- G. Install check valves on each pump discharge and elsewhere as required to control flow direction.
- H. Install angle pattern globe valves on the supply side of each wall mounted terminal unit. If unit has an enclosure, install the valve within the enclosure.
- I. Locate valves for easy access and provide separate support where necessary.

- J. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.
- K. Tag Valves with a metal tag attached with a metal chain.
- L. Install valves in horizontal piping with stem at or above the center of the pipe.
- M. Install valves in a position to allow full stem movement.
- N. Installation of Check Valves: Install for proper direction of flow as follows:
 - 1. Swing Check Valves: Horizontal position with hinge pin level.
 - 2. Wafer Check Valves: Horizontal or vertical position, between flanges.

3.4 PRESSURE REDUCING VALVE INSTALLATIONS

- A. General: Install pressure reducing valves as required to regulate system pressure. Install in a location readily accessible for maintenance and inspection.
- B. Size reducing valves to supply the maximum steam requirements of the heating system or equipment indicated, at the indicated inlet and outlet pressures.
- C. Provide bypass around each reducing valve, with a globe valve equal in size to the area of the reducing valve seat ring.
- D. Install gate valves and unions around each reducing valve to facilitate removal and repair of reducing valves. Unions may be omitted for reducing valves with flanged connections.
- E. Install pressure gages on the low-pressure side of each reducing valve and ahead of the shutoff valve plus one downstream for the shutoff valve.
- F. Install strainers upstream for each reducing valve.
- G. Install safety valves downstream from each reducing valve set a 5 psig higher than the reduced pressure when the reduced pressure is under 35 psig; and at 10 psig higher than the reduced pressure, if the reduced pressure is above 35 psig or the first-stage of two-stage reducing.

3.5 RELIEF VALVE INSTALLATIONS

- A. Install relief valves in accordance with and where required by ASME B 31.1 - "Power Piping".
- B. Pipe discharge to atmosphere outside the building, without stop valves.
- C. Terminate vent pipe with screened vent cap.
- D. Install a drip pan elbow fitting adjacent to the safety valve.
- E. Pipe drip pan elbow drain connection to the nearest floor drain without valves.
- F. Comply with ASME Boiler and Pressure Vessel Code for the installation requirements.

3.6 SOLDER CONNECTIONS

- A. Cut tube square and to exact lengths. Ream interior of tubing.
- B. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket in same manner.
- C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

- D. Open gate and globe valves to fully open position.
- E. Remove the cap and disc holder of swing check valves having composition discs.
- F. Insert tube into valve socket, making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.
- G. Apply heat evenly to outside of valve around joint until solder will melt upon contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.7 THREADED CONNECTIONS

- A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
- B. Align threads at point of assembly.
- C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).
- D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.8 FLANGED CONNECTIONS

- A. Align flange surfaces parallel.
- B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

3.9 FIELD QUALITY CONTROL

- A. Tests: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.

3.10 ADJUSTING AND CLEANING

- A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

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3.11 VALVE SCHEDULES

VALVE	SIZE	CLASSIFICATION
Domestic Water, 125 Class:		
Gate	None	Use Butterfly or Ball Valve
Globe	1/2" to 2"	125# SWP Bronze Screwed
	3" to 4"	125# IBBM RF FLGD
Check	1/2 to 2"	125# SWP Bronze Screwed
	3" & 4"	125# Iron Body Swing Check
Ball Valves	1/2" to 2"	125# SWP Bronze Screwed
	2" & Up	Use Butterfly
Butterfly	3" to 4"	125#/200# LUG Pattern
Chilled Water, 150 Class:		
Gate	1/2" to 2"	150# Screwed Bronze
	3" to 10"	Use Butterfly Valve
Globe	1/2" to 2"	150# SWP Bronze Screwed
	3" to 10"	150# IBBM FLGD RF
Check	1/2" to 2"	150# SWP Bronze Screwed
	3" to 10"	150# IBBM Swing Check
Ball Valves	1/2" to 2"	150# SWD Bronze Screwed
Butterfly Valves	3" to 30"	150#/250# Lug Pattern
Condenser Water, 125 Class:		
Gate	None	Use Butterfly or Ball Valve
Globe	1/2" to 2"	125# SWP Bronze Screwed
	2 1/2" to 10"	125# Bronze Flanged
Check	1/2" to 2"	125# SWP Bronze Screwed
	2 1/2" to 10"	125# IBBM Wafer Check
Ball Valves	1/2" to 2"	125# SWP Bronze Screwed
	3" to 10"	None, Use Butterfly
Butterfly	3" to 12"	125#/200# Lug Pattern
	14" to 16"	250# Lug Pattern
Hot Water, 150 Class:		
Gate	1/2" to 2"	150# Screwed Bronze
	3" to 10"	125# IBBM FLGD RF
Globe	1/2" to 2"	150# SWP Bronze Screwed
	3" to 10"	150# IBBM FLDG RF
Check	1/2" to 2"	150# SWP Bronze Screwed
	3" to 10"	150# IBBM Swing Check
Ball Valves	1/2" to 2"	150# SWD Bronze Screwed
Butterfly Valves	None	Use Gate or Ball Valves

3.12 VALVE SCHEDULE LEGEND

OS&Y	-	OUTSIDE SCREW & YOKE
RF	-	RAISED FACE
RS	-	RAISED STEM
SWD	-	SOLID WEDGE DISC
SWP	-	STEAM WORKING PRESSURE
IBBM	-	Iron Body, Bronze Mounted

END OF SECTION 23 05 23

SECTION 23 05 93 – TESTING, ADJUSTING, & BALANCING

PART 1 – GENERAL

This Section specifies the requirements and procedures total mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications and recording and reporting the results. Test and Balance Contractor must be AABC or NEBB certified.

The Contractor shall procure the services of an independent balancing and testing agency which specializes in the balancing and testing of heating, ventilating, and air conditioning systems. The agency will balance, adjust, and test all heating, ventilating, and air conditioning systems within the building. The Contractor shall provide test and balance to place the system in operation. The Contractor shall participate in the Test and Balance, make any changes necessary, and be responsible for any retesting that may be required to meet specification and drawing requirements. This initial test and balance shall be performed in accordance with this specification and a written report shall be provided. The project will not be accepted as substantially complete until this report has been made and reviewed with NO EXCEPTIONS TAKEN. The Test & Balance Contractor shall coordinate with the BAS Contractor as required to set all design parameters.

Test, adjust, and balance the following mechanical systems:

Fans;

Supply, return, outside and exhaust air systems, all pressure/flow ranges; including variable volume systems. Test and balance all air devices and traverse duct at each air handler, and exhaust fan (record static and CFM).

Test & Balance Contractor shall identify outside air and return air damper positions for design OA flow rate for varying SA flow rates and advise Control Contractor.

Hydronic Systems;

- WSHP Condenser Coils
 - Measure and Adjust Flow
 - Measure and record entering and leaving temperatures.

Electric Resistance Heating Systems;

- Duct or Unit Mounted Electric Heat & Controls
 - Measure and Adjust (Design Maximum & Minimum) Air Flow
 - Measure and Heat Strip resistance.
 - Verify SCR and/or Staging function

HVAC Control Systems

Verify temperature control system operation in both heating and cooling modes.

Sound and Vibration

In retrofit projects, record preliminary flow and pressure data to confirm proper operation of existing equipment prior to any demolition work and to confirm new operating conditions can be achieved. Submit preliminary report to Engineer.

The installing mechanical contractor shall make any necessary sheave/pulley and belt changes or motor speed adjustments to obtain final air flows.

The test and balance contractor shall provide preliminary testing as necessary to assist the mechanical contractor.

Test systems for proper sound and vibration levels. Record sound and vibration levels in final report.

1.1 SUBMITTALS

- A. Agency Data: Submit proof that the proposed testing, adjusting, and balancing agency meets the qualifications specified below.
- B. Engineer and Technicians Data:
- C. Submit proof that the Test and Balance Engineer assigned to supervise the procedures, and the technicians proposed to perform the procedures meet the qualifications specified below.
- D. Forms shall be those standard forms prepared by the AABC or NEBB.
- E. Certified Reports: Submit testing, adjusting, and balancing reports bearing the seal and signature of the Test and Balance Engineer. The reports shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below:
- F. Draft reports: Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on the approved forms. Draft reports may be handwritten, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.
- G. Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 6 complete sets of final reports and one electronic set.
- H. Report Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents. Divide the contents of the binder into the below listed divisions, separated by divider tabs:
 - General Information and Summary
 - Air Systems
 - Hydronic Systems
 - HVAC Control Systems
 - Sound & Vibration
- I. Report Contents: Provide the following minimum information, forms, and data:
- J. General Information and Summary: Inside cover sheet to identify testing, adjusting, and balancing agency, Contractor, Owner, Architect, Engineer, and Project. Include addresses, and contact names and telephone numbers. Also include a certification sheet containing the seal and name address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentations used for the procedures along with the proof of calibration.
- K. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on the standard report forms prepared by the AABC and NEBB, for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form.
- L. Calibration Reports: Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

1.2 QUALITY ASSURANCE

- A. Test and Balance Engineer's Qualifications: A Professional Engineer (either on the installer's staff or and independent consultant), registered in the State in which the services are to be performed, and having at least 3-years of successful testing, adjusting, and balancing experience on projects with testing and balancing requirements similar to those required for this project.
- B. Agency Qualifications: The independent testing, adjusting, and balancing agency certified by National Environmental Balancing Bureau (NEBB) in those testing and balancing disciplines required for this project and having at least one Professional Engineer registered in the State in which the services are to be performed, certified by NEBB as a Test and Balance Engineer.
- C. Codes and Standards:

NEBB: "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

AABC: "National Standards For Total System Balance."

ASHRAE: ASHRAE Handbook, 1984 Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.

- D. Pre-Balancing Conference: Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a conference with the Architect/Engineer and representatives of installers of the mechanical systems. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing. The T&B contractor shall conduct a thorough pre-balance site review and submit a written report for the HVAC design engineer's approval regarding the suitability of site conditions for commencing T&B procedures.
- E. Other Trade Contractors will be required to provide the following information and capabilities as required by the T&B Contractor for completion of work:
 - 1. Equipment (Approved) Submittals;
 - 2. Equipment Start-up Reports;
 - 3. BMS Control Point Lists;
 - 4. Access to the BMS Network;
 - 5. Project Drawings (for reference and mark-up purposes).
- F. T&B Contractor shall submit the following items to the HVAC design engineer, CM, Commissioning Agent and Owner:
 - 1. A Detailed overview of all T&B procedures;
 - 2. A Detailed description of each testing procedure;
 - 3. Regular field reports regarding progress, observed deficiencies, etc; and,
 - 4. Reports as indicated herein.

1.3 PROJECT CONDITIONS

- A. Systems Operation: Systems shall be fully operational prior to beginning procedures.

1.4 SEQUENCING & SCHEDULING

- A. Test, adjust, and balance the air systems before hydronic, ~~steam~~, and refrigerant systems.
- B. Test, adjust and balance air conditioning systems during summer season and heating systems during winter season, including at least a period of operation at outside conditions within 5°F wet bulb temperature of maximum summer design condition, and within 10°F dry bulb temperature of minimum winter design condition. Take final temperature readings during seasonal operation.

PART 2 – PRODUCTS - Not Used

PART 3 – EXECUTION

3.1 PRELIMINARY PROCEDURES FOR AIR SYSTEM BALANCING

- A. Before operating the system, perform these steps:
- B. Obtain design drawings and specifications and become thoroughly acquainted with the design intent.
- C. Obtain copies of approved shop drawings of all air handling equipment, outlets (supply, return, and exhaust) and temperature control diagrams.
- D. Compare design to installed equipment and field installations.
- E. Walk the system from the system air handling equipment to terminal units to determine variations of installation from design.
- F. Check filters for cleanliness.
- G. Check dampers (both volume and fire) for correct and locked position, and temperature control for completeness of installation before starting fans.
- H. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a crosscheck with required fan volumes.
- I. Determine best locations in main and branch ductwork for most accurate duct traverses.
- J. Place outlet dampers in the full open position.
- K. Prepare schematic diagrams of system "as-built" ductwork and piping layouts to facilitate reporting of deficiencies.
- L. Lubricate all motors and bearings
- M. Check fan rotation

3.2 PRELIMINARY PROCEDURES FOR HYDRONIC SYSTEM BALANCING

- A. Before operating the system perform these steps:
- B. Open valves to full open position. Close coil bypass valves.
- C. Remove and clean all strainers.
- D. Examine hydronic systems and determine if water has been treated and cleaned.
- E. Check pump rotation.
- F. Clean and set automatic fill valves for required system pressure.
- G. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
- H. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
- I. Set temperature controls so all coils are calling for full flow.

- J. Check operation of automatic bypass valves.
- K. Check and set operating temperatures of chillers and boilers to design requirements.
- L. Lubricate all motors and bearings.

3.3 MEASUREMENTS

- A. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage.
- B. Provide instruments meeting the specifications of the referenced standards.
- C. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.
- D. Apply instrument as recommended by the manufacturer.
- E. Use instruments with minimum scale and maximum subdivisions and with scale ranges proper for the value being measured.
- F. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than five (5) percent. When measuring a single point, repeat readings until two (2) consecutive identical values are obtained.
- G. Take all reading with the eye at the level of the indicated value to prevent parallax.
- H. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.
- I. Take measurements in the system where best suited to the task.

3.4 PERFORMING TESTING, ADJUSTING, & BALANCING

- A. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards.
- B. Test and document a minimum of eight (8) measured points for the variable flow pumping systems to verify system pumping performance.
- C. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.
- D. Patch insulation, ductwork, and housings, using materials identical to those removed.
- E. Seal ducts and piping, and test for and repair leaks.
- F. Seal insulation to re-establish integrity of the vapor barrier.
- G. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
- H. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.5 HVAC CONTROL SYSTEM TEST & BALANCE

- A. The TAB agency shall work with the BMS contractor to ensure the most effective total system operation is within the design limitations, and to obtain mutual understanding of the intended control system performance.
- B. Verify that all control devices are properly connected and operated by the intended controller.
- C. Observe that all valves are properly installed in the piping system in relation to direction of flow and location.
- D. Observe the calibration of all controllers.
- E. Verify the proper operation and application of all normally open and normally-closed valves.
- F. Observe the locations of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media.
- G. Verify that the sequence of operation for any control mode is in accordance with approved shop drawings and the engineer's specifications.
- H. Verify the operation of all interlock systems.
- I. Perform variable volume system verification to assure the system and its components track with changes from full flow to minimum flow

3.6 TESTING FOR SOUND & VIBRATION

- A. Test and adjust mechanical systems for sound and vibration in accordance with the detailed instructions of the referenced standards.

Sound: Read and record sound levels at up to 15 locations in the building designated by the engineer. All measurements shall be made using an octave band analyzer. All tests shall be conducted when the building is quiet and in the presence of the engineer, if required by the engineer.

Vibration: Record vibration readings on all equipment where motor horsepower is equal to or greater than 10 HP (7.46 kW)

3.7 RECORD & REPORT DATA

- A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms.
- B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.
- C. Record the total CFM measured at all of the outlets and compare to the total air flow measured at the unit.

END OF SECTION 23 05 93

SECTION 23 07 00 – MECHANICAL INSULATION

PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of mechanical insulation required by this section is indicated on drawings and schedules, and by requirements of this section.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.
- C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics, and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation and its intended use. Submit schedule showing manufacturer's product number, R-value, thickness, and furnished accessories for each mechanical system requiring insulation.
- B. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product data in maintenance manual.

1.4 DELIVERY, STORAGE, & HANDLING

- A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.
- B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

1.5 STANDARDS

2023 Florida Building Code, 8th Edition
Fiberglass Piping Insulation: ASTM C 547.
Cellular Glass Insulation: ASTM C 552
Flexible Unicellular Insulation: ASTM C 534
Jackets for Insulation: ASTM C 921
Rigid Fiberglass Insulation ASTM C 612
Flexible Fiberglass Insulation: ASTM C 553

NOTE: All insulation in Plenums must have fire/smoke 25/50 rating.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products of one of the following:
 - Armstrong World Industries, Inc.
 - Babcock & Wilcox; Insulating Products Div.

CertainTeed Corp.
Kingspan Corp.
Knauf Fiber Glass GmbH.
Manville Products Corp.
Owens-Corning Fiberglas Corp.
Pittsburgh Corning Corp.
Rubatex Corp.
Cell-U-Foam Corp.

2.2 MISCELLANEOUS INSULATION ACCESSORIES & COMPOUNDS

- A. General: Provide band wires, tape, anchors, corner angles, cement, adhesives, coatings, sealants, protective finishes, mastics, metal covers, wire netting, etc. as recommended by insulation manufacturer for application indicated.
- B. Paper laminated jackets shall be permanently fire and smoke resistant. Chemicals used for treating paper in laminated jacket shall not be water soluble and shall be unaffected by water and humidity.

2.3 PIPING SYSTEM INSULATION

- A. Fiberglass Pipe Insulation: Owens Corning ASJ/SSL-11 pipe insulation. Fittings to be fiberglass insulation inserts and PVC fitting covers. PVC fittings shall be Manville "Zeston 200" or Proto "Low smoke".
- B. Inorganic glass fibers, bonded with a thermosetting resin. Jacket shall be all-purpose, factory applied, laminated glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil having self-sealing lap. ASTM C 612, Class 2, semi-rigid foil scrim kraft jacketed board.
- C. Thermal Conductivity shall be 0.24 (BTU-in/hr - ft² - Deg F) average maximum, at 75°F mean temperature. Density, 6 pcf average. Adhesive produced under the UL classification and follow-up service.
 - 1. Non-flammable, solvent-based, minus 20 to 180°F.
- D. Vapor barrier sealant shall be flexible elastomer based, vapor barrier sealant designed to seal fiberglass joints, water vapor permeance, 0.02 per maximum, minus 50 to 250°F, of a color gray.
- E. Cellular Glass Insulation: Pittsburgh Corning "Foamglass" or Cell-U-Foam Corp. "Ultra-Cuf" insulation for above grade pipe insulation and below grade pipe insulation with conductivity of 0.40 BTU/SF/F at 75°F and a permeability of 0.00 perms.
- F. Finish for machine rooms and piping subject to heavy traffic and chilled or hot water piping exposed to weather shall include Pittcote 404, Foster 30-70, or 30-80 reinforced with white glass fabric of not less than 7.8 ounces per yard. Then apply a second coat of Pittcote 404, Foster 30-70 or 30-80 and brush lightly with a wet brush to a smooth finish. Elbows, valves, and fittings shall be finished with Pittcote 404, Foster 30-70 or 30-80 reinforced with white glass fabric and aluminum jacket.
- G. Finish above ground insulation with white Kraft or vinyl-foil laminated fire-rated all-service jacket, all joints and laps sealed with fire-rated adhesive. Finish elbows, valves, fittings, etc., with Pittcote 404 reinforced with white glass fabric. All exposed piping shall have aluminum jacket unless indicated otherwise.
- H. Flexible Elastomeric Insulation: Armstrong "AP Armaflex" pipe insulation and Armstrong "Armaflex II" sheet and roll insulation, 25/50 compliance.
- I. General: Provide insulation of thickness and type indicated on the following schedule (NOTE: Provide finish and jacketing as indicated above; provide additional field applied jacketing as

indicated below.) (NOTE: Comply with schedules noted below or FBC 2023 8th Ed., whichever is greater):

PIPE INSULATION SCHEDULE

INTERIOR DOMESTIC COLD WATER, HOT WATER & RECIRCULATED HOT WATER PIPING

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
1/2 TO 1-1/4	Armaflex AP 25/50	1	NO	(A)(SS)*
1-1/2 TO 4	Armaflex AP 25/50	1 1/2	NO	(A)(SS)*
5 TO 10	Armaflex AP 25/50	1 1/2	NO	(A)(SS)*

INTERIOR HYDRONIC (85 TO 250 DEG F) EXPOSED & CONCEALED

PIPE SIZES (NPS)	MATERIALS	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
1/2 TO 4	GLASS FIBER	1-1/2	NO	(A)(SS)
	CELLULAR GLASS	1-1/2	NO	(A)(SS)
5 TO 10	GLASS FIBER	2	NO	(A)(SS)
	CELLULAR GLASS	2-1/2	NO	(A)(SS)
12 TO 36	GLASS FIBER	2-1/2	NO	(A)(SS)
	CELLULAR GLASS	3	NO	(A)(SS)

*Note: Field applied jacket not required for concealed piping.

DUCT SYSTEMS INSULATION SCHEDULE

INTERIOR CONCEALED HVAC SUPPLY, OUTSIDE AIR, EXHAUST AIR AND RETURN DUCTS AND PLENUMS

MATERIAL	FORM	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
GLASS FIBER	WRAP	2 (1.5# Density)	YES	NONE

INTERIOR EXPOSED MECHANICAL ROOM HVAC SUPPLY, OUTSIDE AIR, EXHAUST AIR, & RETURN DUCTS AND PLENUMS

MATERIAL	FORM	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
GLASS FIBER	BOARD-RECT. 2 (3# Density)		YES	(A) (SS)

P = Paper A = Aluminum PVC = White PVC Jacket K = Kraft SS = Stainless Steel

2.4 CONDENSATE DRAINS

- A. Insulate condensate drain piping above concealed spaced and in all mechanical rooms with 3/4" thick "AP" Armaflex (25/50 compliance) or approved equal. Insulate all condensate lines located in return air plenums (in their entirety) with 3/4" thick AP Armaflex (ASTM E84, 25/50 Compliance) pipe insulation. Exposed piping shall be primed and painted; color by Owner.

2.5 HANDICAPPED FIXTURES

- A. Insulate hot water and cold-water valves, supplies, and drains at handicapped lavatories with 1/2" thick "AP" Armaflex insulation, secured with Armstrong 520 adhesive. Insulate drains at handicapped lavatories with insulation jackets of similar composition to Armaflex with a vinyl cover.

2.6 PLUMBING VENTS, FLOOR DRAINS & HUB DRAINS

- A. Insulate the body, trap, and all horizontal piping from floor drains, hub drains, and floor sinks receiving cold condensate water with 1" thick AP Armaflex (ASTM E84, 25/50 Compliance) pipe insulation.
- B. Insulate the first 10 feet of piping from plumbing vents receiving cold condensate water with 1" thick AP Armaflex pipe insulation.

2.7 STORM WATER PIPING

- A. Insulate roof drain bodies and horizontal rainwater leaders of storm water piping. All exposed piping shall be primed and painted, color selection by architect.

2.8 FLEXIBLE CONNECTIONS

- A. Provide 1" thick "AP" Armaflex (25/50 compliance) insulation at all flexible connectors. Armaflex shall extend adequately beyond the foamglass or other rigid pipe insulation and secured by stainless steel bands.

2.9 DUCTWORK

- A. Insulate all galvanized steel supply, return and outside air ductwork. Exhaust ducts shall not be insulated, except internally lined with insulation 10 feet of ductwork attached to and including the discharge plenums at exhaust louvers for noise considerations. Insulate exterior exhaust duct. Insulate outside air ducts.
- B. Duct wrap shall be specifically designed for wrapping heating and air conditioning ductwork and include 2" overlap facing tab to provide for continuous vapor seal. Duct wrap shall be 2" thick, 1.5 lb. density, foil-scrim-Kraft laminated vapor barrier facing, minimum installed R-value equal to 6.0, and a maximum flame spread/smoke development rating of 25/50 per ASTM E84.
- C. Insulate HVAC plenums and unit housings not pre-insulated at factory or lined with 2" thick, 3.0 lb density (minimum) board insulation with foil scrim Kraft vapor barrier.

2.10 AIR DEVICES

- A. Insulate all exposed metal surfaces on back and neck of ceiling diffusers with 1" thick fiberglass with vapor barrier.

2.11 ACCESSORIES AND ATTACHMENTS

- A. Glass Cloth (for fiberglass and calcium silicate insulation only): Woven glass fiber fabrics, plain weave, pre-sized a minimum of 8 ozs. per sq. yd.
 - 1. Cloth Standard: MIL-C-20079H, Type I.
- B. Bands: 3/4" wide, in one of the following materials compatible with jacket:
 - 1. Stainless Steel: type 304, 0.020 inch thick.
 - 2. Galvanized Steel: 0.005 inch thick.
 - 3. Aluminum: 0.007 inch thick.
 - 4. Brass: 0.01 inch thick.
 - 5. Nickel-Copper Alloy: 0.005 inch thick.
- C. Wire: 14-gage nickel copper alloy, 16-gage, soft-annealed stainless steel, or 16-gage, soft-annealed galvanized steel.
- D. Corner Angles: 28-gage, 1" x 1" aluminum, adhered to 2" x 2" Kraft paper.

- E. Anchor Pins: Capable of supporting 20 pounds each. Provide anchor pins and speed washers of sizes and diameters as recommended by the manufacturer for insulation type and thickness.

PART 3 – EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.2 GENERAL

- A. Insulation shall be applied on clean, dry surfaces.
- B. All insulation shall be continuous through floor, wall and ceiling openings (including sleeves).
- C. Insulation on all cold surfaces where vapor barrier jackets are used must be applied with a continuous, unbroken vapor seal; hangers, supports, anchors, etc., that are secured directly to cold surfaces, must be adequately insulated and vapor sealed to prevent condensation.

3.3 PIPE INSULATION INSTALLATION, GENERAL

- A. Tightly butt longitudinal seams and end joints; bond with sealant or adhesive on closed cell insulation. Stagger joints on double layers of insulation.
- B. Apply insulation continuously over fittings, valves, and specialties, except as otherwise indicated.
- C. Apply insulation with a minimum number of joints.
- D. Exterior Wall Penetrations: For penetrations of exterior walls, extend metal jacket for exterior insulation through penetration to a point 2" from interior surface of wall inside the building. Seal ends of metal jacket with vapor barrier coating. Secure metal jacket ends with metal band. At point where insulation metal jacket contacts mechanical sleeve seal, insert cellular glass preformed pipe insulation to allow sleeve seal tightening against metal jacket. Tighten and seal sleeve to jacket to form a watertight seal.
- E. Interior Walls and Partitions Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions. Apply an aluminum jacket with factory applied moisture barrier over insulation. Extend 2" from both surfaces of wall or partition. Secure aluminum jacket with metal bands at both ends. Seal ends of jacket with vapor barrier coating. Seal around penetration with joint sealer.
- F. Fire-Rated Walls and Partitions Penetrations: Terminate insulation at penetrations through fire-rated walls and partitions. Seal insulation ends with vapor barrier coating. Seal around penetration with fire-stopping or fire-resistant joint sealer.
- G. Flanges, Fitting, and Valves - Interior Exposed and Concealed: Coat pipe insulation ends with vapor barrier coating. Apply premolded, precut, or field-fabricated segments of insulation around flanges, unions, valves, and fittings. Make joints tight, bond with adhesive.
 - 1. Use same material and thickness as adjacent pipe insulation.
 - 2. Overlap nesting insulation by 2" or 1 pipe diameter, whichever is greater.
 - 3. Insulate elbows and tees with premolded insulation or insulation material segments. Use at least three (3) segments for each elbow.
 - 4. Cover insulation except for metal jacketed insulation, with two (2) layers of lagging adhesive to a minimum thickness of 1/16". Install glass cloth between layers. Overlap adjacent insulation by 2" in both directions from joint with glass cloth and lagging adhesive.

- H. Hangers and Anchors: Apply insulation continuously through hangers and around anchor attachments. Install shields, as specified in Division 23, Section 232529 – "Hangers and Supports."

- 1. Shields: Cover hanger shields with jacket material matching adjacent pipe insulation.

- I. Apply insulation continuously through sleeves and manholes, except as specified above for exterior wall penetrations.

3.4 CELLULAR GLASS PIPE INSULATION INSTALLATION

- A. Cellular Glass Insulation: Butter pipes and joints of foamglass insulation with Pittseal 444, Foster 95-60 or 95-44, or Childers CP-70. Apply insulation to pipe and fittings with all joints tightly fitted.
- B. Secure with aluminum bands (not greater than 12" on center) so that each length of insulation shall be secured with two bands (minimum). Insulation shall be applied with all joints fitted to eliminate voids. Voids shall be eliminated by refitting or replacing insulation. Do not fill voids with joint sealer.
- C. Mastic finish application: Prior to application of the finish, the insulation shall be inspected for voids, cracked segments and open joints between segments. Cracked or broken segments, and open joints shall be refitted. Voids shall be filled with pieces of cellular glass insulation.
- D. Cut the PC Fabric 79 or 4224 MAST-A-FAB to fit around the pipe or fitting allowing for 3" to 4" overlap. Using a glove or trowel, apply a tack coat of PITTCOAT 404, Foster 30-70 or 30-80 coating to a section of the insulation. The tack coat should be applied at a rate of 3-4 gal/100 sf.
- E. Embed the PC Fabric 79 or 4224 MAST-A-FAB in the tack coat using a trowel, squeegee or glove to push the fabric in. Work the fabric into the coating until the appearance is uniform and there are no wrinkles or pinholes.
- F. As an alternate method, the PC Fabric 79 or 4224 MAST-A-FAB may be applied to the insulation first and the tack coat of PITTCOTE 404 coating troweled or gloved through the fabric.
- G. Apply another section of mastic overlapping the previous section by 3" and embed PC Fabric 79 or 4224 MAST-A-FAB as described in the above step. Each successive fabric section should overlap the previous one 3".
- H. Continue working following the procedure above, until the entire line has received the PITTCOTE 404, Foster 30-70 or 30-80 coating tack coat and PC Fabric 79. Care should be taken to ensure the mastic is pinhole free.
- I. Allow the first coat to dry a minimum of 24 hours (a minimum of 48 hours when relative humidity is higher than 80%) prior to application of the second coat.
- J. With a glove or trowel, apply a second coat of PITTCOTE 404, Foster 30-70 or 30-80 coating at a rate of 2-3 gal/100 sf. Here again, it is important that the mastic be applied pinhole free.

3.5 INSTALLATION OF DUCTWORK INSULATION

- A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purposes.
- B. Insulation shall be continuous throughout the duct length and shall comply with NFPA Bulletin 90A requirements for flame spread and smoke developments. Insulation shall be applied to the duct with a solid surface of fire retardant adhesive equal to Insul-Coastic 215 Sure-Stik.
- C. Insulation applied to the top surface of horizontal duct shall overlap the side pieces to provide maximum support. In addition, insulation shall be secured with pins and clips not to exceed 12"

on center. All exposed edges of board insulation shall receive brush coat of coating equal to Insul-Cooustic 110.

- D. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
- E. Maintain integrity of vapor barrier on ductwork insulation and protect it to prevent puncture and other damage.
- F. Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated.
- G. Install Blanket Wrap Insulation as Follows: Install uniform and smooth. Secure to ducts having long sides or diameters as follows:
 - 1. Smaller Than 24": Bonding adhesive applied in 6-inch-wide transverse strips on 12" centers.
 - 2. 12" and Larger: Anchor pins spaced 12" apart each way. Apply bonding adhesive to prevent sagging of the insulation.
 - 3. Overlap joints 3".
 - 4. Seal joints, breaks, and punctures with glass fabric and mastic. **(Tape is not allowed.)**
- H. Install rigid board insulation as follows:
 - 1. Adhesive and Band Attachment: Secure board insulation tight and smooth with at least 50 percent coverage of adhesive. Install bands spaced 12" apart. Protect insulation under bands and at exterior corners with metal corner angles. Fill joints, seams, and chipped edges with vapor barrier compound.
 - 2. Speed Washers Attachment: Secure insulation tight and smooth with speed washers and welded pins. Space anchor pins 12" apart each way and 3" from insulation joints. Apply vapor barrier coating compound to insulation in contact, open joints, breaks, punctures, and voids in insulation. **(Tape is not allowed.)**
- I. Cellular Glass Insulation: Install in same manner as cellular glass pipe insulation, including aluminum jacketing.

3.6 INSTALLATION OF EQUIPMENT INSULATION

- A. General: Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose.
- B. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.
- C. Maintain integrity of vapor barrier on equipment insulation and protect it to prevent puncture and other damage.
- D. Do not apply insulation to equipment while hot or cold.
- E. Apply insulation using staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.
- F. Coat insulated surfaces with layer of insulating cement, troweled in workmanlike manner, leaving smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.

- G. Cover insulated surfaces with all-service jacketing neatly fitted and firmly secured. Lap seams at least 2". Apply over vapor barrier where applicable.
- H. Provide removable insulation sections to cover parts of equipment that must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.
- I. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of weather-barrier mastic protective finish, and aluminum jacketing on all exterior equipment.

3.7 INSULATION JACKETS

- A. Exterior Exposed Insulation: Install continuous aluminum jackets and seal all joints and seams with waterproof sealant.
- B. Install corrugated aluminum (ASTM B209, 3003 alloy, H-14 temper 0.02" thick) jacket with 2" overlap at longitudinal and butt joints. Overlap longitudinal joints to shed water. Seal butt joints and longitudinal joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with aluminum or stainless-steel draw bands 12" on center and at butt joints. Jacket shall be continuous. Include screws or bands on elbows and other fittings as necessary.
- C. Foil and Paper Jackets (FP): Install jackets drawn tight. Install lap or butt strips at joints with material same as jacket. Secure with adhesive. Install jackets with 1-1/2" laps at longitudinal joints and 3" wide butt strips at end joints.
- D. Seal openings, punctures, and breaks in vapor barrier jackets and exposed insulation with vapor barrier compound.

3.8 FINISHES

- A. Flexible Elastomeric Cellular Insulation: After adhesive has fully cured, apply two coats of protective coating to exposed insulation. Color selected by Architect.
- B. Exposed Insulation shall have Aluminum Jacket or painted as indicated in the Construction Documents.

3.9 INSULATION REPAIR

- A. Repair damaged sections of mechanical insulation damaged during this construction period.

3.10 PROTECTION & REPLACEMENT

- A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
- B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

3.11 PAINT:

- A. Refer to Section 23 05 12 and Drawings for painting requirements. All exposed insulation shall be primed and painted; color selected by Owner.

END OF SECTION 23 07 00

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

1.3 DEFINITIONS

- A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
- B. CxA: Commissioning Authority.
- C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.
- D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 INFORMATIONAL SUBMITTALS

- A. Certificates of readiness.
 - 1. This may be provided on the Contractor's letterhead, simply stating that the equipment has been started by the manufacturer (where applicable) and all systems to be commissioned are ready for the commissioning process.
- B. Manufacturer startup reports.

1.5 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning functional performance tests at the direction of the CxA.
- B. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- C. Provide information requested by the CxA for final commissioning documentation.
- D. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.6 CxA'S RESPONSIBILITIES

- A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.
- B. Direct commissioning testing.
- C. Verify testing, adjusting, and balancing of Work are complete.
- D. Provide test data, inspection reports, and certificates in Systems Manual.

1.7 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
5. Test and inspection reports and certificates.
6. Corrective action documents.
7. Testing, adjusting, and balancing reports.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

- A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

- D. The CxA along will prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.
 - 1. Note: This project is inclusive of construction level commissioning only.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
 - 1. This will not be done without approval by the EOR.
- H. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- I. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

END OF SECTION 23 08 00

SECTION 23 09 23 – BUILDING MANAGEMENT SYSTEM

PART 1 – GENERAL

1.1 SCOPE

- A. The intent of this specification is to provide a complete Building Management System (BMS) designed to accomplish the sequences of operations. This specification describes standards in product and performance for all BMS systems installed at FSU facilities. All applicable standards described herein for this project shall be utilized unless otherwise stated.
- B. All new work shall fully integrate with the remote FSU Campus Building Management Control System and Workstation(s). Update existing systems and provide new Workstation/Server, hardware, firmware, software, communication systems and interface, etc. as required for full integration, monitoring and control from the remote FSU Campus Central Monitoring & Control Center. Update and provide new controls, graphics, etc at all Local Graphic User Interface and Central Graphic User Interface Systems.
- C. The Building Management System (BMS) manufacturer shall furnish and install a fully integrated building management system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.
- D. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer. The installing manufacturer shall certify in writing, that the shop drawings have been prepared by the equipment manufacturer and that the equipment manufacturer has supervised their installation. In addition, the equipment manufacturer shall certify, in writing, that the shop drawings were prepared by their company and that all temperature control equipment was installed under their direct supervision.
- E. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specially for this project. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.
- F. BMS manufacturer shall be responsible for all BMS and Temperature Control wiring for a complete and operable system. All wiring shall be done in accordance with all local and national codes. Wiring shall be a combination of plenum wire not in conduit outside of mechanical rooms and wiring in conduit in mechanical rooms and as required by codes.

1.2 WORK BY OTHERS

- A. Mechanical contractor installs all wells, valves, taps, dampers, flow stations, etc. furnished by BMS manufacturer.
 - 1. Controls (BMS) Contractor provides all control valves and control dampers and Mechanical Contractor shall install same. Electronic actuators furnished and installed by BMS contractor.
 - 2. All smoke, fire smoke, and fire dampers furnished complete with actuators and end switches by mechanical contractor. Wiring unless otherwise stated in other divisions shall be by BMS contractor.
 - 3. All taps, tap valves are by mechanical contractor.
 - 4. Access doors and installation are by mechanical contractor.
- B. Electrical Contractor provides (unless noted otherwise):
 - 1. Emergency 120V power to all BMS and/or Temperature control panels (by BMS Contractor; coordinate with Electrical Contractor and Construction Manager prior to Bid).

2. Wiring of all power feeds through all disconnect starters to electrical motor.
3. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by BMS manufacturer.
4. Line voltage wiring of any electrical sub-metering devices furnished by BMS manufacturer. Enclosure required for main building power monitor to be provided by electrical contractor with lockable door. (By BMS Contractor – coordinate with Electrical Contractor and Construction Manager prior to Bid.)

C. Products furnished but not installed under this section.

1. Section 23 - Hydronic Piping:
Control Valves
Temperature Sensor Wells and Sockets
Flow Meters
2. Section 23 - Ductwork Accessories:
Air-flow Stations
Control Dampers
3. Section 23 – VAV Air Terminals:
Terminal Unit Controls (BMS contractor shall include all costs for factory mounting of controls.)
4. BMS Contractor is responsible for coordinating with CM, General Contractor or Prime Contractor to identify and verify all required BMS work scope is included in the bid (whether or not shown directly on drawings or in these specifications). Items not provided and installed by Mechanical Contractor and Electric Contractor is the responsibility of the BMS Contractor.

1.3 RELATED WORK

- A. Division 00 & 01 – General and Special Conditions
- B. Division 23 – Mechanical
- C. Division 26 & 28 – Electrical & Fire Alarm

1.4 QUALITY ASSURANCE

- A. The BMS system shall be furnished and installed by Siemens Industry, Inc. Building Technologies Division.
- B. The BMS system shall be designed and installed, commissioned and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-place support facility within 120 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. Distributors or licensed installing contractors are not acceptable.
- C. The BMS manufacturer shall provide on site experienced project management for this work, responsible for direct supervision of the design, installation, start up and commissioning of the BMS.
- D. The Bidder shall be regularly engaged in the manufacturing, installation and maintenance of BMS systems and shall have a minimum of ten (10) years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of BMS systems similar in size and complexity to this project. A local maintained service organization consisting of competent servicepersons for a period of not less than ten years and provide a list of 10 projects, similar in size and scope to this project, completed within the last five years.
- E. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be

manufacturer's latest standard design that complies with the specification requirements and BMS system manufacturer.

- F. All BMS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX; Standard ULC C100, category UUKL7; and under Standard UL 864, categories UUKL, UDTZ, and QVAX and be so listed at the time of bid. All floor level controllers shall comply, at a minimum, with UL Standard UL 916 category PAZX; Standard UL 864, categories UDTZ and QVAX, and be so listed at the time of Bid.
- G. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.
- H. The manufacturer of the building management system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-140001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.
- I. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology, and extend new field panels on a previously installed network.
- J. Compatibility shall be defined as the ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers or protocol converters.

1.5 SUBMITTALS

- A. Submit six (6) complete sets of documentation in the following phased delivery schedule:
 - 1. Valve and damper schedules
 - 2. Equipment data cut sheets
 - 3. System schematics, including:
 - a. sequence of operations
 - b. point names
 - c. point addresses
 - d. interface wiring diagrams
 - e. panel layouts.
 - f. system riser diagrams
 - 4. Auto-CAD compatible as-built drawings
- B. Upon project completion, submit operation and maintenance manuals, consisting of the following:
 - 1. Index sheet, listing contents in alphabetical order
 - 2. Manufacturer's equipment parts list of all functional components of the system, Auto-CAD disk of system schematics, including wiring diagrams
 - 3. Description of sequence of operations
 - 4. As-Built interconnection wiring diagrams
 - 5. Operator's Manual
 - 6. Trunk cable schematic showing remote electronic panel locations, and all trunk data
 - 7. List of connected data points, including panels to which they are connected and input device (ionization detector, sensors, etc.)
 - 8. Conduit routing diagrams

1.6 WARRANTY

- A. Provide all services, materials and equipment necessary for the successful operation of the entire BMS system for a period of one year after Substantial Completion (and successful BMS Demonstration).
- B. The adjustment, required testing, and repair of the system includes all computer equipment, transmission equipment and all sensors and control devices.
- C. The on-line support services shall allow the local BMS subcontractor to dial out over telephone lines to monitor and control the facility's building management system. This remote connection to the facility shall be within 2 hours of the time that the problem is reported. This coverage shall include normal business hours, after business hours, weekends and holidays.
- D. If the problem cannot be resolved on-line by the local office, the national office of the BMS manufacturer shall have the same capabilities for remote connection to the facility. If the problem cannot be resolved with on-line support services, the BMS manufacturer shall dispatch the appropriate personnel to the job site to resolve the problem within 4 hours of the time that the problem is reported.

1.7 CODE REQUIREMENTS

- A. Perform work in accordance with applicable statutes, ordinances, codes, and regulations of governmental authorities having jurisdiction. Applicable codes include, but are not limited to, the following:

American National Standards Institute (ANSI).
National Electrical Code (NEC).
National Electrical Manufacturers Association (NEMA).
National Electrical Safety Code (NESC).
Underwriters' Laboratories (UL).
Standards of National Board of Fire Underwriters.
Regulations of the Electric Utility concerning Electrical Installations.
Regulations of the Florida Department of Commerce regarding safety.
2023 Florida Building Code (8th Edition)
Occupational Safety and Health Regulations (OSHA).
National Fire Protection Association (NFPA).
National Fire Codes.

- B. Resolve any code violation discovered in contract documents with the Engineer prior to award of the contract. After award of the contract, make any correction or addition necessary for compliance with applicable codes at no additional cost to Owner/ Engineer.
- C. Where there is a conflict between the contract documents and an applicable "CODE," the "CODE" shall govern except where the requirements of the contract documents are more stringent; where there is a conflict between the contract drawings and the contract specifications, the most stringent shall govern.

1.8 PERMITS, FEES, AND INSPECTIONS

- A. Obtain all permits, fees and systems inspections.
- B. Deliver all certificates of inspection issued by authorities having jurisdiction to the Engineer.

1.9 WORKMANSHIP

- A. Install materials and equipment in a professional manner. The Engineer may direct replacement of items that, in his opinion, do not present a professional appearance. Replace or reinstall items at the expense of the Contractor.

1.10 CONNECTING TO WORK OF OTHERS

- A. Examine all work installed by others where it applies to work of Division 23. Notify the Engineer if conditions exist which prevent satisfactory results. Start of work by the Contractor shall be construed as acceptance by him of all claims or questions as to suitability of the work of others to receive his work.

1.11 DAMAGE TO OTHER WORK AND PERSONNEL

- A. Adequately protect work, equipment, fixtures, and materials. At work completion, all work must be clean and in good condition.
- B. Carry insurance as prescribed by law and as required in this specification for protection of employees, other persons, materials and equipment on the building site.
- C. Contractor shall pay for all damages caused by his personnel, including his Subcontractors.

1.12 CUTTING, PATCHING AND EXCAVATION

- A. Cut and patch all walls, partitions, floors, pits and chases in wood and masonry as indicated or required by the contract documents or as directed by the Engineer.
- B. Obtain approval of Engineer prior to cutting of steel, wood or other structural member.
- C. Complete all necessary excavation and backfilling incidental to work of Division 23.

Structures – Cutting & Patching:

- A. On buildings, openings through concrete structures shall be "core bored"; where 3 or more openings penetrate in the same location the concrete may be sawed. All penetrations shall be re-sealed around pipes with "WATER-PLUG" by Thoro with top surface finished smooth.
- B. Where paved surfaces are to be removed for installation of materials and equipment as a part of this contract, said paved surfaces shall be removed and replaced at the expense of the Subcontractor requiring its removal. Replacement of the paved surface shall match the existing surface, as originally installed, in all respects. Where trenching is done through and under said paved surfaces, the trench shall be backfilled with clean, dry sand. The fill shall be uniformly compacted in horizontal layers, 6" to 9" thick to a density of 98 percent of the Standard Proctor Maximum in accordance with ASTM Specifications D-698T. Do not use water (puddling) for compaction of fill.
- C. The contractor shall verify the existence of any hazardous material or waste with FSU prior to the start of any work.

"Fire and Smoke Rated" Walls, Floors, Roofs and Ceilings:

- A. Where "rated" walls, floor, roofs and ceilings are penetrated or cut to install equipment, materials, devices, etc. the Contractor shall provide and install all materials required to reestablish the rating of the wall, floor, roof or ceiling to the satisfaction of the authority having jurisdiction.

1.13 REMOVAL OF RUBBISH

- A. During construction keep the job site clean and remove all rubbish caused by work of Division 23.
- B. Upon completion of work leave the premises and work in a clean and acceptable condition. Remove all tools, scaffolding, materials and rubbish from the building and site. Clean all pipe chases. Remove all plaster, concrete, cement, etc. from exposed and concealed pipe, hangers and equipment prior to painting and/or concealment.

1.14 MATERIALS AND EQUIPMENT

- A. Furnish new and unused materials and equipment manufactured in the U.S.A. Where two or more units of the same type or class of equipment are required provide units of a single manufacturer.
- B. Only manufacturer's products specified hereinafter or listed in addenda, prior to the acceptance of bids, shall be furnished and installed under this contract.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Siemens Industry, Inc. Apogee, Building Technologies Division (Contact Jason Taylor, 513-368-9073 or jason.taylor@siemens.com)

2.2 NETWORKING COMMUNICATIONS

- A. The design of the BMS shall support networking of operator workstations and Building Controllers. The network architecture shall consist of two levels, an Ethernet based primary network for all operator workstations, servers, and primary DDC controllers along with secondary Floor Level Networks (FLN) for terminal equipment application specific controllers.
- B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.

Operator Workstation Communication:

- A. All color graphic operator workstations shall reside on the Ethernet network and the consoles shall be set up in a client/server configuration.
- B. The servers will act as the central database for system graphics and databases to provide consistency throughout all system workstations.
- C. The network shall allow concurrent use of multiple BMS software site licenses.

Primary Network Communication:

- A. All PCs shall simultaneously direct connect to the Ethernet Management Level Network without the use of an interposing device.
- B. Operator Workstation shall be capable of simultaneous direct connection and communication with BACnet/IP, OPC and TCP/IP corporate level networks without the use of interposing devices.
- C. The Primary Network shall not impose a maximum constraint on the number of operator workstations.
- D. Any controller residing on the primary network shall connect to Ethernet network without the use of a PC or a gateway with a hard drive.
- E. Any PC on the Primary Network shall have transparent communication with controllers on the building level networks connected via Ethernet.
- F. Any break in Ethernet communication from the PC to the controllers on the Primary Network shall result in a notification at the PC.
- G. The standard client and server workstations on the Primary Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3.

- H. System software applications will run as a service to allow communication with Primary Network Controllers without the need for user log in. Closing the application or logging off shall not prevent the processing of alarms, network status, panel failures, and trend information.
- I. Any break in Ethernet communication between the standard client and server workstations on the Primary Network shall result in a notification at each workstation.
- J. Access to the system database shall be available from any standard client workstation on the Primary Network.

Primary Network - Panel to Panel Communication:

- A. All Building Controllers shall directly reside on the primary Ethernet network so that communications may be executed directly between Building Controllers, directly between server and Building Controllers on a peer-to-peer basis.
- B. Systems that operate via polled response or other types of protocols that rely on a central processor, file server, or similar device to manage panel-to-panel or device-to-device communications shall not be acceptable.
- C. All operator interfaces shall have the ability to access all point status and application report data or execute control functions for any and all other devices. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.
- D. The primary network shall use TCP/IP over Ethernet. All devices must:
 - 1. Auto-sense 10/100 Mbps networks.
 - 2. Receive an IP Address from a Dynamic Host Configuration Protocol (DHCP) Server or be configured with a Fixed IP Address.
 - 3. Resolve Name to IP Addresses for devices using a Domain Name Service (DNS) Server on the Ethernet network.
 - 4. Allow MMI access to an individual Primary Network Controller using industry standard Telnet software to view and edit entire Primary Network.
- E. The primary network shall provide the following minimum performance:
 - 1. Provide high-speed data transfer rates for alarm reporting, report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any Building Controller is displayed at any PC workstations, all Building Controllers, and other alarm printers within 15 seconds.
 - a. Message and alarm buffering to prevent information from being lost.
 - b. Error detection, correction, and re-transmission to guarantee data integrity.
 - 2. Synchronization of real-time clocks between Building Controllers, including automatic daylight savings time corrections.
 - 3. The primary network shall allow the Building Controllers to access any data from, or send control commands and alarm reports directly to, any other Building Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. Building Controllers shall send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The network shall also allow any Building Controller to access, edit, modify, add, delete, back up, restore all system point database and all programs.
 - 4. The primary network shall allow the Building Controllers to assign password access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (e.g., all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant

points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

5. Devices containing custom programming must reside on the Primary Network.

2.3 DDC CONTROLLER FLOOR LEVEL NETWORK (FLN)

- A. This level communication shall support a family of application specific controllers and shall communicate with the peer-to-peer network through DDC Controllers for transmission of global data.

2.4 DDC & HVAC MECHANICAL EQUIPMENT CONTROLLERS

- A. The DDC & HVAC Mechanical Equipment Controllers shall reside on the Building Level Network (BLN).
- B. DDC & HVAC Mechanical Equipment Controllers shall use the same programming language and tools. DDC & HVAC Mechanical Equipment Controllers which require different programming language or tools on a network are not acceptable.
- C. DDC Controllers & HVAC Mechanical Equipment Controllers which do not meet the functions specified are not acceptable.
- D. DDC Controllers (MBC, FLNC) or HVAC Mechanical Equipment Controllers (MEC) shall support FLN networks as described above.

2.5 BUILDING CONTROLLER

- A. Building Controllers shall be 32-bit, multi-tasking, multi-user, real-time 100 MHz digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.
- B. Each Building Controller shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, and dial-up communications.
- C. Provide Universal I/O capability, including software configurable universal inputs and universal outputs.
- D. Each Building Controller shall support a minimum of one directly connected Secondary Network.
- E. Building Controller shall have an integral real-time clock.
- F. Each Building Controller shall support firmware upgrades without the need to change hardware.

Each Building Controller Shall Support:

- A. Monitoring of industry standard analog and digital inputs, without the addition of equipment outside the Building Controller cabinet.
- B. Monitoring of industry standard analog and digital outputs, without the addition of equipment outside the Building Controller cabinet.

Spare Point Capacity:

- A. Each Building Controller shall have a minimum of 10 percent spare point capacity.

- B. The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than one spare of each implemented I/O type.
- C. Provide all processors, power supplies, and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:
 - 1. Expansion modules
 - 2. Sensor/actuator
 - 3. Field wiring/tubing

Serial Communication:

- A. Building Controllers shall provide at least two EIA-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals. Building Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals.

I/O Status and Indication:

- A. Building Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. All wiring connections shall be made to field-removable terminals.
- B. Shall provide I/O modules with LCD's capable of displaying information faults including but not limited to open circuit, short circuit, unreliable input signal, signal under range, and signal over range via informative symbols.

Self Diagnostics:

- A. Each Building Controller shall continuously perform self diagnostics, communication diagnosis, and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.

Power Loss:

- A. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 30 days.

Environment:

- A. Controller hardware shall be suitable for the anticipated ambient conditions.
- B. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
- C. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

Immunity to Power and Noise:

- A. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
 - 1. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

- B. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
 - 1. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
 - 2. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
 - 3. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
 - 4. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)
- C. Isolation shall be provided at all Building Controller's AC input terminals to suppress induced voltage transients consistent with:
 - 1. IEEE Standard 587 1980
 - 2. UL 864 Supply Line Transients
 - 3. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)
- D. Provide a separate DDC Controller for each AHU or other HVAC system as indicated in Section 3.02 of this section and on drawings. Where practical more than one mechanical system may be placed into a single Building controller provided all points for a system reside in single controller and minimum quantity of spare I/O points are maintained.

2.6 BUILDING CONTROLLER RESIDENT SOFTWARE FEATURES

- A. General: Furnish the following applications software to form a complete operating system for building and energy management as described in this specification.
- B. The software programs specified in this Section shall be provided as an integral part of Building Controllers and shall not be dependent upon any higher level computer or another controller for execution.
- C. All points, panels and programs shall be identified by a 30-character name. All points shall also be identified by a 16-character point descriptor. The same names shall be displayed at both Building Controller and the Operator Interface.
- D. All digital points shall have a user defined two-state status indication with 8 characters minimum (e.g., Summer, Enabled, Disabled, Abnormal).
- E. Building Controllers shall have the ability to perform energy management routines including but not limited to time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating/cooling interlock, supply temperature reset, priority load shedding, and power failure restart.
- F. The Building Controllers shall have the ability to perform the following pre-tested control algorithms:
 - 1. Two position control
 - 2. Proportional control
 - 3. Proportional plus integral control
 - 4. Proportional, integral, plus derivative control
 - 5. Automatic tuning of control loops
 - 6. Model-Free Adaptive Control
- G. Each controller shall be provided with an interactive HELP function to assist operators using POTs and remote connected operators.

System Security:

- A. User access shall be secured using individual security passwords and user names.
- B. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
- C. User Log On/Log Off attempts shall be recorded.
- D. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
- E. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.

User Defined Control Applications:

- A. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
- B. It shall be possible to use any system measured point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system.
- C. Any process shall be able to issue commands to points in any and all other controllers in the system.
- D. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
- E. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.
- F. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task oriented information from the user manual.

Alarm Management:

- A. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each Building Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the Building Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
- B. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.
- C. An Alarm "shelving" feature shall be provided to disable alarms during testing. (Pull the Plug, etc.).
- D. Binary Alarms: Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
- E. Analog Alarms: Each analog object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.
- F. All alarm or point change reports shall include the point's user defined language description and the time and date of occurrence.

- G. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, Building Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each Building Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
- H. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display graphics.
- I. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200-character alarm message to more fully describe the alarm condition or direct operator response.
- J. Each Building Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assigned to any number of points in the Controller.
- K. Operator-selected alarms shall be capable of initiating a call to a remote operator device.

Scheduling:

- A. Provide a comprehensive menu driven program to automatically start and stop designated object or group of objects in the system according to a stored time.
- B. Schedules shall reside in the building controller and shall not rely on external processing or network.
- C. It shall be possible to define a group of objects as a custom event (i.e., meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.
- D. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and/or stop within that group.
- E. The operator shall be able to define the following information:
 - 1. Time, day.
 - 2. Commands such as on, off, auto, etc.
 - 3. Time delays between successive commands.
 - 4. There shall be provisions for manual overriding of each schedule by an authorized operator.
- F. It shall be possible to schedule calendar-based events up to one year in advance based on the following:
 - 1. Weekly Schedule: Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, and stop, optimal start, optimal stop, and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.
 - 2. Exception Schedules: Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.
 - 3. Holiday Schedules: Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.

- G. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.
- H. Night Setback Control: The system shall provide the ability to automatically adjust setpoints for night control.
- I. Enthalpy Switchover (Economizer): The Building Controller Software (BCS) shall control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover setpoint, the BCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly change over to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.
- J. Loop Control: A Model-Free Adaptive Control algorithm or alternatively a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, setpoint, and weighting parameters shall be user-selectable.
- K. Sequencing: Provide application software based upon the sequences of operation specified to properly sequence equipment.

Staggered Start:

- A. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order, in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable.
- B. Upon the resumption of power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

Totalization:

- A. Run-Time Totalization: Building Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.
- B. Consumption Totalization: Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.
- C. Event Totalization: Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

Data Collection:

- A. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for all points.
- B. Building Controllers shall store point history data for selected analog and digital inputs and outputs:
 - 1. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controllers point group.
- C. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual

command or when the trend buffers are full. All trend data shall be available for use in third-party personal computer applications.

- D. Loop Tuning: Building Controllers shall also provide high resolution sampling capability for verification of DDC control loop performance. Documented evidence of tuned control loop performance shall be provided on a monthly, seasonal, quarterly, annual period.
- E. For Model-Free Adaptive Control loops, evidence of tuned control loop performance shall be provided via graphical plots or trended data logs. Graphical plots shall minimally include depictions of setpoint, process variable (output), and control variable (e.g., temperature). Other parameters that may influence loop control shall also be included in the plot (e.g., fan on/off, mixed-air temperature).
- F. For PID control loops, operator-initiated automatic and manual loop tuning algorithms shall be provided for all operator-selected PID control loops. Evidence of tuned control loop performance shall be provided via graphical plots or trended data logs for all loops.
 - 1. In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.
 - 2. Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

2.7 FLOOR LEVEL NETWORK APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs) through Floor Level LAN Device Networks.
- 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. Provide the following types of ASCs as a minimum:
 - 1. Terminal Equipment Controllers
 - 2. Digital Energy Monitors
 - 3. Third Party FLN (P-1) BMS Vendor (and Owner) approved devices (variable frequency drives, electric switch gear monitors, etc.)
- C. Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device. Third party devices shall be fully capable of normal non-communicating operations and operator interface as provided by device manufacturer.
- D. Terminal Equipment Controllers (TEC): Provide for control of each piece of equipment, including, but not limited to, the following:
 - Variable Air Volume (VAV) boxes
 - Constant Air Volume (CAV) boxes
 - Dual Duct Terminal Boxes
 - Fan Coil Units
 - Heat Pumps
 - Unit Ventilators
 - Room Pressurization
 - Lab Room Controller
 - Fume Hood Monitor / Controller

- E. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, 0-10v, allowing for interface to a variety of modulating actuators.
- F. All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the network is not acceptable.
- G. Digital Energy Monitors (DEM): Provide three phase digital watt-meters with pre-wired CTs. All watt-meter electronics shall be housed within the CTs. CTs shall include sizes capable of mounting directly on a power bus. Diagnostics visible to the installing electrician (without an operator tool) shall indicate: proper operation, mis-wiring or low power-factor, device malfunction, and over-load condition. The meters shall include the following:
 - 1. The device shall be UL Listed, and shall comply with ANSI C12.1 accuracy specification. The minimum CT/meter combined accuracy shall be no greater than 1% of reading over the range of 5% to 100% of rated load. The meter shall not require calibration.
 - 2. The wattmeter shall directly connect to power from 208 through 480 with no potential transformer. In-line fuses for each voltage tap phase shall be included.
 - 3. The wattmeter CTs shall be split-core and at minimum be sized to accommodate loads ranging from 100 to 2400 Amps. The CTs shall be volt-signal type, and shall not require shorting blocks.
 - 4. The wattmeter shall reside directly on the Floor Level Network along with other FLN devices. Data transferred shall include:
 - KW & KWH
 - Consumption
 - Demand
 - Power Factor
 - Current
 - Voltage
 - Apparent Power
 - Reactive Power

PORTABLE OPERATOR'S TERMINAL (POT)

~~Provide industry standard, commercially available portable operator terminals with a LCD display and a full featured keyboard. The POT shall be handheld and plug directly into all DDC Controllers, HVAC & Mechanical Equipment Controllers, and Floor Level Network Controllers as described below. Provide a user friendly, English language prompted interface for quick access to system information, not codes requiring look-up charts.~~

~~Functionality of the portable operator's terminal connected at any DDC Controller:~~

~~Access all DDC Controllers and ASCs on the network.
Backup and/or restore DDC Controller data bases for all system panels, not just the DDC Controller connected to.
Display all point, selected point and alarm point summaries.
Display trending and totalization information.
Add, modify and/or delete any existing or new system point.
Command, change setpoint, enable/disable any system point.
Program and load custom control sequences as well as standard energy management programs.
Acknowledge alarms~~

~~Functionality of the portable operator's terminal connected to any application specific controller:~~

~~Provide connection capability at either the Floor Level Network Controller or a related room sensor to access controller information.~~

~~Provide status, setup and control reports.~~

~~Modify, select and store controller data base.
Command, change setpoint, enable/disable any controller point.~~

~~Connection of a POT to a DDC or HVAC & Mechanical Equipment Controller, or ASC Controller shall not interrupt nor interfere with normal network operation in any way, prevent alarms from being transmitted or preclude centrally initiated commands and system modification.~~

~~Portable operator terminal access to controller shall be password controlled. Password protection shall be configurable for each operator based on function, points (designating areas of the facility), and edit/view capability.~~

2.8 LOCAL USER DISPLAY

- A. Where specified in the sequence of operation or points list, the controllers on the peer to peer building level network shall have a display and keypad for local interface. A keypad shall be provided for interrogating and commanding points in the controller.
- B. The display shall use the same security password and access rights for points in the display as is used in the associated controller.
- C. The LCD display shall be a minimum of a 2 line 40 character display.
- D. The LCD display shall include the full point name, value (numeric, digital or state text),
- E. Point priority and alarm status on one screen.
- F. The LCD shall dynamically update the value, priority, and alarm status for the point being displayed.
- G. The display shall be mounted either on the door of the enclosure or remote from the controller

2.9 OPERATOR INTERFACE

Workstation Hardware: Required (~~yes~~) (no)

- A. Personal computer operator workstations shall be provided for command entry, information management, system monitor, alarm management and database management functions. All real-time control functions shall be resident in the Building Controllers to facilitate greater distribution, fault tolerance and reliability of the building management control.
- B. Provide workstation(s) of equal capability as located on plans.
- C. Workstation shall consist of a personal computer with minimum 6 GB Memory, 2.2 GHz Processor, high performance hard drive with 500 GB available space, video card with 1.0 GB RAM capable of supporting a minimum of 1280 × 1024 resolution with a minimum of 32-bit color, 16X DVD-RW and DVD-ROM Drive, mouse and 101-key enhanced keyboard. Personal computer shall be a Windows 7, 2000 or comparable operating system and shall include a dual core processor.
- D. The PC monitor shall be of flat panel type and shall support a minimum display resolution of no less than 1280 × 1024 pixels. The display shall have a minimum of 20-inch visible area in diagonal measurement. Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective.
- E. Provide an Epson FX-870 or equivalent printer at each workstation location or on the network (Ethernet) for recording alarms, operator transactions and systems reports.
- F. Provide a color printer for printing of dynamic trend graph report, Excel reports, graphics and any other screen displays.

- G. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.

Server Hardware: Required (~~yes~~) (no)

- A. The server hardware shall be of equal or better capability as that of workstation and shall be equipped as follows.
1. Locate server as located on plans.
 2. Provide a minimum 8 GB RAM, 2.4 GHz Processor, with two hard drives of 2.0 TB available space each, with a RAID controller, a video card with 1.0 GB RAM capable of supporting a minimum of 1280 × 1024 resolution with a minimum of 32-bit color, 16X DVD-RW, and DVD-ROM Drive, mouse and 101-key enhanced keyboard. Server shall be a Windows 2003 or comparable operating system, and shall include a dual core processor or better.
 3. Provide a monitor of flat panel type and shall support a minimum display resolution of no less than 1280 × 1024 pixels. The display shall have a minimum of 20-inch visible area in diagonal measurement. Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective.

Operator Interface Software: Required (~~yes~~); (~~no~~) (**update existing or provide new as required**).

- A. Operator workstation interface software shall minimize operator training through the use of English language prompting, 30 character English language point identification, on-line help, and industry standard PC application software. Interface software shall simultaneously communicate with up to 4 Building Level Networks and share data between any of the 4 networks.
1. The software shall provide, as a minimum, the following functionality:
 - a. Real-time graphical viewing and control of environment
 - b. Scheduling and override of building operations
 - c. Collection and analysis of historical data
 - d. Point database editing, storage and downloading of controller databases.
 - e. Alarm reporting, routing, messaging, and acknowledgment
 - f. Display dynamic data trend plot.
 - Must be able to run multiple plots simultaneously
 - Each plot must be capable of supporting 10 pts/plot minimum
 - Must be able to command points directly off dynamic trend plot application.
 - g. Definition and construction of dynamic color graphic displays.
 - h. Program editing
 - i. Transfer trend data to 3rd party software
 - j. Scheduling reports
 - k. Operator Activity Log
 - l. Open communications via OPC Server (option)
 2. Provide a graphical user interface which shall minimize the use of keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection.
 3. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BMS software shall run on a Windows NT 32 bit operating. These Windows applications shall run simultaneously with the BMS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BMS alarms and monitoring information.
 - a. Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via user-sized windows. Operator shall be able to

- drag and drop information between applications, reducing the number of steps (i.e. Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend).
- 1) Dynamic color graphics and graphic control
 - 2) Alarm management, routing to designated locations, and customized messages
 - 3) Year in advance event and report scheduling
 - 4) Dynamic trend data definition and presentation
 - 5) Graphic definition and construction
 - 6) Program and point database editing on-line.
- b. If the software is unable to display several different types of displays at the same time, the BMS contractor shall provide at least two operator workstations.
 - c. Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.
4. Operator specific password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported).
 5. Reports shall be generated on demand or via pre-defined schedule and directed to CRT displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:
 - a. A general listing of all or selected points in the network
 - b. List of all points currently in alarm
 - c. List of all points currently in override status
 - d. List of all disabled points
 - e. List of all points currently locked out
 - f. List of user accounts and access levels
 - g. List all weekly schedules
 - h. List of holiday programming
 - i. List of limits and deadbands
 - j. Custom reports from 3rd party software
 - k. System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points
 - l. List of programs
 6. Scheduling and Override:
 - a. Provide a calendar type format for simplification of time-of-day scheduling and overrides of building operations. Schedules reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection or function key. Provide the following spreadsheet graphic types as a minimum:
 - 1) Weekly schedules
 - 2) Zone schedules, minimum of 200 unique zones
 - 3) Scheduling for up to 365 days in advance
 - 4) Schedule reports to print at PC.
 7. Collection and Analysis of Historical Data:
 - a. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.
 - b. Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow predefined groups of up to

250 trended points to be easily transferred on-line to Microsoft Excel. DDC contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. DDC contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.

- c. Provide additional functionality that allows the user to view real-time trend data on trend graph displays. A minimum of ten points may be graphed, regardless of whether they have been predefined for trending. The dynamic graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed. A minimum of 8 true graphs shall run simultaneously. Operator shall be able to command points directly on the trend plot by double clicking on the point.
- B. Dynamic Color Graphic Displays: Create standard FSU required color graphic displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, room level terminal units and DX systems shall be provided by the BMS contractor to optimize system performance, analysis and speed alarm recognition. Coordinate with FSU prior to generation of displays for current standards. Update graphics at all existing FSU BMS workstations.
- C. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of AutoCAD or scanned pictures for use in the system.
- D. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
 1. Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.
 2. Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.
 3. Equipment state can be changed by clicking on the point block or graphic symbol and selecting the new state (on/off) or setpoint.
 4. State text for digital points can be defined up to eight characters.
- E. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
- F. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
- G. Off the shelf graphic software, Microgafx Designer or Coral Draw software shall be provided to allow the user to add, modify or delete system graphic displays.
- H. A clipart library of HVAC and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library.
- I. A dynamic display of the site specific architecture showing status of controllers, PC workstations and networks shall be provided.
- J. System Configuration & Definition: Network wide control strategies shall not be restricted to a single DDC Controller or HVAC Mechanical Equipment controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.

- K. Provide automatic backup and restore of all DDC controller and HVAC Mechanical Equipment controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller or HVAC Mechanical Equipment Controller. Changes made at the DDC Controllers or HVAC Mechanical Equipment Controllers shall be automatically uploaded to the workstation, ensuring system continuity.
- L. System configuration, programming, editing, graphics generation shall be performed on-line. If programming and system back-up must be done with the PC workstation off-line, the BMS contractor shall provide at least 2 operator workstations.
- M. Alarm Management: Alarm Routing shall allow the user to send alarm notification to selected printers or PC location based on time of day, alarm severity, or point type.
- N. Alarm Notification shall be provided via two alarm icons, to distinguish between routine, maintenance type alarms and critical alarms. These alarm icons shall be displayed when user is working in other Windows programs. The BMS alarm display screen shall be displayed when the user clicks on the alarm icon.
- O. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.
- P. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.
- Q. Workstation/Controller Communications: Communications for building workstations (and building controllers) are as specified for MLN connection to Campus backbone and shall be performed via fiber optics (within inner ducts) connect to existing campus system or run new as required. This contractor is responsible for all networking and communications for a complete & fully operational and functional building management system. Field verify all conditions prior to bid and include all costs.
- R. Web Based Operator Interface: ~~Provide one (1) Main Mechanical Room Building Controller Mounted Operator Interface Display. The touch screen display shall be 19" and permanently affixed and shall support 1280 x 1024 resolution. Operator shall be able to access controls/graphics for the entire system from either Operator Interface.~~
 - 1. The interface shall provide a web based graphical interface Screen that allows users to access the Siemens APOGEE (or other acceptable BMS Vendor) server systems data via the Internet, extranet, or Intranet. The interface shall use HTML based ASP pages to send and receive data from the BMS to a web browser as described below. Provide updates as required.
 - 2. The existing workstation/server computer(s) shall utilize Siemens APOGEE GO web enabled software (or approved equal). The web server shall use Microsoft's IIS server 4.0 with Windows NT4, or IIS 5.0 with Windows 2000, and support browser access via Microsoft Internet Explorer 5.0 (or higher), or Navigator Netscape 6.0 (or higher).
 - 3. All information exchanged over Siemens (or other BMS vendor) Campus APOGEE Intranet (and/or fiber backbone) shall not require encryption (provided by BMS Vendor). Information provided off campus via the Web Interface shall be optionally encrypted and secure via SSL (provided by Owner).
 - 4. Access to the web interface may be password protected. A user's rights and privileges to points and graphics will be the same as those assigned at the BMS workstation. An option will exist to only allow users "read" access via the web browser, while maintaining "command" privileges via the BMS workstation.
 - 5. Commissioning of the Web interface shall not require modification or creation of HTML or ASP pages. All graphics available at the BMS graphical workstation shall be available to users via a web browser.

6. The web-based interface shall provide the following functionality to users, based on their access and privilege rights:
 - R. Logon Screen: Allows the user to enter their user name, password and Domain name for logging into the web server.
 - S. Alarm Display: A display of current BMS alarms to which the user has access will be displayed. Users will be able to acknowledge and erase active alarms, and link to additional alarm information including alarm messages, and informational and memo text. Any alarm acknowledgements initiated through the web interface will be written to the BMS central workstation activity log.
 - T. Graphic Display: Display of system graphics available in the BMS workstation will be available for viewing over the web browser. Software that requires creation of "web" graphics in order to display them via the browser interface will not be acceptable. A graphic selector list will allow users to select any graphics to which they have access. Graphic displays will automatically refresh with the latest change of values. Users will have the ability to command and override points from the graphic display as determined by their user accounts rights.
 - U. Point Details: Users will have access to point detail information including operational status, operational priority, physical address, and alarm limits, for point objects to which they have access rights.
 - V. Point Commanding: Users will be able to override and command points they have access to via the web browser interface. Any commands or overrides initiated via the web browser interface will be written to the BMS central workstation activity log.
 - W. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the Owner as required to support the web access feature.

2.10 UNINTERRUPTIBLE POWER SUPPLY SYSTEM:

- A. Provide an advanced, modular power management UPS power management package for the computer equipment and all DDC Controllers (MBC, MEC). Provide unit sized for the equipment supplied at a minimum 420 VA, with 15 minute emergency runtime.

2.11 POWER SUPPLIES AND LINE FILTERING:

- A. Control transformers shall be UL Listed. Furnish Class 2 current-limiting type, or furnish over-current protection in both primary and secondary circuits for Class 2 service per NEC requirements. Limit connected loads to 80% of rated capacity.
- B. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100 microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection, and shall be able to withstand a 150% current overload for at least 3 seconds without trip-out or failure.
- C. Unit shall operate between 0°C and 50°C [32°F and 120°F]. EM/RF shall meet FCC Class B and VDE 0871 for Class B, and MIL-STD 810C for shock and vibration.
- D. Line voltage units shall be UL Recognized and CSE Approved.
- E. Power Line Filtering: Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:
 1. Dielectric strength of 1,000 volts minimum.
 2. Response time of 10 nanoseconds or less.
 3. Transverse mode noise attenuation of 65 dB or greater.
 4. Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.

2.12 FIELD DEVICES

- A. Provide instrumentation as required for monitoring, control or optimization functions.

Room Temperature Sensors:

- A. TEC Applications: Provide a loop powered sensor utilizing a 10k ohm thermistors element. Sensor shall include a RJ-11 port to provide means of communication with external portable operator's terminal. Digital room sensors shall have LCD display, day / night override button, and setpoint slide adjustment override options. The setpoint slide adjustment can be software limited by the management system to limit the amount of room adjustment. Color shall be white.
- B. MBC, MEC Applications: Provide a loop powered sensor utilizing a 1k ohm Platinum RTD element. Digital room sensors shall have LCD display, day / night override button, and setpoint slide adjustment override options. The setpoint slide adjustment can be software limited by the management system to limit the amount of room adjustment.

Color shall be white

Temperature Monitoring Range	+20/120°F -13° to 49°C)
Output Signal	Changing resistance
Accuracy at Calibration Point	±0.5°F (+/- 0.3°C)
Set Point and Display Range	55° to 95° F (13° to 35°C)

- C. Temperature Sensors (Duct, Liquid immersion, Outside Air): Provide a loop powered sensor utilizing a 100 ohm Platinum RTD element. Provide separable wells of 300 stainless steel with thermal compound for immersion sensors. Sensors to have connection for conduit. Outside air sensors to have shield to minimize solar effects and shall be mounted to minimize building mass interference.

Non Chilled Water

Liquid Immersion Temperature:	# 536-767
Temperature Monitoring Range	+30/250°F (-1°/121°C)
Output Signal	4-20 ma loop powered
Accuracy at Calibration point	±1°F (+/-0.5°C)

Chilled Water

Liquid Immersion Temperature:	# 536-744
Temperature Monitoring Range	+20/70°F (-7°/21°C)
Output Signal	4-20 ma loop powered
Accuracy at Calibration Point	±0.6°F (+/-0.3°C)
Duct, Outside Air Temperature:	# varies
Temperature Monitoring Range	+20/120°F (-7°/49°C)
Output Signal	4-20 ma loop powered
Accuracy at Calibration Point	±0.5°F (+/-0.3°C)

- D. Humidity Sensors (Room, Duct): Provide a loop powered 4-20 ma sensor utilizing a bulk polymer element Duct Sensors to have connection for conduit. Room sensors color shall be white.

Humidity Sensors

Range	0 to 100% RH
Sensing Element	Bulk Polymer
Output	4 – 20 mA DC
Accuracy	At 77°F (25°C) ± 2% RH

- E. Liquid Differential Pressure Transmitter (Chilled & Hot Water): Provide a loop powered 4-20 ma sensor as manufactured by Setra model 230 or pre-approved equal. Differential Unit shall be provided with a three valve manifold

Ranges	0-5/30 inches H2O 0-25/150 inches H2O 0-125/750 inches H2O
Output	4 – 20 mA DC
Calibration Adjustments	Zero and span
Accuracy	$\pm 0.2\%$ of span
Linearity	$\pm 0.1\%$ of span
Hysteresis	$\pm 0.05\%$ of span

- F. Differential Pressure Switch: Unit for fluid flow proof shall be Penn P74.

Range	8 to 70 psi
Differential	3 psi
Maximum differential pressure	200 psi
Maximum pressure	325 psi

- G. Unit for air flow shall be Siemens Industry SW141 or pre-approved equal.

Set Point Ranges:	0.5" WG to 1.0" WG (124.4 to 248.8 Pa) 1.0" WG to 12.0" WG (248.8 to 497.6 Pa)
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- H. Static & Velocity Air Pressure Transmitter: Provide a loop powered 4-20 ma sensor as manufactured by Setra model C264 or pre-approved equal.

Range	0 to .5" WG (0 to 124.4 Pa) 0 to 1" WG (0 to 248.8 Pa) 0 to 2" WG (0 to 497.7 Pa) 0 to 5" WG (0 to 1.2 kPa) 0 to 10" WG (0 to 2.5 kPa)
Output Signal	4 – 20 mA VDC
Combined static error	0.5% full range
Operating Temperature	-40° to 175° F (-40C to 79.5°C)

- I. Flow Meters (Chilled Water & Hot Water): Provide an ONICON Model F-3500 Insertion Electromagnetic Flow Meter complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. The flow meter shall be hand-insertable up to 400 psi. Materials of construction for wetted metal components shall be 316 SS. The flow meter shall average velocity readings from two sets of diametrically opposed electrodes. Each flow meter shall be individually wet-calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to NIST. A certificate of calibration shall be provided with each flow meter. Accuracy shall be within $\pm 1\%$ of rate from 2-20 ft/s. Overall turndown shall exceed 80:1.
- J. Output signals shall be completely isolated and shall consist of the following: (1) analog output; 4-20mA, 0-10V, or 0-5V jumper selectable, (1) scalable dry contact output for totalization, and (1) high resolution frequency output for use with peripheral devices such as an ONICON display module or Btu meter. FB-3500 for Bi-directional applications shall provide additional contact outputs for direction and flow totalization in each direction. Each flow meter shall be covered by the manufacturer's two-year warranty.
- K. Flow Display: D-100 Series Display Module for network interface and local/remote indication of flow rate and total. (Set display for GPM.)
- L. Flow Meters (Steam): A steam flow meter must be installed on the high side steam pressure entering the building. Flow meter shall be Yokogawa or pre-approved equal. The meter should be flanged or wafer style with a visual local readout. The meter must be sized to cover the range of steam flow with greater emphasis on low flow. Oversized meters will not be accepted. At a minimum the following meter specifications must be met:

- Accuracy + - 0.8% of rate for gases <115 ft/sec
- 5 point linearization function
- mismatched pipe correction
- Reynolds number linearization
- Automatic gas expansion factor correction
- Temperature compensation
- Turn down of at least 20:1
- Display can be rotated in 90 degree increments to match mounting orientation of the meter.
- Shedder bar replacement without removing the meter from the line.

- M. Pressure to Current Transducer (Water, Steam, Refrigeration): Provide a loop powered 4-20 ma sensor as manufactured by Ashcroft Duratran model 2279 or pre-approved equal. All pressure sensors to be fitted with snubber to prevent damage from surges in line pressure. Refrigerant pressure sensors to have range suitable for refrigerant measured.

Range	30" vac to 15 psig (refrig) 0 to 100 psig (Hi press Steam)
Output signal	4 – 20 ma
Accuracy	± 1% of full scale

- N. Steam pressure transmitter on the high & low side of pressure regulators. This transmitter shall be as manufactured by Yokogawa Dpharp model or pre-approved equal with a calibrated range of 0-150 psig. Steam applications shall be provided with steam pigtail siphon.

- O. Conductivity Sensors (Steam condensate & hot water): On the return condensate and leaving heat exchanger hot water lines there shall be a two wire loop powered conductivity transmitter installed. This transmitter should be Yokogawa model SC200 or pre-approved equal. The probe assembly shall be a matched 4-Electrode system. Where pipe sizes are less than 6' the mechanical contractor shall provide a small section of pipe suitable for installation of probe.

- P. CO2 Sensors: Siemens QPA63 series CO2/VOC sensors or pre-approved equal shall be utilized for sensing indoor air quality in rooms or air ducts. The microprocessor-based units consist of a photo-acoustic CO2 sensor and a VOC (Volatile Organic Compound) sensor with a heated stannic dioxide semiconductor. The photo acoustic CO2 sensor experiences shall have less than 1% drift per year for the first two years of operation and negligible drift there after, no calibration of the CO2 sensor is necessary.

Operating characteristics:	
CO2 measuring range	0 — 2000 ppm
Tolerance	±100 ppm
Output	0 – 10 Vdc, linear
Calibration	None required
VOC measuring range	0 — 10 VVOC
Permissible air velocity in the duct	<26.2 ft/s

- Q. Water Valves: Body and trim style and materials shall be per manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service. Valves shall have 5 year product warranty. Valves for building chilled water and building hot water main equipment shall include feed back.

- R. Sizing Criteria:

1. Two-Position Service: Line size.
2. Two-Way Modulating Service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 5 psi, whichever is greater.
3. Three-Way Modulating Service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 35 kPa [5 psi] maximum.

4. Valves 1/2" through 2" shall be bronze body or cast brass ANSI Class 250, spring-loaded, Teflon packing, quick opening for two-position service. Two-way valves to have replaceable composition disc, or stainless steel ball.
 5. 2-1/2" valves and larger shall be cast iron ANSI Class 125 with guided plug and Teflon packing or butterfly valves with 100 psi shutoff minimum and stainless steel trim suitable for service.
- S. Factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of the piping system, unless otherwise indicated.
1. Pressure Independent Control Valves (2-way) (Up to 100 GPM):
 - a. Manufacturers: Belimo Aircontrols (USA), Inc. (or approved Equal)
 - b. The modulating control valves shall be pressure independent.
 - c. The control valves shall accurately control the flow from 0 to 100% full rated flow with an equal percentage flow characteristic. The flow shall not vary more than +/- 5% due to system pressure fluctuations across the valve with a minimum of PSID across the valve.
 - d. Forged brass body rated at no less than 400 PSI, chrome plated brass ball and stem, female NPT union ends, dual EPDM lubricated O-rings and TEFZEL characterizing disc.
 - e. Combination of actuator and valve shall provide a minimum close-off pressure rating of 200 PSID.
 - f. The control valve shall require no maintenance and shall not include replaceable cartridges.
 - g. All actuators shall be electronically programmed by use of a hand-held programming device or external computer software. Programming using actuator mounted switches or multi-turn actuators are NOT acceptable. Actuators for 3-wire floating (tri-state) on 1/2"-1" pressure independent control valves shall fail in place and have a mechanical device inserted between the valve and the actuator for the adjustment of flow. Where indicated, actuators shall be provided with an auxiliary switch to prove valve position.
 - h. The actuator shall be the same manufacturer as the valve manufacturer, integrally mounted to the valve at the factory via a single screw on a four-way DIN mounting base.
 - i. The manufacturer shall warrant all components for a period of 5 years from the date of production with the first two years unconditional.
 - j. Select valves for design flow + 20% spare capacity.
 2. Control Valves (3-Way): Belimo Characterized Control Valves with integral actuator.
- T. Steam Valves: Body and trim materials shall be per manufacturer's recommendations for design conditions and service. Linear ports for modulating service. Heat exchanger and PRV valves shall have a 5 year product warranty and shall include feedback. Actuator stroke shall be no higher than 60 seconds and shall fail closed via spring return.
- U. Sizing Criteria:
1. Two-Position Service: Pressure drop 10% to 20% of inlet psig.
 2. Modulating Service: 100 kPa [15 psig] or less: pressure drop 80% of inlet psig.
 3. Modulating Service: 101 to 350 kPa [16 to 50 psig]: pressure drop 50% of inlet psig.
 4. Modulating Service: Over 350 kPa [50 psig]: pressure drop as scheduled on plans.

Damper and Valve Actuators:

- A. Electric control shall be Siemens Industry, Inc. OpenAir™ direct coupled actuators or pre-approved equal.
- B. Damper actuators shall be Brushless DC Motor Technology with stall protection, bi-directional, fail safe spring return, all metal housing, manual override, independently adjustable dual auxiliary switch.

- C. The actuator assembly shall include the necessary hardware and proper mounting and connection to a standard ½" diameter shaft or damper blade.
- D. Actuators shall be designed for mounting directly to the damper shaft without the need for connecting linkages.
- E. All actuators having more than 100 lb-in torque output shall have a self-centering damper shaft clamp that guarantees concentric alignment of the actuator's output coupling with the damper shaft. The self-centering clamp shall have a pair of opposed "V" shaped toothed cradles; each having two rows of teeth to maximize holding strength. A single clamping bolt shall simultaneously drive both cradles into contact with the damper shaft.
- F. All actuators having more than a 100 lb-in torque output shall accept a 1" diameter shaft directly, without the need for auxiliary adapters.
- G. All actuators shall be designed and manufactured using ISO9000 registered procedures, and shall be Listed under Standards UL873 and CSA22.2 No. 24-93 I.
- H. Damper and valve actuators shall be capable of providing smooth, control under design temperature and pressure conditions. All actuators shall have DDC capabilities and be wired into the DDC controller by two wires. The actuators will be of such design that the DC board in the actuators can be field replaceable. They will receive and interpret commands from the controller and will send response information back to the controller. Actuators to be factory selected, mounted and tested for proper operation based on unit size, type and torque requirements.
- I. All Actuators shall have sufficient power for the specific application. Valve shall not lift off seat (and damper shall not move) unless controlled by actuator.

2.13 MISCELLANEOUS DEVICES

Thermostats:

- A. Room thermostats shall be of the gradual acting type with adjustable sensitivity.
- B. They shall have a bi-metal sensing element capable of responding to a temperature change of one-tenth of one degree. (Provide all thermostats with limit stops to limit adjustments as required.)
- C. Thermostats shall be arranged for either horizontal or vertical mounting.
- D. In the vertical position thermostat shall fit on a mullion of movable partitions without overlap.
- E. Mount the thermostat covers with tamper-proof socket head screws.

Freezestats:

- A. Install freezestats as indicated on the plans and provide protection for every square foot of coil surface area with one linear foot of element per square foot of coil.
- B. Upon detection of low temperature, the freezestats shall stop the associated supply fans and return the automatic dampers to their normal position. Provide manual reset.

Firestats:

- A. Provide manual reset, fixed temperature line voltage type with a bi-metal actuated switch.
- B. Switch shall have adequate rating for required load.

Electronic Airflow Measurement Stations and Transmitters (At Duct Locations):

- A. Provide airflow/temperature measurement devices where indicated on the plans. Fan inlet sensors shall not be substituted for duct or plenum sensor probes indicated on the plans.
 - 1. Duct and plenum mounted sensors shall be fabricated of anodized aluminum alloy tube with 303/304 stainless steel mounting brackets.
 - 2. Fan inlet probes shall be field adjustable to fit the fan inlet and have 303/304 stainless steel mounting feet.
- B. Each measuring device shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter. Each transmitter shall have an LCD display capable of displaying airflow and temperature. Airflow shall be field configurable to be displayed as a velocity or volumetric rate. Each transmitter shall operate on 24 VAC.
- C. Each sensing point shall independently determine the airflow rate and temperature, which shall be equally weighted and averaged by the transmitter prior to output. Devices, which average multiple non-linear sensing point signals, are not acceptable. Pitot tube arrays are not acceptable.
- D. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter at a given measurement location. Probes and transmitters shall not require field matching for proper operation.
- E. The operating airflow range shall be 50-5,000 FPM unless otherwise indicated on the plans.
- F. The operating temperature range for the measuring probes shall be -20° F to 140° F. The operating humidity range for the measuring probe shall be 0-99% RH (non-condensing).
- G. The operating temperature range for the transmitter shall be -20° F to 120° F. The transmitter shall be protected from weather and water.
- H. Each independent airflow sensor shall have a laboratory accuracy of +/-2% of reading over the entire operating airflow range and be wind tunnel calibrated or verified against standards that are traceable to NIST.
 - 1. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
- I. Each independent temperature sensor shall have a laboratory accuracy of +/-0.15° F over the entire operating temperature range and be calibrated or verified against standards that are traceable to NIST.
- J. The number of sensors for each location shall be as follows:

Ducts and Plenums:

Area (sf.)	Sensors
<=1	2
>1 to <4	4
4 to <8	6
8 to <12	8
12 to <16	12
>=16	16

Fan Inlets: Two per inlet

- K. The airflow/temperature measuring device shall be capable of displaying the airflow and temperature readings of each sensor on the transmitter's LCD display.

- L. The transmitter shall be capable of communicating with the host controls using the following interface options:
 - 1. Linear analog output signal: Field selectable, fuse protected and isolated, 0-10VDC and 4-20mA (4-wire).
 - 2. RS-485: Field selectable ModBus-RTU and Johnson Controls N2 Bus
 - 3. 10 Base-T Ethernet: Field selectable ModBus TCP and TCP/IP
 - 4. LonWorks Free Topology
- M. Airflow/Temperature measuring devices shall be UL listed as an entire assembly.
- N. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's placement requirements.
- O. UL 873 – Temperature and Airflow Indicating Equipment

Submittals:

- A. Submit product data sheets for airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system.
- B. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
 - 1. Submit a schedule of airflow measuring devices indicating compliance with specified accuracy at minimum and maximum airflow rates.
 - 2. Submit installation, operation and maintenance documentation.
 - 3. Additional Warranty – manufacturer's parts warranty for 36 months from date of shipment.
- C. Manufacturer: Ebtron, Inc., Gold Series or approved equal. (NOTE: 10 years experience producing products of this type is required.)

Current Sensing Relay:

- A. Provide solid-state, adjustable, current operated relay. Provide a relay which changes switch contact state in response to an adjustable set point value of current in the monitored A/C circuit.
- B. Adjust the relay switch point so that the relay responds to motor operation under load as an "on" state and so that the relay responds to an unloaded running motor as an "off" state. A motor with a broken belt is considered an unloaded motor.
- C. Provide for status device for all fans and pumps.

2.14 DAMPERS AUTOMATIC CONTROL – GENERAL APPLICATIONS

- A. Provide automatic control dampers as indicated, with damper frames not less than formed 16-ga galvanized steel. Provide damper blades not less than formed 16-ga galvanized steel, with maximum blade width of 8".
- B. Secure blades to 1/2" diameter plated steel axles using zinc-plated hardware. Seal off against spring stainless steel blade bearings. Provide blade bearings of nylon and provide thrust bearings at each end of every blade.
- C. Parallel blade operation shall be used for all two position applications and opposed blade configurations for all modulating applications.

Performance Data:

- A. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions.
- B. Closed Position: Maximum pressure of 5" w.g. (1.2 kPa) @ a 12" (305) blade length.
- C. Open Position: Maximum air velocity of 2,000 feet per minute (610 m/min).
- D. Leakage: Maximum 3.7 cubic feet per minute per square foot (1.1 m³/min/m²) at 1" w.g. (0.25 kPa) for all sizes 36" (914 mm) wide and above.
- E. Pressure Drop: Maximum 0.07" w.g. (0.02 kPa) at 1,500 feet per minute (457 m/min) across 24" x 24" (610 x 610 mm) damper.

2.15 DAMPER AUTOMATIC CONTROL – OUTSIDE AIR & EXHAUST AIR APPLICATIONS

- A. Extruded aluminum (6063T5) damper frame shall not be less than .080" (2.03mm) in thickness. Damper frame shall be 4" deep. Aluminum frame shall be clear anodized to a minimum thickness of 0.7mil (18 microns) deep. Frame to be assembled using type 316 stainless steel screws.
- B. Extruded aluminum blades shall be clear anodized to a minimum thickness of 0.7mil (18 microns) deep. Aluminum end caps are to be press fitted to blade ends and shall be clear anodized. Aluminum blade pivot rods shall be clear anodized.
- C. Blade and frame seals shall be of extruded silicone. Seals are to be secured in an integral slot within the aluminum extrusions.
- D. Bearings are to be composed of a Celcon inner bearing fixed to a 1/16" (11.11mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
- E. Linkage hardware to be installed in the frame side. All aluminum linkage hardware parts shall be clear anodized. All non-aluminum linkage hardware parts shall be type 316 stainless steel. To be complete with cup-point trunnion screws for slip-proof grip. Adjustable hexagon drive rod, U-bolt fastener and retaining nuts are to be type 316 stainless steel.
- F. Dampers are to be designed for operation in temperatures ranging between -40°F (-40°C) and 212°F (100°C).
- G. Dampers shall be provided with opposed blade action.
- H. Dampers shall meet Leakage Class I rating. Standard air leakage data to be certified under the AMCA Ratings Program.
- I. Pressure drop of a fully open 48" x 48" (1220mm x 1220mm) damper shall not exceed .02" (.004kPa) w.g. at 1000 fpm (5.08 m/s).
- J. Dampers shall be made to size required without blanking off free area.
- K. Dampers shall be available in two mounting types: i.e., "Installed in Duct" or "Flanged to Duct".
- L. Installation of dampers must be in accordance with current manufacturer's installation guidelines provided with each shipment of dampers.
- M. Acceptable product shall be TAMCO Series 1500 SW Salt Water Resistance Enhanced Air-Foil Control Damper, as manufactured by T. A. Morrison & Co., Inc. (Tel: 1-800-561-3449, USA & Canada) or pre-approved equal.

2.16 LABORATORY SUPPLY, EXHAUST and FUME HOOD VENTURI AIR VALVES

- A. Laboratory air valves shall provide a minimum turndown ratio of 5 to 1 for fume hood exhaust applications and adequate turndown for room supply and general exhaust applications to assure that room pressurization is maintained. All air valves shall be controlled to be pressure independent and include actual airflow measurement feedback as an integral part of their control process. Minimum airflow measurement accuracy shall be +/- 5% of actual reading over the published airflow range of each device. Siemens Laboratory Single Duct Air Terminal, Siemens Laboratory Exhaust Air Terminal or pre-approved equal.
- B. Exhaust airflow measurement shall be provided by airflow sensing techniques that are not likely to obstruct the exhaust duct or become inoperative due to the accumulation of chemical deposits. For example, Pitot tube arrays are NOT acceptable for exhaust airflow measurement since they may collect tissues and other debris and their minute pressure sensing holes become plugged with deposits.
- C. All supply, exhaust and fume hood venturi air valves shall include factory-installed airflow sensors. The air valves should provide stable and precise airflow control of room supply, room general exhaust and fume hood exhaust. The valves shall be constructed of aluminum including the casing and cone. The control shaft shall be 316 stainless steel. For highly corrosive environments, Teflon® coated steel and Heresite® coated aluminum shall be available. Flange or slip fitting end connections should also be available to match ductwork construction. Single body air valves should be available in sizes from 4" to 18" diameter, with airflow ranges from 40 CFM to 5,500 CFM.
- D. Airflow measurement and fume hood exhaust application shall be accomplished by a unique orifice plate sensing technology that minimizes pressure loss and duct obstruction. Airflow measurement accuracy shall be within +/-5% of reading down to duct velocities of 450fpm.
- E. Fast-acting flow control applications use shall utilize full PID airflow control as "fine tuning" of the venturi air valve's calibrated relationship of control position to airflow rate, allowing control below 450 fpm duct velocities, down to the minimum specified flows for each size. High speed, precise response is delivered using the Siemens Lab Electronic Actuator. Minimum to maximum valve airflow (or visa versa) shall be attained in less than 1 second.
- F. Basic electronic actuation can also be used for constant volume and constant volume, 2-position airflow control applications, with the controller utilizing the integral airflow measuring technology and the venturi air valve's inherent pressure-independence.
- G. The venturi air valve package shall have the following features (as a minimum):
 - 1. Fast-acting or basic electronic actuation
 - 2. Multiple sizes and end configurations to match laboratory supply and exhaust duct requirements
 - 3. Coating and material options for highly corrosive environments
 - 4. Air valve is Factory Calibrated and Field commissionable
 - 5. Controllers utilize airflow measurement for performance diagnostics
 - 6. Controllers utilize automatic airflow sensor calibration
 - 7. All venturi air valves shall have a three range pressure drop options, low (0.3"-3.0"), medium (0.6"-3.0") and high (1.0"-6.0").
 - 8. A loss, increase and/or decrease of airflow shall be transmitted to the fume hood or room controller as appropriate.
 - 9. Discharge and Radiated sound power level data for all venturi air valves shall be available and provided at the owner's or engineer's request. The data shall be in accordance with the test procedure in ARI 880 Standard for Venturi air valves (latest edition) and all data shall be obtained in a qualified, accredited and ARI approved testing laboratory.
 - 10. Venturi air valves that require factory calibration shall be calibrated to the job specific airflow's indicated on the drawings. Factory calibration shall be conducted on certified NIST traceable air stations and shall be conducted for eight airflows including a test of

pressure independence at three static pressures. NIST instrument certificates shall be provided as evidence of compliance. Each air valve shall be individually marked with its specific factory calibration data. As a minimum, include tag number, serial number, model number, eight point characterization information, and quality control inspection numbers. All information shall be available for inclusion on as-built drawings.

11. Room and fume hood airflow accuracy and performance shall be guaranteed as specified irrespective of field conditions.
12. In order to guarantee safety and compliance, LACS systems that do not measure actual airflow must provide independent airflow measuring stations. Independent airflow measuring stations shall be provided at each supply air valve, general exhaust air valve and fume hood exhaust air valve for each laboratory or pressurized space. The signals from these measurement stations shall be directly linked to the central BMS. Airflow measurement stations shall consist of an averaging airflow sensor, which shall provide an average duct velocity pressure to an airflow transmitter. Airflow transmitters shall provide an output of 4-20 mA proportional to velocity pressure. Airflow transmitters shall have an accuracy of at least $\pm 0.5\%$ of the transmitter range.

2.17 LABORATORY ROOM CONTROLLERS

- A. Each supply and associated exhaust terminal shall be controlled to maintain an actual CFM airflow differential between total room exhaust and supply air that is equal to 10% of the maximum laboratory room design airflow or 200 CFM, whichever is greater, to meet space pressurization requirements. For negatively pressurized rooms, supply airflow shall be controlled to equal the total room exhaust airflow less the required airflow differential. For positively pressurized rooms, total exhaust airflow shall track supply airflow less the required airflow differential. Room airflow tracking shall be accomplished via actual measurement of terminal unit airflow. Controllers that track within a range of airflow's versus actual airflow setpoints shall not be acceptable.
- B. Each laboratory room controller shall be specifically designed for control of laboratory temperature, (humidity and differential pressure monitoring where applicable) and room ventilation. Each controller shall be a microprocessor-based, multi-tasking, real-time digital control processor. Control sequences shall be included as part of the factory supplied software. These sequences shall be field customized by adjusting parameters such as control loop algorithm gains, temperature setpoint, alarm limits, airflow differential setpoint, and pressurization mode. Closed loop Proportional Integral Derivative (PID) control algorithms shall be used to maintain temperature and airflow offset set points.
- C. Controllers using a differential pressure switch to monitor differential pressure across control devices such as an air valve shall include provisions for manual and automatic zeroing in order to maintain stable control and ensure against drift over time.
- D. Controller shall include all inputs and outputs necessary to perform all the specified control sequences.
- E. Each controller shall operate stand alone, performing its specified control responsibilities independently.
- F. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM memory, or a minimum of 72-hour battery backup shall be provided. All controllers shall return to full normal operation without any need for manual intervention after a power failure of unlimited duration.
- G. Should a power failure or operational failure occur within the controller, the terminal unit damper shall automatically be positioned to the fully open or fully closed (failsafe) position as defined by the owner.

VARIABLE AIR VOLUME FUME HOOD CONTROLLER

~~Where VAV Hood operation is required provide a UL 916 listed individual VAV fume hood controller for each fume hood, which shall maintain the face velocity setpoint (adjustable) in response to sash position.~~

~~In operation, the VAV fume hood control process consists of calculating the fume hood exhaust flow necessary to provide the required average face velocity at any sash position based upon actual sash position and total fume hood open area. The controller shall then position the fume hood exhaust terminal damper to attain the required exhaust airflow in conjunction with constant feedback from an integral exhaust airflow sensor. The controller shall perform this exhaust airflow calculation ten times per second to ensure maximum speed of response to changes in sash position. Even when no change has occurred in sash position since the previous calculation, the controller shall continue to position the exhaust terminal damper in response to its airflow measurement feedback to ensure that the required fume hood exhaust is always maintained independently of variations in exhaust system static pressure or room conditions that could otherwise affect fume hood exhaust airflow.~~

~~The VAV fume hood controller shall initiate corrective action immediately upon sash movement and be completed when sash movement stops so as to restore the required average face velocity within 1 second after completion of sash movement. Control scenarios that are not based upon sash sensing such as those utilizing side wall airflow sensing must substantiate that fume hood face velocity will be restored within 1 second after completion of sash movement. ASHRAE 110 VAV fume hood response time test data substantiating this performance requirement shall be submitted. All such ASHRAE 110 testing shall be conducted by a qualified, accredited and independent testing source.~~

~~Air velocity sensors utilized for side wall sensing shall be UL 913 listed. Documentation of UL listing shall be submitted with the technical proposal and included with the submittals.~~

~~A "Sash Alert" feature shall provide periodic beeps at the Operator Display Panel when the sash remains open above the recommended safe working height (adjustable) for an adjustable period of time. This feature shall enhance fume hood safety operation and energy efficiency. This feature shall include a beep interval and be capable of being implemented on individual fume hoods as desired by authorized owner personnel.~~

~~The face velocity setpoint shall be adjustable by authorized owner personnel.~~

~~Controllers shall include the ability to accept and incorporate into the control sequence a dry contact closure from auxiliary sensors. Example: Occupancy override, Emergency button, etc.~~

~~Controllers shall provide a general alarm output for use with auxiliary devices.~~

~~Momentary or extended losses of power shall not change or affect any of the control system's setpoints, calibration settings, or emergency exhaust mode status. After power returns the system shall continue operation exactly as before without need for any manual intervention.~~

FUME HOOD OPERATOR DISPLAY

~~An operator display panel shall be provided for each fume hood to comply with laboratory safety standards. The operator display panel shall provide the following functionality:~~

~~Indicator lights that verify normal operation (green), marginal operation (yellow), and alarm condition (red). An alarm condition shall automatically be initiated for both high and low face velocity conditions.~~

~~An audible alarm device shall also be initiated in response to an alarm condition. The audible alarm device shall be capable of being silenced by a user silence button; however the alarm device shall automatically resound upon another alarm occurrence.~~

~~A user initiated emergency purge function shall initiate a visual and audible alarm and increase the fume hood exhaust to maximum airflow. When the emergency purge button is depressed, a second time, the emergency sequence shall be terminated and fume hood control shall return to normal operation.~~

SASH SENSOR

~~Where VAV Hood Operation is required provide, sash position sensors for each fume hood to indicate the actual position of each sash. The sash sensor shall be a precision, linear device with repeatable location accuracy within one half inch.~~

~~Sash sensors material shall be corrosion resistant.~~

~~Sash sensors shall allow complete and easy removal of the sashes for cleaning and maintenance.~~

~~Operational life of each sash sensor shall be a minimum of 1000,000 full cycles.~~

~~Sash sensor failure shall be indicated as an alarm at the fume hood operator display panel.~~

PART 3 – EXECUTION

3.1 PROJECT MANAGEMENT

- A. Provide a designated project manager who will be responsible for the following:
 - 1. Construct and maintain project schedule
 - 2. On-site coordination with all applicable trades, subcontractors, and other integration vendors
 - 3. Authorized to accept and execute orders or instructions from owner/architect
 - 4. Attend project meetings as necessary to avoid conflicts and delays
 - 5. Make necessary field decisions relating to this scope of work
 - 6. Coordination/Single point of contact

3.2 SEQUENCE OF OPERATION – Refer to Drawings.

3.3 POINT SCHEDULE MATRIX - I/O SCHEDULE – Refer to Drawings.

- A. NOTE: All Point names and panel numbers will be coordinated with FSU prior to submission of technical documentation.

3.4 START-UP AND COMMISSIONING

- A. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting and final field tests shall be completed by the manufacturer. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.
- B. Provide any recommendation for system modification in writing to owner. Do not make any system modification, including operating parameters and control settings, without prior approval of owner.
- C. After manufacturer has completed system start-up and commissioning. Joint commissioning of integrated system segments shall be completed.

3.5 ELECTRICAL WIRING AND MATERIALS

- A. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings, and related wiring accessories. All wiring shall be installed in conduit or plenum rated not installed in conduit as allowed and in accordance with all

applicable codes. All wiring and conduit shall be concealed (except in Mechanical Equipment Room).

- B. BMS contractor to provide 120 volt, single phase, 60 hertz emergency power to every B.A.S. DDC Controller panel, HVAC/Mechanical Equipment Controller, Air Terminal Controllers, PC console, power supply, transformer, enunciator, modems, printers and to other devices as required. It is the intent that the entire building management system except terminal equipment shall be operative under emergency power conditions in the building. (Note: Division 26 contractor will provide circuit space at any new panels for BMS contractor to obtain power.) BMS Contractor must coordinate this with Prime Contractor / Electrical Contractor prior to bid and include all costs for fully operational system.
- C. All wiring to be compliant to local building code and the NEC.
- D. Provide electrical wall box and conduit sleeve for all wall mounted devices.
- E. All plenum rated wiring installed shall be supported with J hooks or other approved devices utilizing plenum rated tie-wraps or bare copper wire #16 solid or as approved

3.6 PERFORMANCE

- A. Unless stated otherwise, control temperatures within plus or minus 2°F humidity within plus or minus 3% of the set point and static pressure within 10% of set point.

3.7 COMMISSIONING, TESTING AND ACCEPTANCE

- A. Perform commissioning procedures consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets which shall be submitted prior to acceptance. Commissioning work which requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager may present throughout the commissioning procedure.
- B. Prior to system program commissioning, verify that each control panel has been installed according to plans, specifications and approved shop drawings. Test, calibrate and bring on line each control sensor and device. Commissioning to include, but not be limited to:
 - 1. Sensor accuracy at 10, 50 and 90% of range.
 - 2. Sensor range.
 - 3. Verify analog limit and binary alarm reporting.
 - 4. Point value reporting.
 - 5. Binary alarm and switch settings.
 - 6. Actuator ranges.
 - 7. Fail safe operation on loss of control signal, electric power, network communications.
- C. After control devices have been commissioned (i.e. calibrated, tested and signed off), each BMS program shall be put on line and commissioned. The contractor shall, in the presence of the owner and construction manager, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy's. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and retested.

3.8 EXISTING CONTROL DEVICES

- A. The bid for the control work shall be based on the premise that existing control devices are operational and are not in need of repair or replacement, unless otherwise noted.

- B. This subcontractor shall notify the owner's representative of existing control devices that need to be replaced or repaired that may be noted in the process of installation of the new work.
- C. **Contractor shall upgrade and replace all existing non-compatible controls, controllers, end devices, software, firmware, etc., as required for full interface, control, and compatibility with new controls.**

3.9 TRAINING

- A. The manufacturer shall provide factory trained instructor to give full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The manufacturer shall provide all students with a student binder containing product specific training modules for the system installed. All training shall be held during normal working hours of 8:00 am to 4:30 PM weekdays. Schedule training in not greater than 4 hour sessions. Schedule training to meet Owner's schedule requirements.
 - 1. Two (2) hours of training for four (4) of the owners personnel to be delivered before final acceptance.
 - 2. Two (2) hours of jobsite installation and programming familiarization for the Owner's personnel.

3.10 LABORATORY / ANIMAL LAB EXHAUST/SUPPLY HVAC SYSTEMS INSTALLATION

- A. ~~The laboratory ventilation system contractor shall install the sash sensors, control equipment, and operator display panels on fume hoods.~~ This contractor shall install and terminate all low voltage control wiring between each controller and all control and sensing devices, and provide 24 VAC power where required by the controllers and control devices.

~~The electrical contractor shall provide 120volt power circuit in the laboratory ceiling space for connection to the laboratory control equipment.~~

- B. Supply venturi air valves with reheat coils, exhaust venturi air valves and valves shall be installed by the mechanical contractor.
- C. Commission Laboratory Controls, Terminal Boxes, etc as recommended by MFR and as it typical for Owner's Laboratory Projects (but not less than herein indicated).

3.11 BMS

- A. BMS Contractor shall update all existing BMS graphics, floor plans with new room names, room numbers, new locations of existing devices/equipment, modifications to sequences, updating point lists and schematics, etc. BMS Contractor shall also add/modify all new controls, schematics, sequences, floor plan locations, etc. for a fully complete, operational system in compliance with all FSU BMS requirements and full graphics. Update Graphics, etc at all existing Campus BMS Workstations. Interface all new controls to existing Campus Workstations (or provide new as specified); update (or provide new as specified) all existing hardware, firmware, software and communication systems and interface as required.

3.12 Tags, Charts and Identification

- A. Tag all automatic control valves, dampers and controlled devices in accordance with FSU standards/requirements. Tags must match as-built drawings.
- B. **Copy, laminate, frame, and mount HVAC Schematics and Sequences in MER's.**

END OF SECTION 23 09 23

SECTION 23 21 00 – BASIC PIPING MATERIALS AND METHODS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY:

- A. This Section specifies piping materials and installation methods common to more than one section of Division 23 and includes joining materials, piping specialties, and basic piping installation instructions.

1.3 RELATED SECTIONS:

- A. Division 23 Mechanical Requirements section applies to the work at this Section.
- B. Piping materials and installation methods peculiar to individual systems are specified within their respective system specification sections of Divisions 2 and 23.
- C. Valves are specified in a separate section and in individual piping system sections of Division 23.
- D. Supports and Anchors are specified in a separate section of Division 23.
- E. Mechanical Identification is specified in a separate section of Division 23.
- F. Fire Barrier Penetration Seals are specified in Division 7 and/or Section 23 05 12 and Drawings.

1.4 SUBMITTALS

- A. Refer to Division 1 and Basic Mechanical Requirements for administrative and procedural requirements for submittals.
- B. Product Data: Submit product data on the following items:
 - Escutcheons
 - Dielectric Unions and Fittings
 - Mechanical Sleeve Seals
 - Strainers

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.
- B. Protect stored pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.
- C. Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

PART 2 – PRODUCTS

2.1 MANUFACTURERS:

- A. Subject to compliance with requirements, provide piping materials and specialties from one of the following:

1. Pipe Escutcheons:
Chicago Specialty Mfg. Co.
Sanitary-Dash Mfg. Co.
Grinnell
2. Dielectric Waterway Fittings:
Epco Sales, Inc.
Victaulic Company of America
3. Dielectric Unions:
Eclipse, Inc.
Perfection Corp.
Watts Regulator Co.
4. Strainers:
Armstrong Machine Works.
Hoffman Specialty ITT; Fluid Handling Div.
Metraflex Co.
R-P&C Valve; Div. White Consolidated Industries, Inc.
Spirax Sarco.
Trane Co.
Tour and Andersson
Victaulic Co. of America. (Low pressure applications only)
Watts Regulator Co.
5. Mechanical Sleeve Seals:
Thunderline Corp.

2.2 PIPE & FITTINGS

- A. Refer to the individual piping system specification sections in Division 23 for specifications on piping and fittings relative to that particular system.

2.3 JOINING MATERIALS

- A. Welding Materials: Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.
- B. Brazing Materials: Comply with SFA-5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials appropriate for the materials being joined.
- C. Soldering Materials: Refer to individual piping system specifications for solder appropriate for each respective system.

2.4 LEAD SOLDER

- A. Contractor shall be responsible for the removal and replacement of any material used on the project which contains lead solder.
- B. Contractor shall provide a notarized statement addressed to the Owner stating that no lead solder material has been used or installed on the Project. This statement shall be submitted to the Engineer prior to authorization of Final Payment.
- C. Gaskets for Flanged Joints: Gasket material shall be full-faced for cast-iron flanges and raised-face for steel flanges. Select materials to suit the service of the piping system in which installed, and which conform to their respective ANSI Standard (A21.11, B16.20, or B16.21). Provide materials that will not be detrimentally affected by the chemical and thermal conditions of the fluid being carried.

2.5 PIPING SPECIALTIES

- A. Escutcheons: Chrome-plated, stamped steel, hinged, split-ring escutcheon, with set screw. Inside diameter shall closely fit pipe outside diameter or outside of pipe insulation where pipe is insulated. Outside diameter shall completely cover the opening in floors, walls, or ceilings as indicated on drawings.
- B. Unions: Malleable-iron, Class 150 for low pressure service and class 250 for high pressure service (i.e., over 80 psi); hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; female threaded ends.
- C. Dielectric Unions: Provide Class 250 dielectric unions with appropriate end connections for the pipe materials in which installed (screwed, soldered, or flanged), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.
- D. Dielectric Waterway Fittings: electroplated steel or brass nipple, with an inert and non-corrosive, thermoplastic lining.
- E. Dielectric Flanges: Factory-fabricated, companion-flange assembly for 150-or 300 psig (1035kPa or 2070kPa) minimum pressures to suit system pressures.
- F. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 1. Provide separate companion flanges and steel bolts and nuts for 150-or 300 psig (1035kPa or 2070kPa) minimum working pressure to suit system pressures.
- G. Dielectric Couplings: Galvanized-steel coupling, having inert and non-corrosive, thermoplastic lining, with threaded ends and 300-psig (2070kPa) minimum working pressure at 225°F (107°C) temperature.
- H. Dielectric Nipples: Electroplated steel nipple, having inert and non-corrosive thermoplastic lining, with combination of plain, threaded, or grooved end types and 300-psig (2070kPa) working pressure at 225°F (107°C) temperature.
- I. Connections between PVC and flanged steel or cast-iron pipe shall be made with a ductile iron bolt-on adaptor flange, equal to Uni-Flange Corp. Series 900.
- J. Grooved Mechanical Couplings: Consist of ductile or malleable iron housing, a synthetic rubber gasket of a central cavity pressure-responsive design; with nuts, bolts, locking pin.
- K. Y-Type Strainers: Provide strainers full line size of connecting piping, with ends matching piping system materials. Screens shall be Type 304 stainless steel, with 3/64" perforations at 233 per square inch.
 - 1. Provide strainers with 125 psi working pressure rating for low pressure applications, and 250 psi pressure rating for high pressure application.
 - 2. Threaded Ends, 2" and Smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.
 - 3. Flanged Ends, 2-1/2" and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.
 - 4. Butt Welded Ends, 2-1/2" and Larger For Low Pressure Application: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.
 - 5. Butt Welded Ends, 2-1/2" and Larger For High Pressure Application: Schedule 80 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.
 - 6. Grooved Ends, 2-1/2" and Larger: Tee pattern, ductile-iron or malleable-iron body and access end cap, access coupling with EDPM gasket.
- L. Sleeves:

1. Sheet-Metal Sleeves: 10 gage, galvanized sheet metal, round tube closed with welded longitudinal joint.
2. Steel Sleeves: Schedule 40 galvanized, welded steel pipe, ASTM A53, Grade A.
 - a. Mechanical Sleeve Seals: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.
 - b. Sleeves for Copper or Brass Pipe: Same material as pipe.

PART 3 – EXECUTION

3.1 PREPARATION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris for both inside and outside of piping and fittings before assembly.

3.2 INSTALLATIONS

- A. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated. Refer to individual system specifications for requirements for coordination drawing submittals.
- B. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated otherwise.
- C. Exterior Wall Penetrations: Use steel pipe sleeves for all penetrations smaller than 6"- and 10-gauge sheet metal for all penetrations over 6".
- D. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.
- E. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated on the Drawings.
- F. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1" clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.
- G. Locate groups of pipes parallel to each other, spaced to permit applying full insulation and servicing of valves.
- H. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4" ball valve, and short 3/4" threaded nipple and cap.
- I. Exterior Wall Penetrations (Sleeve Seals): Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6" shall be steel; pipe sleeves 6" and larger shall be sheet metal.
- J. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, or floors, the fire rated integrity shall be maintained. Refer to Division 7 and Section 230512 for special sealers and materials.

3.3 FITTINGS & SPECIALTIES

- A. Use domestically manufactured fittings for all changes in direction and all branch connections.

- B. Remake leaking joints using new materials.
- C. Install strainers on the supply side of each control valve, pressure reducing or regulating valve, solenoid valve, and elsewhere as indicated.
- D. Install unions adjacent to each valve and at the final connection to each piece of equipment and plumbing fixture having 2" and smaller connections, and elsewhere as indicated.
- E. Install Weld-Neck Flanges in piping 2-1/2" and larger, where indicated, adjacent to each valve, and at the final connection to each piece of equipment.
- F. Install flexible connectors at inlet and discharge connections to pumps and other vibration producing equipment.
- G. Install dielectric unions to connect piping materials of dissimilar metals in dry piping systems (gas, compressed air, vacuum).
- H. Install dielectric fittings to connect piping materials of dissimilar metals in wet piping systems (water, steam).

3.4 JOINTS

A. Steel Pipe Joints:

- 1. Pipe 2" and Smaller: Thread pipe with tapered pipe threads in accordance with ANSI B2.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint lubricant or sealant suitable for the service for which the pipe is intended on the male threads at each joint and tighten joint to leave not more than 3 threads exposed.
- 2. Pipe Larger Than 2":
 - a. Weld pipe joints in accordance with ANSI/AWS D10/12 - 89, Recommended Practices and Procedures for Welding Low Carbon Steel Pipe.
 - b. Install flanges on all valves, apparatus, and equipment. Weld pipe flanges to pipe ends in accordance with ASME B31.1.0 Code for Pressure Piping. Clean flange faces and install gaskets.
 - c. Tighten bolts to torque specified by manufacturer of flange and flange bolts, to provide uniform compression of gaskets.

B. Non-ferrous Pipe Joints:

- 1. Brazed and Soldered Joints: For copper tube and fitting joints, braze joints in accordance with ANSI B31.1.0 - Standard Code for Pressure Piping, Power Piping and ANSI B9.1 - Standard Safety Code for Mechanical Refrigeration.
- 2. Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emery cloth, prior to making soldered or brazed joints. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.
- 3. Mechanical Joints: Flared compression fittings may be used for refrigerant lines 3/4" and smaller.

C. Joints for other piping materials are specified within the respective piping system sections.

3.5 FIELD QUALITY CONTROL

- A. Testing: Refer to individual piping system specification sections.

END OF SECTION 23 21 00

SECTION 23 21 13 – HYDRONIC PIPING

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section includes piping systems for hot water heating, chilled water cooling, condenser water, make-up water for these systems, blow down drain lines, and condensate drain piping. Piping materials and equipment specified in this Section include:

Pipes, fittings, and specialties
Special duty valves
Hydronic specialties

1.2 DEFINITIONS

- A. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).

1.3 SUBMITTALS

- A. Product Data, including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties and accessories, and installation instructions for each hydronic specialty and special duty valve specified.
- B. Furnish flow and pressure drop curves for diverting fittings and calibrated plug valves, based on manufacturer's testing.
- C. Maintenance Data for hydronic specialties and special duty valves, for inclusion in operating and maintenance manual specified in Division 1 and Division 23, Section "Basic Mechanical Requirements".
- D. Welders' certificates certifying that welders comply meet the quality requirements specified in Quality Assurance below. Certificates must be current (within the last 12 months) and pertain to the type and position of welds required in the Work.
- E. Certification of compliance with ASTM and ANSI manufacturing requirements for pipe, fittings, and specialties.
- F. Reports specified in Part 3 of this Section.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the provisions of the following:
1. ASME B 31.9 "Building Services Piping" for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.
 2. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
 3. ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators
 4. 2023 Florida Building Code, 8th Edition

1.5 SEQUENCING & SCHEDULING

- A. Coordinate the size and location of equipment supports with other trades.
- B. Coordinate the installation of pipe sleeves for foundation, floor, and wall penetrations.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide hydronic piping system products from one of the following:

Pre-Insulated Piping Systems:

Perma Pipe
Thermacor
Thermal Pipe Systems

Calibrated Globe Balancing Valves:

Armstrong, Inc.
Tour and Anderson
Mepco

Calibrated Plug Valves and Balancing Valves:

Bell & Gossett ITT; Fluid Handling Div.
Taco, Inc.
Griswold

Air Vents (manual and automatic):

Armstrong Machine Works.
Bell & Gossett ITT; Fluid Handling Div.
Hoffman Specialty ITT; Fluid Handling Div.
Spirax Sarco.

Y-Pattern Strainers:

Armstrong Machine Works.
Hoffman Specialty ITT; Fluid Handling Div.
Metraflex Co.
Spirax Sarco.
Trane Co.
Victaulic Co. of America.
Watts Regulator Co.

2.2 CONDENSER WATER PIPING

- A. General: Where more than one piping product is listed for a system, the contractor shall provide material to match field piping (i.e. black steel to existing black steel and copper to existing copper).
- B. Above Ground, Pipe Size 10" and Smaller: Schedule 40 black steel ASTM A53 seamless or ERW pipe with class 150 malleable-iron threaded fittings for 2" and under, butt welded fittings for over 2". Elbows 2-1/2" and larger to be long radius. Weld-o-lets may be used on pipes 3" and smaller in lieu of tees.
- C. Above Ground, Pipe size 2.5" and Smaller: Type 'L' hard drawn copper ASTM B42 with wrought copper solder joint fittings.
- D. Above Ground, Pipe Size 12" and Larger: Standard weight black steel ASTM A53 seamless or ERW pipe with butt welded fittings; elbows to be long radius.

2.3 CONDENSATE DRAIN PIPING

- A. Type "L" copper with wrought copper or cast brass solder joint fittings. Provide cleanout at all changes of direction. Piping shall be supported at 5' intervals and pitched for complete drainage.

2.4 FITTINGS

- A. Steel Flanges and Flanged Fittings: ANSI B16.5, including bolts, nuts, and gaskets of the following material group, end connection, and facing.

Material Group: 1.1.

End Connections: Butt Welding.

Facings: Raised face.

- B. Flexible Connectors: Stainless steel bellows with woven flexible bronze wire reinforcing protective jacket; minimum 150 psig working pressure, maximum 250°F operating temperature. Connectors shall have flanged or threaded end connections to match equipment connected; and shall be capable of 3/4" misalignment.

2.5 JOINING MATERIALS

- A. Solder Filler Metals: 95-5 tin-antimony for condenser water, chilled water, and make-up water and drain piping.
- B. Welding Materials: Comply, with Section II, Part C. ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.
- C. Gasket Material: Thickness, material, and type suitable for fluid to be handled, and design temperatures and pressures.
- D. Wrought – Copper Fittings: ANSI B16.22, streamlined pattern.

2.6 GENERAL DUTY VALVES

- A. General duty valves (i.e., gate, globe, check, ball, and butterfly valves) are specified in Division 23 Section "Valves". Special duty valves are specified below by their generic name; refer to Part 3, Article "VALVE APPLICATION", for specific uses and applications for each valve specified.

2.7 SPECIAL DUTY VALVES

- A. Calibrated Balancing Valves: 125 psig water working pressure, 250°F maximum operating temperature, bronze body, globe valve with calibrated orifice. Provide with connections for portable differential pressure meter with integral check valves and seals. Valve shall have integral pointer and calibrated scale to register degree of valve opening. Valves 2" and smaller shall have threaded connections and 2-1/2" valves shall have flanged connections.

2.8 HYDRONIC SPECIALTIES

- A. Manual Air Vent: Bronze body and nonferrous internal parts; 150 psig working pressure, 225°F operating temperature; manually operated with screwdriver or thumbscrew; and having 1/8" discharge connection and 1/2" inlet connection.

PART 3 – EXECUTION

3.1 PIPING INSTALLATIONS

- A. Use fittings for all changes in direction and all branch connections. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.
- B. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1" clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

- C. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- D. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4" ball valve, and short 3/4" threaded nipple and cap.
- E. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Refer to drawing details.
- F. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity.
- G. Smoke Tight Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, seal all around pipe to maintain smoke tight rated integrity.
- H. Install piping at a uniform grade of 1" in 40' toward all drain points.
- I. Install manual air vents at the high points in piping system.
- J. Make reductions in pipe sizes using eccentric reducer fitting installed with the level side up.
- K. Install unions in pipes 2" and smaller, adjacent to each valve, at final connections each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.
- L. Install dielectric unions to join dissimilar metals.
- M. Install flanges on valves, apparatus, and equipment having 2-1/2" and larger connections.
- N. Install flexible connectors at inlet and discharge connections to pumps (except inline pumps) and other vibration producing equipment.
- O. Install strainers on the supply side of each control valve, pressure reducing valve, pressure regulating valve, solenoid valve, inline pump, and elsewhere as indicated.
- P. Install nipple and ball valve in blow down connection of strainers 2" and larger.
- Q. Anchor piping to ensure proper direction of expansion and contraction.

3.2 HANGERS & SUPPORTS

- A. General: Hanger, supports, and anchors devices are specified in Division 23, Section 232529.

3.3 PIPE JOINT CONSTRUCTION

- A. Soldered Joints: Comply with the procedures contained in the AWS "Soldering Manual."
- B. Brazed Joints: Comply with the procedures contained in the AWS "Brazing Manual."

3.4 CAUTION:

- A. Remove stems, seats, and packing of valves and accessible internal parts at piping specialties before brazing.
- B. Fill the pipe and fittings during brazing, with an inert gas (i.e., nitrogen or carbon dioxide) to prevent formation of scale.
- C. Heat joints using oxy-acetylene torch. Heat to proper and uniform temperature.
- D. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe fittings and valves as follows:

- E. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
- F. Align threads at point of assembly.
- G. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).
- H. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.
- I. Damaged Threads: Do not use pipe with threads which are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.
- J. Welded Joints: Comply with the requirement in ASME Code B31.9-"Building Services Piping."
- K. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.

3.5 VALVE APPLICATIONS

- A. General Duty Valve Applications: The Drawings indicate valve types to be used. Where specific valve types are not indicated the following requirements apply:
- B. Shut-off duty: Use gate, ball, and butterfly valves.
- C. Throttling duty: Use globe, ball, and butterfly valves.
- D. Install shut-off duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, and elsewhere as indicated.
- E. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, elsewhere as indicated.
- F. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.

3.6 HYDRONIC SPECIALTIES INSTALLATION

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

3.7 FIELD QUALITY CONTROL

- A. Preparation for Testing: Prepare hydronic piping in accordance with ASME B31.1 and B31.9 and as follows:
- B. Leave joints including welds uninsulated and exposed for examination during the test.
- C. Flush system with clean water. Clean strainers.
- D. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
- E. Install relief valve set at a pressure no more than one-third higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.
- F. Testing: Test hydronic piping as follows:

- G. Use ambient temperature water as the testing medium, except where there is a risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping system components.
- H. Use vents installed at high points in the system to release trapped air while filling the system. Use drains installed at low points for complete removal of the liquid.
- I. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated.
- J. Examine test equipment to ensure that it is tight and that low pressure filling lines are disconnected.
- K. Subject piping system to a hydrostatic test pressure which at every point in the system is not less than 1.5 times the design pressure. If 1.5 times the design pressure is less than 100 psi, pressure test shall be performed at a minimum of 100 psi, per FBC Mechanical 1208.1. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test. Make a check to verify that the stress due to pressure at the bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength, or 1.7 times the "SE" value in Appendix A of ASME B31.9, Code For Pressure Piping, Building Services Piping.
- L. After the hydrostatic test pressure has been applied for at least 2 hours with no loss in pressure, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.
- M. A final Leak Detection Panel Test is required with the Owner's representative present, along with the Contractor and the pre-insulated pipe manufacturer's Field Service Representative.

3.8 ADJUSTING & CLEANING

- A. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.
- B. Mark calibrated name plates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

3.9 COMMISSIONING

- A. Fill system and add chemical treatment. Coordinate with Owner for chemical treatment requirements specific to system equipment.
- B. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
- C. Before operating the system perform these steps:
- D. Open valves to full open position.
- E. Remove and clean strainers.
- F. Check pump for proper direction of correct improper wiring.
- G. Set automatic fill valves for required system pressure.
- H. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).

- I. Set temperature controls so all coils are calling for full flow.
- J. Check operation of automatic bypass valves.
- K. Check and set operating temperatures of chillers to design requirements.
- L. Lubricate motors and bearings.

3.10 PAINT

- A. See "Paint" requirements in Specification Section 230512.

END OF SECTION 23 21 13

SECTION 23 23 00 – REFRIGERANT PIPING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 00 & 01 Specification Sections, apply to this Section.
- B. Requirements of Division 23 Sections apply to this section:

1.2 SUMMARY

- A. This Section includes refrigerant piping used for air conditioning applications. This Section includes:
 - 1. Pipes, tubing, fittings, and specialties.
 - 2. Special duty valves.
 - 3. Refrigerants.
- B. Related Sections: The following sections contain requirements that relate to this section:
 - 1. Division 23, Section "Mechanical Insulation" for pipe insulation.
- C. Products installed but not furnished under this Section include pre-charged tubing, refrigerant specialties, and refrigerant accessories furnished as an integral part of or separately with packaged air conditioning equipment.

1.3 SUBMITTALS

- A. Product data for the following products:
 - 1. Each type valve specified.
 - 2. Each type refrigerant piping specialty specified.
- B. Shop Drawings showing layout of refrigerant piping, specialties, and fittings including, but not necessarily limited to, pipe and tube sizes, valve arrangements and locations, slopes of horizontal runs, wall and floor penetrations, and equipment connection details. Show interface and spatial relationship between piping and proximate to equipment.
- C. Brazer's Certificates signed by Contractor certifying that brazers comply with requirements specified under "Quality Assurance" below.
- D. Maintenance data for refrigerant valves and piping specialties, for inclusion in Operating and Maintenance Manual specified in Division 00 & 01 and Division 23 Section "Basic Mechanical Requirements."

1.4 QUALITY ASSURANCE

- A. Qualify brazing processes and brazing operators in accordance with ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications".
- B. Regulatory Requirements: Comply with provisions of the following codes:
 - 1. ANSI B31.5: ASME Code for Pressure Piping - Refrigerant Piping.
 - 2. ANSI/ASHRAE Standard 15: Safety Code for Mechanical Refrigeration.
 - 3. 2023 Florida Building Code

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the Work include, but are not limited to, the following:
 - 1. Refrigerant Valves and Specialties:
 - a. Alco Controls Div, Emerson Electric.
 - b. Danfoss Electronics, Inc.
 - c. EATON Corporation, Control Div.
 - d. Henry Valve Company.
 - e. Parker-Hannifin Corporation, Refrigeration and Air Conditioning Division.
 - f. Sporlan Valve Company.

2.2 PIPE AND TUBING MATERIALS

- A. General: Refer to Part 3, Article "PIPE APPLICATION" for identification of systems where the below specified pipe and fitting materials are used.
- B. Copper Tubing: ASTM B 280, Type ACR, hard-drawn straight lengths, and soft-annealed coils, seamless copper tubing. Tubing shall be factory cleaned, ready for installation, and have ends capped to protect cleanliness of pipe interiors prior to shipping.

2.3 FITTINGS

- A. Wrought-Copper Fittings: ANSI B16.22, streamlined pattern.

2.4 JOINING MATERIALS

- A. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (Silver).

2.5 VALVES

- A. General: Complete valve assembly shall be UL-listed and designed to conform to ARI 760.

2.6 REFRIGERANT PIPING SPECIALTIES

- A. General: Complete refrigerant piping specialty assembly shall be UL-listed and designed to conform to ARI 760.
- B. Moisture/liquid Indicators: 500 psig maximum operation pressure, 200 deg. F maximum operating temperature; forged brass body, with replaceable polished optical viewing window, and solder end connections.
- C. Flanged Unions: 400 psig maximum working pressure, 330 deg. F maximum operating temperature; two brass tailpiece adapters for solder end connections to copper tubing; flanges for 7/8 inch through 1-5/8 inch unions shall be forged steel, and for 2-1/8 inch through 3-1/8 inch shall be ductile iron; four plated steel bolts, with silicon bronze nuts and fiber gasket. Flanges and bolts shall have factory-applied rust-resistant coating.
- D. Flexible Connectors: 500 psig maximum operating pressure; seamless tin bronze or stainless steel core, high tensile bronze braid covering, solder connections, and synthetic covering; dehydrated, pressure tested, minimum 7 inch in length.

2.7 REFRIGERANT

- A. Refrigerant (required for Unit), in accordance with ASHRAE Standard 34.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine rough-in for refrigerant piping systems to verify actual locations of piping connections prior to installation.

3.2 PIPE APPLICATIONS

- A. Use Type ACR drawn copper tubing with wrought copper fittings and brazed joints above ground, within building. Use Type K, annealed temper copper tubing for 2 inch and smaller without joints, below ground and within slabs. Mechanical fittings (crimp or flair) are not permitted.
- B. Install annealed temper tubing in pipe duct. Vent pipe duct to the outside.

3.3 PIPING INSTALLATIONS

General:

- A. Install refrigerant piping in accordance with ASHRAE Standard 15 - "The Safety Code for Mechanical Refrigeration."
- B. Install piping in as short and direct arrangement as possible to minimize pressure drop.
- C. Install piping for minimum number of joints using as few elbows and other fittings as possible.
- D. Arrange piping to allow normal inspection and servicing of compressor and other equipment. Install valves and specialties in accessible locations to allow for servicing and inspection.
- E. Provide adequate clearance between pipe and adjacent walls and hanger, or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full thickness insulation.
- F. Insulate suction lines. Liquid line are not required to be insulated, except where they are installed adjacent and clamped to suction lines, where both liquid and suction lines shall be insulated as a unit.
- G. Do not install insulation until system testing has been completed and all leaks have been eliminated.
- H. Install branch tie-in lines to parallel compressors equal length, and pipe identically and symmetrically.
- I. Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.
- J. Slope refrigerant piping as follows:
- K. Install horizontal hot gas discharge piping with 1/2" per 10 feet downward slope away from the compressor.
- L. Install horizontal suction lines with 1/2 inch per 10 feet downward slope to the compressor, with no long traps or dead ends which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.
- M. Install traps and double risers where indicated, and where required to entrain oil in vertical runs.
- N. Liquid lines may be installed level.
- O. Use fittings for all changes in direction and all branch connections.

- P. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.
- Q. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.
- R. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.
- S. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.
- T. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

Exterior Wall Penetrations:

- A. Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6-inch shall be steel; pipe sleeves 6-inch and larger shall be sheet metal.

Fire Barrier Penetrations:

- A. Where pipes pass through fire-rated walls, partitions, ceilings, and floors, maintain the fire-rated integrity. Refer to Division 23 for special sealers and materials.
- B. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.
- C. Install strainers immediately ahead of each expansion valve, solenoid valve, hot gas bypass valve, compressor suction valve, and as required to protect refrigerant piping system components.
- D. Install moisture/liquid indicators in liquid lines between filter/driers and thermostatic expansion valves and in liquid line to receiver.
- E. Install moisture/liquid indicators in lines larger than 2-1/8-inch OD, using a bypass line.
- F. Install unions to allow removal of solenoid valves, pressure regulating valves, expansion valves, and at connections to compressors and evaporators.
- G. Install flexible connectors at the inlet and discharge connection of compressors.

3.4 HANGERS AND SUPPORTS

- A. General: Hangers, supports, and anchors are specified in Division 23 Section "HANGERS AND SUPPORTS." Conform to the table below for maximum spacing of supports:
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet in length.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
 - 3. Pipe rollers complete supports for multiple horizontal runs, 20 feet or longer supported by a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Install hangers with the following minimum rod sizes and maximum spacing:

<u>NON. PIPE SIZE</u>	<u>MAX. SPAN-FT</u>	<u>MIN. ROD SIZE – INCHES</u>
Up to 3/4"	5	3/8
1"	6	3/8
1 1/4"	7	3/8
1 1/2"	8	3/8

6. Support vertical runs at each floor.

3.5 PIPE JOINT CONSTRUCTION

- A. Brazed Joints: Comply with the procedures contained in the AWS "Brazing Manual."
- B. WARNING: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes. Provide adequate ventilation.
- C. CAUTION: When solenoid valves are being installed, remove the coil to prevent damage. When sight glasses are being installed, remove the glass. Remove stems, seats, and packing of valves, and accessible internal parts of refrigerant specialties before brazing. Do not apply heat near the bulb of the expansion valve.
- D. Fill the pipe and fittings during brazing, with an inert gas (i.e., nitrogen or carbon dioxide) to prevent formation of scale.
- E. Heat joints using oxy-acetylene torch. Heat to proper and uniform brazing temperature.

3.6 VALVE INSTALLATIONS

- A. General: Install refrigerant valves where indicated, and in accordance with manufacturer's instructions.
- B. Install globe valves on each side of strainers and driers, in liquid and suction lines at evaporators, and elsewhere as indicated.
- C. Install pressure regulating and relieving valves as required by ASHRAE Standard 15.

3.7 EQUIPMENT CONNECTIONS

- A. The Drawings indicate the general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow servicing and maintenance.

3.8 FIELD QUALITY CONTROL

- A. Repair leaking joints using new materials, and retest for leaks.

3.9 ADJUSTING AND CLEANING

- A. Verify actual evaporator applications and operating conditions, and adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.
- B. Clean and inspect refrigerant piping systems in accordance with requirements of Division-23 Basic Mechanical Materials and Methods section "Pipes and Pipe Fittings".
- C. Adjust controls and safeties. Replace damaged or malfunctioning controls and equipment with new materials and products.

3.10 COMMISSIONING

- A. Charge system using the following procedure:
- B. Install core in filter dryer after leak test but before evacuation.
- C. Complete charging of system, using new filter dryer core in charging line. Provide full operating charge.

- D. Train Owner's maintenance personnel on procedures and schedules related to start-up and shut-down, troubleshooting, servicing, and preventative maintenance of refrigerant piping valves and refrigerant piping specialties.
- E. Review data in Operating and Maintenance Manuals. Refer to Division 00 & 01 section "Project Closeout."

END OF SECTION 23 23 00

SECTION 23 25 29 – HANGERS AND SUPPORTS

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section includes hangers and supports for mechanical systems piping and equipment.

1.2 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 01 Specification Sections.
- B. Product data for each type of hanger and support.
- C. Submit pipe hanger and support schedule showing manufacturer's Figure No., size, location, and features for each required pipe hanger and support.
- D. Shop drawings for each type of hanger and support, indicating dimensions, weights, required clearances, and methods of component assembly.

1.3 QUALITY ASSURANCE

- A. NFPA Compliance: Comply with NFPA 13 for hangers and supports used as components of fire protection systems.
- B. Listing and Labeling: Provide hangers and supports that are listed and labeled as defined in NFPA 70, Article 100.
 - 1. UL and FM Compliance: Hangers, supports, and components include listing and labeling by UL and FM where used for fire protection piping systems.
 - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- C. Licensed Operators: Use operators that are licensed by powder-operated tool manufacturers to operate their tools and fasteners.

PART 2 – PRODUCTS

2.1 MANUFACTURED UNITS

- A. Hangers, Supports, and Components: Factory-fabricated according to MSS SP-58.
 - 1. Components include galvanized coatings where installed for piping and equipment that will not have a field-applied finish.
 - 2. Pipe attachments include nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.
- B. Thermal-Hanger Shield Inserts: 100-psi (690kPa) average compressive strength, waterproofed calcium silicate, encased with sheet metal shield. Insert and shield cover entire circumference of pipe and are of length indicated by manufacturer for pipe size and thickness of insulation.
- C. Powder Actuated Drive Pin Fasteners: Powder actuated type, drive pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used. Fasteners for fire protection systems include UL listing and FM approval.
- D. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used. Fasteners for fire protection systems include UL listing and FM approval.

2.2 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.
- B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex-head, track bolts and nuts.
- C. Washers: ASTM F 844, steel, plain, flat washers.
- D. Grout: ASTM C 1107, Grade B, non-shrink, nonmetallic.
 - 1. Characteristics include post-hardening, volume-adjusting, dry, hydraulic cement-type grout that is non-staining, non-corrosive, non-gaseous and is recommended for both interior and exterior applications.
 - 2. Design Mix: 5000-psi (34.5MPa), 28-day compressive strength.
 - 3. Water: Potable.
 - 4. Packaging: Premixed and factory-packaged.

PART 3 – EXECUTION

3.1 HANGER & SUPPORT APPLICATIONS

- A. Specific hanger requirements are specified in the Section specifying the equipment and systems.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping specification Sections.

3.2 HANGER & SUPPORT INSTALLATION

- A. General: Comply with MSS SP-69 and SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Arrange for grouping of parallel runs of horizontal piping supported together on field-fabricated, heavy-duty trapeze hangers where possible.
- C. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20' in length.
 - 2. Adjustable roller hangers and spring hangers for individual horizontal runs 20' or longer.
 - 3. Pipe roller complete – MSS Type 44 for multiple horizontal runs, 20' or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.

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D. Install hangers for horizontal piping with the following maximum spacing and minimum rod sizes:

Nom. Pipe Size - In.	Steel Pipe Max. Span - Ft.	Copper Tube Max. Span - Ft.	Min. Rod Dia. - In.
Up to $\frac{3}{4}$	7	5	$\frac{3}{8}$
1	7	6	$\frac{3}{8}$
1-1/4	7	7	$\frac{3}{8}$
1-1/2	9	8	$\frac{3}{8}$
2	10	8	$\frac{3}{8}$
2-1/2	11	9	$\frac{1}{2}$
3	12	10	$\frac{1}{2}$
3-1/2	13	11	$\frac{1}{2}$
4	14		$\frac{5}{8}$
5	15		$\frac{5}{8}$
6	15		$\frac{3}{4}$
8	15		$\frac{7}{8}$
10	15		$\frac{7}{8}$
12	15		$\frac{7}{8}$
14	15		1
16	15		1
18	15		1-1/4
20	15		1-1/4
24	15		1-1/2
30	15		1-1/2

- E. Support vertical steel pipe and copper tube at each floor.
- F. Support plastic pipe and tubing in accordance with manufacturer's recommendations.
- G. Install Cast-Iron Pipe with piping supports located at end of each length of pipe in horizontal lines, at each bend, and vertical supports at maximum intervals of 14'. Locate supports near couplings, not in center of pipe.
- H. Install supports with maximum spacing complying with MSS SP-69.
- I. Where pipes of various sizes are supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
- J. Install building attachments within concrete or to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Install reinforcing bars through openings at top of inserts.
- K. Install concrete inserts in new construction prior to placing concrete.
- L. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual. Do not use in lightweight concrete slabs or in concrete slabs less than 4" (100 mm) thick.
- M. Install mechanical anchor fasteners in concrete after concrete is placed and completely cured.
- N. Install according to fastener manufacturer's written instructions. Do not use in lightweight concrete slabs or in concrete slabs less than 4" (100 mm) thick.
- O. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

- P. Heavy-Duty Steel Trapezes: Field-fabricate from ASTM A 36 steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.
- Q. Support fire protection systems piping independent of other piping.
- R. Install hangers and supports to allow controlled movement of piping systems, permit freedom of movement between pipe anchors, and facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- S. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
- T. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so that maximum pipe deflections allowed by ASME B31.9 "Building Services Piping" is not exceeded.
- U. Insulated Piping: Comply with the following installation requirements.
 - 1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.9.
 - 2. Saddles: Install protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.
 - 3. Shields: Install MSS Type 40, protective shields on cold piping with vapor barrier. Shields span an arc of 180 degrees (3.1 rad) and have dimensions in inches (mm) not less than the following:

NPS (Inches)	LENGTH (Inches)	THICKNESS (Inches)
¼ to 3-1/2	12	0.048
4	12	0.060
5 and 6	18	0.060
8 to 14	24	0.075
16 to 24	24	0.105

Pipes 8" and Larger: Include wood inserts.

Insert Material: Length at least as long as the protective shield.

Thermal-Hanger Shields: Install with insulation of same thickness as piping.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural steel stands to suspend equipment from structure above or support equipment above floor. Refer to Drawing Details (and Architectural Drawing/Spec's) for roof supports.
- B. Grouting: Place grout under supports for equipment and make a smooth bearing surface.

3.4 METAL FABRICATION

- A. Cut, drill, and fit miscellaneous metal fabrications for pipe and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for manual shielded metal-arc welding, appearance and quality of welds, methods used in correcting welding work, and the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.

4. Finish welds at exposed connections so that no roughness shows after finishing, and so that contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

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

3.6 PAINTING

- A. Touching Up: Clean field welds and abraded areas of shop paint and paint exposed areas immediately after erection of hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces. Also, refer to Section 230512 for painting requirements.

1. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

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

3.7 FIELD QUALITY CONTROL

- A. Licensed Engineer's Report: Prepare hanger and support installation report. Include seal and signature of Registered Engineer, licensed in jurisdiction where Project is located, certifying compliance with specifications.

END OF SECTION 23 25 29

SECTION 23 31 00 – DUCTWORK

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Divisions 00 and 01 Specification Sections, apply to this Section.
- B. Requirements of Division 23 Sections apply to this section (including, but not limited to):
 - 1. Basic Mechanical Requirements
 - 2. Basic Mechanical Materials and Methods

1.2 SUMMARY

- A. This Section includes rectangular and round metal ducts and plenums for heating, ventilating, and air conditioning systems in pressure classes from minus 2" to plus 10" water gage.
- B. Related Sections: The following sections contain requirements that relate to this Section:
 - 1. Division 23 Section "Mechanical Insulation" for exterior duct and plenum insulation.
 - 2. Division 23 Section "Duct Accessories" for flexible duct materials, dampers, duct-mounted access panels and doors, and turning vanes.
 - 3. Division 23 Section "Air outlets and Inlets."
 - 4. Division 23 Section "Testing, Adjusting, and Balancing."
 - 5. Division 23 Section "Controls" for automatic volume control dampers and operators.

1.3 DEFINITIONS

- A. Sealing Requirements Definitions: For the purposes of duct systems sealing requirements specified in this Section, the following definitions apply:
- B. Seams: A seam is defined as joining of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on the perimeter are deemed to be joints.
- C. Joints: Joints include girth joints; branch and sub-branch intersections; so-called duct collar tap-ins; fitting subsections; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

1.4 SYSTEM PERFORMANCE REQUIREMENTS

- A. The duct system design, as indicated, has been used to select and size air moving and distribution equipment and other components of the air system. Changes or alterations to the layout or configuration of the duct system must be specifically approved in writing. Accompany requests for layout modifications with calculations showing that the proposed layout will provide the original design results without increasing the system total pressure.
- B. The duct system shall be tested for leakage in accordance with SMACNA HVAC Duct Leakage Test Manual – Latest Edition. Medium pressure duct (i.e. ductwork upstream of VAV boxes) shall meet Class 6 requirements (rectangular) or Class 3 (round).
- C. Construct, Secure and Support Exterior Ductwork to Comply with FBC Wind Loads.

1.5 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.

- B. Product data including details of construction relative to materials, dimensions of individual components, profiles, and finishes for the following items:

Sealing Materials

Fire-Stopping Materials

- C. Welding certificates including welding procedures specifications, welding procedures qualifications test records, and welders' qualifications test records complying with requirements specified in Section 23 05 10, Section "Basic Mechanical Requirements".
- D. Record drawings including duct systems routing, fittings details, reinforcing, support, and installed accessories and devices, in accordance with Division 23 05 10, Section "Basic Mechanical Requirements" and Division 01.
- E. Maintenance data for volume control devices, fire dampers, and smoke dampers, in accordance with Division 23 Section "Basic Mechanical Requirements" and Division 01.

1.6 QUALITY ASSURANCE

- A. NFPA Compliance: Comply with the following NFPA Standards:

- 1. NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems," except as indicated otherwise.

PART 2 – PRODUCTS

2.1 FLEXIBLE DUCTS

- A. General: Comply with UL 181, Class 1.
- B. Flexible Ducts – Insulated: Factory-fabricated, insulated, round duct, with an outer jacket enclosing glass fiber (minimum (R-6), 1" thick in conditioned areas, 1-1/2" thick in non-conditioned spaces) insulation around a continuous inner liner.
 - 1. Reinforcement: Steel-wire helix encapsulated in the inner liner.
 - 2. Outer Jacket: Glass-reinforced, silver Mylar with a continuous hanging tab, integral fiber glass tape, and nylon hanging cord.
 - 3. Inner Liner: Polyethylene film.
- C. Acoustical Medium Pressure Flexible Duct:
- D. Provide where indicated on drawings Flexmaster (or approved equal) Type 8M UL181 Class 1 Air Duct.
- E. The duct shall be constructed of a CPE fabric supported by helical wound galvanized steel.
- F. The internal working pressure rating shall be at least 10" w.g. positive and 4" w.g. negative with a bursting pressure of at least 2 ½ times the working pressure.
- G. The duct shall be rated for a velocity of at least 4000 feet per minute.
- H. The duct must be suitable for continuous operation at a temperature range of -20°F to +250°F.
- I. Acoustical performance, when tested by an independent laboratory in accordance with the Air Diffusion Council's Flexible Air Duct Test Code FD 72-R1, Section 3.0, Sound Properties, shall be as follows:
 - 1. The insertion loss (dB) of a 10-foot length of straight duct when tested in accordance with ASTM E477, at a velocity of 2500 feet per minute, shall be at least:

Octave Band	2	3	4	5	6	7
Hz	125	250	500	1000	2000	4000
6" Diameter	7	31	40	38	40	27
8" Diameter	13	29	36	35	38	22
12" Diameter	21	28	29	33	26	12

2. The radiated noise reduction (dB) of a 10-foot length of straight duct when tested in accordance with ASTM E477, at a velocity of 2500 feet per minute, shall be at least:

Octave Band	2	3	4	5	6	7
Hz	125	250	500	1000	2000	4000
6" Diameter	5	8	7	8	11	15
8" Diameter	10	7	7	8	10	13
12" Diameter	9	6	6	5	9	13

3. The self generated sound power levels (LW) dB re 10^{-12} watt of a 10-foot length of straight duct for an empty sheet metal duct when tested in accordance with ASTM E477, at a velocity of 1000 feet per minute, shall not exceed.

Octave Band	2	3	4	5	6	7
Hz	125	250	500	1000	2000	4000
6" Diameter	42	31	23	18	17	21
8" Diameter	41	34	27	19	18	21
12" Diameter	54	45	38	31	27	23

- J. Factory insulate the flexible duct with fiberglass insulation. The R value shall be at least $R=6.0$ at a mean temperature of 75°F.

- K. Cover the insulation with a fire-retardant metalized vapor barrier jacket reinforced with cross-hatched scrim having a permeance of not greater than 0.05 perms when tested in accordance with ASTM E96, Procedure A.

- L. Manufacturers Flexible Duct Connectors:

Clevaflex
Genflex type
Wiremold
Flexmaster

2.2 SHEET METAL MATERIALS

- A. Sheet Metal, General: Provide sheet metal in thicknesses indicated, packaged, and marked as specified in ASTM A 700.
- B. Galvanized Sheet Steel: Lock-forming quality, ASTM A 653, Coating Designation G 90. Provide mill phosphatized finish for exposed surfaces of ducts exposed to view.

- C. Reinforcement Shapes and Plates: Unless otherwise indicated, provide galvanized steel reinforcing where installed on galvanized sheet metal ducts. For aluminum and stainless-steel ducts provide reinforcing of compatible materials.
- D. Tie Rods: Galvanized steel, 1/4" minimum diameter for 36" length or less; 3/8" minimum diameter for lengths longer than 36".

2.3 SEALING MATERIALS

- A. Joint and Seam Sealant: One-part, non-sag, solvent-release-curing, polymerized butyl sealant complying with FSTT-S-001657, Type I; formulated with a minimum of 75% solids; High Pressure Sealant.
- B. Flanged Joint Mastics: One-part, acid-curing, silicone elastomeric joint sealants, complying with ASTM C 920, Type S, Grade NS, Class 25, Use O, high pressure sealant.

2.4 FIRE STOPPING

- A. Fire-Resistant Sealant: Provide one-part elastomeric sealant formulated for use in a through-penetration fire-stop system for filling openings around duct penetrations through walls and floors, having fire-resistance ratings indicated as established by testing identical assemblies per ASTM E 814 by Underwriters Laboratory, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction.
- B. Products: Subject to compliance with requirements, provide one of the following:
 - Dow Corning Fire Stop Sealant; Dow Corning Corp.
 - 3M Fire Barrier Caulk CP-25; Electrical Products Div./3M.
 - RTV 7403; General Electric Co.
 - Fyre Putty; Standard Oil Engineered Materials Co.

2.4 HANGERS & SUPPORTS

- A. Building Attachments: Concrete inserts, powder actuated fasteners, or structural steel fasteners appropriate for building materials. Do not use powder actuated concrete fasteners for lightweight aggregate concretes or for slabs less than 4" thick.
- B. Hangers: Galvanized sheet steel, or round, steel, threaded rod.
 - 1. Hangers Installed in Corrosive Atmospheres: Electro-galvanized, all-thread rod or hot-dipped-galvanized rods with threads painted after installation.
 - 2. Straps and Rod Sizes: Conform to Table 4-1 in SMACNA HVAC Duct Construction Standards, 1985 Edition, for sheet steel width and gage and steel rod diameters.
- C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- D. Trapeze and Riser Supports: Steel shapes conforming to ASTM A 36. Where galvanized steel ducts are installed, provide hot-dipped-galvanized steel shapes and plates.

2.5 RECTANGULAR DUCT FABRICATION

- A. General: Except as otherwise indicated, fabricate rectangular ducts with galvanized sheet steel, in accordance with SMACNA "HVAC Duct Construction Standards," Tables 1-3 through 1-19, including their associated details. Conform to the requirements in the referenced standard for metal thickness, reinforcing types and intervals, tie rod applications, and joint types and intervals.
- B. Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.

- C. Provide materials that are free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.
- D. Static Pressure Classifications: Except where otherwise indicated, construct duct systems to the following pressure classifications:
 - 1. Supply Ducts Upstream of Terminal Boxes: 8" water gage, positive.
 - 2. Supply Ducts Downstream of Terminal Boxes: 4" water gage, positive.
 - 3. Return Ducts: 4" water gage, negative pressure.
 - 4. Exhaust Ducts: 2" water gage, positive and negative.
 - 5. Outside Air Ducts: 4" water gage, positive and negative.
- E. Cross-breaking or Cross Beading: Cross-break or bead duct sides that are 19" and larger and are 20 gage or less, with more than 10 sf. of unbraced panel area, as indicated in SMACNA "HVAC Duct Construction Standard."

2.6 RECTANGULAR DUCT FITTINGS

- A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA "HVAC Metal Duct Construction Standard," 1985 Edition, Figures 2-1 through 2-10.
- B. Double Wall Rectangular (Insulated) Ducts & Fittings: Duct is of galvanized steel construction, double-wall with an outer shell, insulation, and an inner liner as specified below. Dimensions indicated on internally insulated ducts are nominal inside dimensions. Double Wall Duct shall be manufactured by McGill Airflow's K-27 or approved equal.
 - 1. Thermal Conductivity: 0.27 Btuh/sq. ft./deg F/inch thickness at 75°F mean temperature.
 - 2. Outer Shell: Base outer shell gage on actual outer shell dimensions. Appearance of outer shell shall be as "clean" as possible for exposed view by occupants.
 - 3. Insulation: Unless otherwise indicated, provide 1-inch-thick, 1.5 # density fiberglass insulation. Provide insulation ends where internally insulated duct connects to single wall duct or non-insulated components. The insulation end shall terminate the insulation and reduce the outer shell diameter to the inner liner diameter.
 - 4. Solid Inner Liner: Construct inner liners with solid sheet metal with sealed seams.
 - 5. Maintain clearance of liner to outer shell by mechanical means. Retain insulation from dislocation by mechanical means.
 - 6. Turning vanes: Provide turning vanes in all 90° Elbows.
 - 7. System Pressure Classification: Material thickness from galvanized steel shall be in accordance with SMACNA'S HVAC Duct Construction Standards for 4"+ water gauge pressure. Provide stiffeners and reinforcement as required.
 - 8. Joint Sealing: Pittsburgh lockseam construction with TDC end connectors and gaskets. The system tightness shall be factory warranted to meet SMACNA's Leakage Class 6 Performance.
 - 9. Painting: Prime and paint duct & fittings. Color selected by Architect.

2.7 ROUND DUCT FABRICATION

- A. General: "Basic Round Diameter" as used in this article is the diameter of the size of round duct. Except where interrupted by fittings, provide round in lengths not less than 12'.
- B. Round Ducts: Provide round supply and return ducts and fittings as indicated with spiral lock-seam construction, except for diameters greater than 72". Use longitudinal butt-welded seams. Comply with SMACNA "HVAC Duct Construction Standards," Table 3-2 for galvanized steel gages.
- C. System Pressure Classifications: Refer to rectangular duct fabrication for minimum pressure applications.

- D. Note: Snap-lock duct is Prohibited.

2.8 ROUND FITTINGS FABRICATION

- A. 90-Degree Tees and Laterals and Conical Tees: Fabricate to conform to SMACNA "HVAC Duct Construction Standards," 1985 Edition, Figures 3-4 and 3-5 and with metal thicknesses specified for longitudinal seam straight duct.
- B. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from the body onto branch tap entrance.
- C. Elbows: Fabricate in die-formed, gored, pleated, or mitered construction. Fabricate the bend radius of die-formed, gored, and pleated elbows 1.5 times the elbow diameter. Unless elbow construction type is indicated, provide elbows meeting the following requirements:
1. Mitered Elbows: Fabricate mitered elbows with welded construction in gages specified below.
 - a. Mitered Elbows Radius and Number of Pieces: Unless otherwise indicated, construct elbow to comply with SMACNA "HVAC Duct Construction Standards," Table 3-1.
 - b. Round Mitered Elbows: Solid welded and with metal thickness listed below for pressure classes from 2" to 10":

3 to 14": 24 gage.

15 to 26": 22 gage.

27 to 50": 20 gage.
 - c. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems, or exhaust systems for material handling classes A and B; and only where space restrictions do not permit the use of 1.5 bend radius elbows. Fabricate with a single-thickness turning vanes.
 2. Round Elbows - 8" and Smaller: Die-formed elbows for 45° and 90° elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend angle configurations or ½" diameter (e.g. 3-1/2" and 4-1/2") elbows with gored construction.
 3. Round Elbows - 9 Through 14": Gored or pleated elbows for 30, 45, 60, and 90 degrees, except where space restrictions require a mitered elbow. Fabricate nonstandard bend angle configurations or ½-inch-diameter (e.g. 9-1/2- and 10-1/2-inch) elbows with gored construction.
 4. Round Elbows - Larger Than 14" Elbows: Gored elbows, except where space restrictions require a mitered elbow.
 5. Die-Formed Elbows for Sizes Through 8" and All Pressures: 20 gage with 2-piece welded construction.
 6. Round Gored Elbows Gages: Same as for non-elbow fittings specified above.
 7. Pleated Elbows Sizes Through 14" and Pressures Through 10": 26 gage.
- D. System Pressure Classifications: Refer to rectangular duct fabrication for minimum pressure applications.
- E. Double-Wall Round (Insulated) Ducts & Fittings: Duct is of spiral lock-seam construction, double-wall with an outer shell, insulation, and an inner liner as specified below. Dimensions indicated on internally insulated ducts are nominal inside dimensions. Double Wall Duct with push joint fittings shall be manufactured by Lindab or approved equal.
1. Thermal Conductivity: 0.26 Btuh/sq. ft./deg F/inch thickness at 75°F mean temperature.
 2. Outer Shell: Base outer shell gage on actual outer shell dimensions.
 3. Insulation: Unless otherwise indicated, provide 1-inch-thick, 1.5 # density fiberglass insulation. Provide insulation ends where internally insulated duct connects to single wall duct or non-insulated components. The insulation end shall terminate the insulation and

- reduce the outer shell diameter to the inner liner diameter.
- 4. Solid Inner Liner: Construct inner liners with solid sheet metal.
- 5. Maintain concentricity of liner to outer shell by mechanical means. Retain insulation from dislocation by mechanical means.
- 6. System Pressure Classification: Material thickness from galvanized steel shall be in accordance with SMACNA'S HVAC Duct Construction Standards for 10"+ water gauge pressure.
- 7. Joint Sealing: Fitting ends shall be equipped with factory installed double-lipped, U-profile gaskets. The system tightness shall be factory warranted to meet SMACNA's Leakage Class 3 Performance.
- 8. Painting: Prime and paint duct & fittings. Color selected by Architect.

PART 3 – EXECUTION

3.1 DUCT INSTALLATION, GENERAL

- A. Flexible duct runs shall be a maximum of 6' and shall be supported every 3' with minimum 1 1/2" strap. Maximum permissible sag is 1/2" per foot.
- B. Flexible duct connections shall include 3 wraps of approved tape and stainless-steel draw band. Insulation jacket shall be sealed with 3 wraps of approved UL 181B tape.
- C. Duct System Pressure Class: Construct and install each duct system for the specific duct pressure classification indicated.
- D. Seal ALL duct seams, joints, etc with generous coating of High-Pressure Duct Sealant (except double wall duct which shall be sealed with push joints or other means for "clean finished" look).
- E. Install ducts with the fewest possible joints.
- F. Use fabricated fittings for all changes in directions, changes in size and shape, and connections. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.
- G. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel, and perpendicular to building lines; avoid diagonal runs. Install duct systems in shortest route that does not obstruct usable space or block access for servicing building and its equipment.
- H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- I. Provide clearance of 1" where furring is shown for enclosure or concealment of ducts, plus allowance for insulation thickness, if any.
- J. Install insulated ducts with 1" clearance outside of insulation.
- K. Conceal ducts from view in finished and occupied spaces by locating in mechanical shafts, hollow wall construction, or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown.
- L. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.
- M. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- N. Non-Fire-Rated Partition Penetrations: Where ducts pass interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gage as duct. Overlap opening on 4 sides by at least 1-1/2".

3.2 HANGING & SUPPORTING

- A. Install rigid round, rectangular, and flat oval metal duct with support systems indicated in SMACNA "HVAC Duct Construction Standards," Tables 4-1 through 4-3 and Figures 4-1 through 4-8.
- B. Support horizontal ducts within 2' of each elbow and within 4' of each branch intersection.
- C. Support vertical ducts at a maximum interval of 16' and at each floor.
- D. Upper attachments to structures shall have an allowable load not exceeding one fourth of the failure (proof test) load but are not limited to the specific methods indicated.
- E. Install concrete insert prior to placing concrete.
- F. Install powder actuated concrete fasteners after concrete is placed and completely cured.
- G. Provide all supplemental steel as required to support new ductwork. Comply with SMACNA HVAC Duct Construction Standards and Manufacturer's recommendations.
- H. All Exterior Ductwork shall be fabricated, supported, and secured to comply with FBC Wind Loads.

3.3 CONNECTIONS

- A. Equipment Connections: Connect equipment with flexible connectors in accordance with Division 23 Section "Duct Accessories".
- B. Branch Connections: Comply with SMACNA "HVAC Duct Construction Standards," Figures 2-7 and 2-8.
 - 1. Note: Branch Take-Off's shall have a 1 inch gasketed flange collar. Spin-in collars are NOT acceptable.
- C. Outlet and Inlet Connections: Comply with SMACNA "HVAC Duct Construction Standards," Figures 2-16 through 2-18.
- D. Terminal Units Connections: Comply with SMACNA "HVAC Duct Construction Standards," Figure 2-19.
- E. Double Wall Duct Connections: Shall comply with MFR's Requirements and SMACNA "HVAC Duct Construction Standards." Connections between single wall duct and double wall duct shall be done in such a way that no exposed insulation is in the airstream. Overlap insulation work as required to prevent duct sweating.
- F. Double Wall Insulated Duct: Shall be used for all exposed to view duct.
- G. Flexible Duct: Maximum length shall be eight (8) feet.

3.4 FIELD QUALITY CONTROL

- A. The Contractor will contract with an independent testing agency to perform, record, and report leakage tests in the presence of the Engineer.
- B. Remake leaking seams and joints as required and apply sealants to achieve specified maximum allowable leakage.

3.5 ADJUSTING & CLEANING

- A. Adjust volume control devices as required by the testing and balancing procedures to achieve required air flow. Refer to Division 23 Section "TESTING, ADJUSTING, AND BALANCING" for requirements and procedures for adjusting and balancing air systems.
- B. Vacuum ducts systems prior to final acceptance to remove dust and debris.

END OF SECTION 23 31 00

SECTION 23 33 00 – DUCT ACCESSORIES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Divisions 00 and 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Flexible Connections
 - 2. Manual Volume Control Dampers
 - 3. Fire Dampers
 - 4. Fire/Smoke Dampers & Smoke Dampers
 - 5. Turning Vanes
 - 6. Duct-Mounted Access Doors and Panels
 - 7. Accessories Hardware
 - 8. Duct Silencers
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 23 Section "Air Outlets and Inlets" for diffusers, registers, and grilles.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.
- B. Product data including details for materials, dimensions of individual components, profiles, and finishes for the following items:
 - 1. Manual volume control dampers.
 - 2. Fire dampers.
 - 3. Duct-mounted access panels and doors.
- C. Shop drawings from manufacturer detailing assemblies. Include dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Detail the following:
 - 1. Special fittings and volume control damper installation (both manual and automatic) details.
 - 2. Fire damper installations, including sleeves and duct-mounted access door and panel installations.
- D. Product Certification: Submit certified test data on dynamic insertion loss; self-noise power levels, and airflow performance data, static pressure loss, and dimensions and weights.

1.4 QUALITY ASSURANCE

- A. NFPA Compliance: Comply with the following NFPA Standards:
 - 1. NFPA 80, "Standard for Fire Doors and Other Opening Protective's"
 - 2. NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.5 EXTRA MATERIALS

- A. Furnish extra materials matching products installed as described below, packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Owner.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 – PRODUCTS

2.1 FLEXIBLE CONNECTIONS

- A. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric (or as required for duct pressure classification) crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and capable of absorbing vibrations of connected equipment.
- B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering flexible connections which may be incorporated in the work include, but are not limited to, the following:

American/Elgen Co.; Energy Div.
Duro Dyne Corp.
Flexaust (The) Co.
Ventfabrics, Inc.

2.2 MANUAL VOLUME CONTROL DAMPERS

- A. General: Provide factory-fabricated volume-control dampers, complete with required hardware and accessories. Stiffen damper blades to provide stability under operating conditions. Provide locking quadrant device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class. Provide end bearings or other seals for ducts with pressure classifications of 3 inches or higher. Extend axles full length of damper blades. Provide bearings at both ends of operating shaft, which must extend through insulation.
- B. Standard Volume Control Dampers: Multiple-blade, opposed-blade design (20 gauge) as indicated, standard leakage rating, with linkage outside of air stream, and suitable for horizontal or vertical applications. Blades shall not exceed 6" and shall be selected for fit in each specific application. Select and install damper for easy access to manual operator.
 1. Steel Frames: Hat-shaped, galvanized-steel channels, minimum of 18 gage, and with mitered and welded corners.
 2. Provide flangeless frames where indicated for installation in ducts.
 3. Roll-Formed Steel Blades: 20-gage galvanized steel.
 4. Blade Axles: Galvanized steel.
 5. Tie Bars and Brackets: Galvanized steel.

2.3 FIRE DAMPERS

- A. General: Provide fire dampers for all fire rated partitions, walls, and floors as defined by the Architectural drawings and specifications. For renovation projects, contractors shall field verify existing conditions prior to submitting their bids. Fire dampers shall be UL labeled according to UL Standard 555 "Standard for Fire Dampers."
- B. Fire Rating: 1-1/2 hr. for 1 hr. and 2 hr. rated walls and 3 hr. for 3 hr. and 4 hr. rated walls as indicated by the fire rating of the wall to be penetrated. Refer to architectural drawings.
- C. Frame: Type B; with frame and retracted blades outside of airstream fabricated with roll-formed, 21-gage, galvanized-steel; with mitered and interlocking corners.
- D. Mounting Sleeve: Factory-installed or field-installed galvanized steel. Breakaway connections shall be utilized. Rigid connections require specific approval by the Engineer.

1. Minimum Thickness: 20 gauge for ducts 84" wide and smaller. Sleeve gauge shall in no case be less than the connecting ducts.
 2. 18 gauge for ducts 85" wide and larger.
- E. Mounting Orientation: Vertical or horizontal as indicated.
- F. Blades: Roll-formed, interlocking, 21-gage galvanized steel. In place of interlocking blades, provide full-length, 21-gage, galvanized-steel blade connectors.
- G. Horizontal Dampers: Include a blade lock and stainless steel negator closure spring.
- H. Fusible Link: Replaceable, 165 deg F.
- I. Available Manufacturers: Subject to compliance with requirements, manufacturers offering fire and smoke dampers which may be incorporated in the work include the following:
- Air Balance, Inc.
American Warming and Ventilating, Inc.
Arrow Louver and Damper; Div. of Arrow United Industries Inc.
Louvers and Dampers, Inc.
Penn Ventilator Co.
Phillips-Aire.
Ruskin Mfg. Co.
- J. Motor Driven Fire/Smoke Dampers & Smoke Dampers: Provide motor-driven fire/smoke dampers and smoke dampers (damper and actuator must comply with UL 555, UL 555S and NFPA 90A) in types and sizes indicated, with frame constructed with minimum 16 gage galvanized steel, and factory supplied sleeve constructed of 20 gage galvanized steel for dampers 84" wide or smaller and 18 gage galvanized steel for dampers 85" and up (except, sleeve gage must be at least equal to the gage of the duct) with bonded red acrylic enamel finish, fusible link 160 to 165°F (71 to 74 deg. C), unless otherwise indicated, for fire dampers, and steel inter-locking blades, with electric motor equipped with instant closure clutch (i.e. power to open, spring closed), stainless steel cable damper blade linkage, motor mounting bracket, and 32" long wire leads for connecting to smoke detector, and with the following construction feature:
- K. Unit Assembly: Motor mounted outside air stream. 120-1-60 (Coordinate prior to Bidding and Ordering with electrical & fire alarm subcontractors).
- L. Fire/Smoke damper and smoke damper must be fully operational while HVAC system is in operation.
- M. Available Manufacturers: Subject to compliance with requirements, manufacturers offering fire and smoke dampers which may be incorporated in the work include, but are not limited to, the following:
- Air Balance, Inc.
American Warming & Ventilating, Inc.
Arrow Louver and Damper; Div. of Arrow United Industries Inc.
Louvers and Dampers, Inc.
Penn Ventilator Co.
Phillips-Aire.
Ruskin Mfg. Co.

2.4 TURNING VANES

- A. Fabricate turning vanes according to SMACNA HVAC Duct Construction Standards, Figures 2-2 through 2-7.
- B. Manufactured Turning Vanes: Fabricate of 1 ½" wide, curved blades set at ¾" in center, support with bars perpendicular to blades set at 2" on center and set into side strips suitable for mounting in ducts.

2.5 DUCT-MOUNTED ACCESS DOORS & PANELS

- A. General: Refer to the Access Door Materials Schedule at the end of this Section for frame and door thickness, number of hinges and locks, and location of locks. Provide construction and airtightness suitable for duct pressure class.
- B. Frame: Galvanized sheet steel. Provide with bend-over tabs and foam gaskets.
- C. Door: Double-wall, galvanized sheet metal construction with insulation fill and thickness, number of hinges and locks as indicated for duct pressure class. Provide vision panel where indicated. Provide 1" by 1" butt hinge or piano hinge and cam latches.
- D. Seal around frame attachment to duct and door to frame with neoprene or foam rubber seals.
- E. Insulation: 1" thick fiber glass or polystyrene foam board.

2.6 ACCESSORIES HARDWARE

- A. Splitter Damper Accessories: Zinc-plated damper blade bracket, 1/4", zinc-plated operating rod, and a duct-mounted, ball-joint bracket with flat rubber gasket and square-head set screw.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof and resistant to gasoline and grease.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of duct accessories. Do not proceed with installation until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install duct accessories according to manufacturer's installation instructions and applicable portions of details of construction as shown in SMACNA standards.
- B. Provide test holes at fan inlet and outlet and elsewhere as indicated.
- C. Install fire dampers and smoke dampers according to the manufacturer's UL approved printed instructions.
- D. Provide access doors in ductwork and in hard ceilings for maintenance of fire dampers, smoke dampers and fire/smoke dampers, damper operators, etc.
- E. Install fusible links in fire dampers. Demonstrate to Engineer access and replacement of fusible links; adjust duct size, access door size (note min 12"x12" but larger size shall be used to improve ease of access) and placement, duct configuration, etc as required for ease of maintenance and access of fire dampers and linkages.
- F. Fire and Fire/Smoke Dampers: Install properly rated damper in rated construction as required to maintain rating of construction.
- G. Activation of the fire alarm panel shall close all smoke dampers and immediately shutdown associated AHU(s). Smoke Damper shall open automatically upon restoration of the fire alarm "all clear" signal. Smoke Dampers shall open automatically upon restoration of building power. Coordinate the wiring of the smoke damper and combination fire/smoke damper with the Fire Alarm Contractor accordingly.
- H. Label access doors according to Division 23 Section "Mechanical Identification" and NFPA 80, NFPA 101 and FBC Mech, Ch 6, with letters min 1/2" high.

- I. Install electric duct heater in strict accordance with manufacturer's instructions and NEC, FBC, and UL requirements

3.3 ADJUSTING

- A. Adjust duct accessories for proper settings.
- B. Adjust fire and smoke dampers for proper action.
- C. Final positioning of manual dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing."

ACCESS DOOR MATERIALS SCHEDULE

DUCT PRESSURE CLASS	DOOR SIZE INCHES	NUMBER OF HINGES	NUMBER OF LOCKS	METAL GAUGE		
				FRAME	DOOR	BACK
2 INCHES & LESS*	12X12	2	1-S	24	26	26
	16x20	2	2-S	22	24	26
	24X24	3	2-S	22	22	26
3 INCHES*	12X12	2	1-S	22	22	26
	16X20	2	1-S,1-T,1-B	20	20	26
	24X24	3	2-S,1-T,1-B	20	20	24
4 TO 10** INCHES	12X12	2	1-S,1-T,1-B	20	20	26
	16X20	3	2-S,1-T,1-B	20	18	24
	24X24	3	2-S,2-T,2-B	18	18	24

S: SIDE

T: TOP

B: BOTTOM

*NOTE: Ruskin M#ADH-24 or pre-approved equal.

**NOTE: Ruskin M#ADH-24HP or pre-approved equal.

END OF SECTION 23 33 00

SECTION 23 34 00 - EXHAUST FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Divisions 00 and 01 Specification Sections, apply to this Section.
- B. Requirements of Division 23 Sections apply to this section (including, but not limited to):
 - 1. Basic Mechanical Requirements
 - 2. Basic Materials and Methods

1.2 SUMMARY

- A. This Section includes the following types of air-handling units:
 - 1. Inline Centrifugal Fans
- B. Related Sections: The following sections contain requirements that relate to this section:
 - 1. Division 26 Section "Disconnects and Enclosed Circuit Breakers" for disconnect switches and motor starters.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.
- B. Product data for selected models, including specialties, accessories, and the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound power ratings.
 - 3. Motor ratings and electrical characteristics plus motor and fan accessories.
 - 4. Materials gages and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
- C. Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, required clearances, components, and location and size of field connections.
- D. Coordination drawings, in accordance with Division 23 Section "Basic Mechanical Requirements," for fan room layouts, and reflected ceiling plans drawn accurately to scale and coordinating penetrations and units mounted above ceiling. Show the following:
 - 1. Roof and wall framing and support members relative to duct penetrations.
 - 2. Ceiling suspension members.
 - 3. Method of attaching hangers to building structure.
 - 4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinkler heads, access panels, and special moldings.
- E. Wiring diagrams that detail power, signal, and control wiring. Differentiate between manufacturer-installed wiring and field-installed wiring.
- F. Product certificates, signed by manufacturers of air-handling units, certifying that their products comply with specified requirements.
- G. Maintenance data for air-handling units, for inclusion in Operating and Maintenance Manual specified in Division 01 and Division 23 Section "Basic Mechanical Requirements."

1.4 QUALITY ASSURANCE

- A. UL Compliance: Fans shall be designed, manufactured, and tested in accordance with UL 705 "Power Ventilators."
- B. UL Compliance: Fans and components shall be UL listed and labeled.
- C. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Fans and components shall be NRTL listed and labeled. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.
- D. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- E. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Lift and support units with the manufacturer's designated lifting or supporting points.
- B. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.
- C. Deliver fan units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

1.6 SEQUENCING AND SCHEDULING

- A. Coordinate the installation of equipment supports.
- B. Coordinate the size and location of structural steel support members.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include but are not limited to, the following:
 - 1. Centrifugal Roof Ventilators:
Cook (Loren) Co.
Greenheck Fan Corp.
Penn Ventilator Co.

2.2 SOURCE QUALITY CONTROL

- A. Testing Requirements: The following factory tests are required:
 - 1. Sound Power Level Ratings: Comply with AMCA Standard 301 "Method for Calculating Fan Sound Ratings From Laboratory Test Data." Test fans in accordance with AMCA Standard 300 "Test Code for Sound Rating." Fans shall be licensed to bear the AMCA Certified Sound Ratings Seal.
 - 2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210/ASHRAE Standard 51 - Laboratory Methods of Testing Fans for Rating.

2.3 FANS, GENERAL

- A. General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics.

- B. Fans: Statically and dynamically balanced per AMCA Standard 204-05 and designed for continuous operation at the maximum rated fan speed and motor horsepower. Wheel shall be centrifugal, backward inclined, constructed of 100% aluminum, with precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone.
- C. Motors: Motor shall be an electronically commutated motor (ECM) rated for continuous duty and furnished with leads. Motor leads shall connect to manufacturer provided 0-10VDC external speed controller. Coordinate with Control Vendor prior to Bid and provide interface for building controls (refer to Control Sequences and Schematics).
- D. Dampers: Provide with gravity backdraft dampers, either integral to fan outlet or installed in duct, downstream of fan.
- E. Factory Finish: The following finishes are required:
 - 1. Sheet Metal Parts: Prime coating prior to final assembly.
 - 2. Exterior Surfaces: Hot-dipped galvanized.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads, and other conditions affecting performance of fans.
- B. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install fans level and plumb, in accordance with manufacturer's written instructions. Support units as described below, using the vibration control devices indicated and/or shown.
 - 1. Suspended Units: Suspend units from structural steel support frame using threaded steel rods and vibration isolation springs.
 - 2. Arrange installation of units to provide access space around air- handling units for service and maintenance.

3.3 CONNECTIONS

- A. Duct installations and connections are specified in other Division 23 sections. Make final duct connections with flexible connections.
- B. Electrical Connections: The following requirements apply:
 - 1. Electrical power wiring is specified in Division 26.
 - 2. Temperature control wiring and interlock wiring are specified in "Integrated Automation".
 - 3. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Inspection: Arrange and pay for a factory- authorized service representative to perform the following:
 - 1. Inspect the field assembly of components and installation of fans including ductwork and electrical connections.
 - 2. Prepare a written report on findings and recommended corrective actions.

3.5 ADJUSTING, CLEANING, AND PROTECTING

- A. Adjust damper linkages for proper damper operation.
- B. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet.

3.6 COMMISSIONING

- A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:
 - 1. Remove shipping blocking and bracing.
 - 2. Verify unit is secure on mountings and supporting devices and that connection for piping, ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
 - 3. Perform cleaning and adjusting specified in this Section.
 - 4. Verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations.
 - 5. Lubricate bearings and other moving parts with factory-recommended lubricants.
 - 6. Verify manual and automatic volume control and that fire and smoke dampers in connected ductwork systems are in the full-open position.
 - 7. Disable automatic temperature control operators.
- B. Starting procedures for fans:
 - 1. Energize motor: verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.
 - 2. Measure and record motor electrical values for voltage and amperage.
- C. Shut unit down and reconnect automatic temperature control operators.
- D. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.

3.7 DEMONSTRATION

- A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner's maintenance personnel on the following:
 - 1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
 - 2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 01 Section "Project Closeout" and Division 23 Section "Basic Mechanical Requirements."
- B. Schedule training with at least 7 days advance notice.

END OF SECTION 23 34 00

SECTION 23 37 00 – AIR OUTLETS AND INLETS

PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

- A. Extent of air outlets and inlets work is indicated by drawings and schedules, and by requirements of this section.
- B. Types of air outlets and inlets required for project include the following:
 - 1. Ceiling air diffusers.
 - 2. Registers and grilles.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air outlets and inlets of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. ARI Compliance: Test and rate air outlets and inlets in accordance with ARI 650 "Standard for Air Outlets and Inlets."
 - 2. ASHRAE Compliance: Test and rate air outlets and inlets in accordance with ASHRAE 70 "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets."
 - 3. ADC Compliance: Test and rate air outlets and inlets in certified laboratories under requirements of ADC 1062 "Certification, Rating and Test Manual."
 - 4. ADC Seal: Provide air outlets and inlets bearing ADC Certified Rating Seal.
 - 5. AMCA Compliance: Test and rate louvers in accordance with AMCA 500 "Test Method for Louvers, Dampers and Shutters."
 - 6. AMCA Seal: Provide louvers bearing AMCA Certified Rating Seal.
 - 7. NFPA Compliance: Install air outlets and inlets in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems."
 - 8. Florida Product Approval

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for air outlets and inlets including the following:
 - 1. Schedule of air outlets and inlets indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.
 - 2. Data sheet for each type of air outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details.
 - 3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature, and velocity traverses, throw and drop, and noise criteria ratings. Indicate selections on data.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air outlet and inlet, indicating materials and methods of assembly of components.
- C. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 01.

1.4 PRODUCT DELIVERY, STORAGE & HANDLING

- A. Deliver air outlets and inlets wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.
- B. Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 – PRODUCTS

2.1 CEILING AIR DIFFUSERS

- A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity, and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.
- C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.
- D. Insulation: For lay-in ceiling installation, provide with manufacturer's factory insulation for diffuser backpan; strictly adhere to manufacturer's installation instructions. **Do not use FSK tape to secure diffuser to ceiling grid.** For hard ceiling installation, provide field applied insulation per 23 07 00.
- E. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on diffuser schedule.
- F. Manufacturer: Subject to compliance with requirements, provide diffusers of one of the following:
 - Anemostat Products Div.; Dynamics Corp. of America.
 - Carnes Co.; Div. of Wehr Corp.
 - Krueger Mfg. Co.
 - Metalaire
 - Price Industries
 - Titus Products Div., Philips Industries, Inc.
 - Tuttle & Bailey; Div. of Interpace Corp.

2.2 REGISTERS AND GRILLES

- A. General: Except as otherwise indicated, provide manufacturer's standard registers and grilles where shown; of size, shape, capacity, and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- B. Performance: Provide registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.
- C. Ceiling, Wall and Duct Compatibility: Provide duct grilles with border styles that are compatible with adjacent ceiling, wall and duct systems and that are specifically manufactured to fit into ceiling, wall and duct construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall and duct construction which will contain each type of register and grille.

- D. Types: Provide ceiling or wall registers and grilles of type, capacity, and with accessories and finishes as listed on the schedule.
- E. Manufacturer: Subject to compliance with requirements, provide registers and grilles of one of the following:

Anemostat Products Div.,; Dynamics Corp. of America.
Carnes Co.; Div. of Wehr Corp.
Krueger Manufacturing Company
Price
Metalaire
Titus Products Div.; Philips Industries, Inc.
Tuttle and Bailey

PART 3 – EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which air outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and in accordance with recognized industry practices to ensure that products serve intended functions.
- B. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air outlets and inlets with other work.
- C. Locate and support ceiling air diffusers, registers, and grilles, as indicated on general construction "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling modules and support independently from ceiling.
- D. Do not use FSK tape to secure diffusers to ceiling grid.

3.3 SPARE PARTS

- A. Furnish to Owner, with receipt, three (3) operating keys for each type of air outlet and inlet that require them.

END OF SECTION 23 37 00

SECTION 23 81 28 - MINI-SPLIT AIR CONDITIONERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Furnish all labor, materials, equipment, tools and services required to fully complete all Split-System Air-Conditioner work as is indicated on the drawings and/or specified herein including, but not limited to, the following described items.
 - 1. Mini-Split air-conditioning units consisting of separate evaporator-fan and compressor condenser components. Units are designed for exposed mounting.

1.2 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated, including but not limited to, refrigerant detector. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and Maintenance Data: For mini-split air-conditioning units to include in emergency, operation, and maintenance manuals.
- D. Warranty: Special warranty specified in this Section.

1.3 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- D. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- E. Units shall be designed and installed to operate with refrigerants in compliance with current ASHRAE Standards 15 & 34. Provide labeling and safety detection in accordance with these standards. See additional requirements in this Section.
- F. 2023 Florida Building Code (8th Edition).

1.4 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of Mini-split air-conditioning units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years Parts & Labor from date of Substantial Completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or pre-approved equal:
1. Mitsubishi
 2. Carrier
 3. York: A Johnson Controls Company

2.2 WALL-MOUNTING, EVAPORATOR-FAN COMPONENTS

- A. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
- B. Unit Cabinet: Cabinet discharge and inlet grilles shall be attractively styled, high-impact polystyrene. Cabinet shall be fully insulated for improved thermal and acoustic performance.
- C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve. A drip pan under the coil shall have a drain connection for hose attachment to remove condensate. Condensate pan shall have internal trap and auxiliary drip pan under coil header.
- D. Fan: Direct drive, centrifugal fan. Air sweep operation shall be user selectable. Horizontal direction may be manually adjusted (using remote controller) and vertical air sweep may be manually set.
- E. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
1. Special Motor Features: Multi-tapped, multispeed with internal thermal protection and permanent lubrication.
- F. Filters: Permanent, cleanable.
- G. Controls: Controls shall consist of a microprocessor-based control system which shall control space temperature, determine optimum fan speed, and run self-diagnostics. The control system shall be BACnet IP compatible. Provide all interface hardware and software required for BACnet IP integration to the BMS. The temperature control range shall be from 64 deg F to 84 deg F. The unit shall have the following functions as a minimum:
1. An automatic restart after power failure at the same operating conditions as at failure.
 2. A timer function to provide a minimum 24-hour timer cycle for system Auto Start/Stop.
 3. Temperature-sensing controls shall sense return-air temperature. Indoor-air high discharge temperature shutdown shall be provided.
 4. Indoor coil freeze protection.
 5. Wireless infrared remote control to enter set points and operating conditions.
 6. Auto Stop features shall have integral setback control.
 7. Automatic air sweep control to provide on or off activation of air sweep louvers.
 8. Dehumidification mode shall provide increased latent removal capability by modulating system operation and set point temperature.
 9. Fan-only operation to provide room air circulation when no cooling is required.
 10. Diagnostics shall provide continuous checks of unit operation and warn of possible malfunctions. Error messages shall be displayed at the unit and at the remote controller.
 11. An indoor to outdoor thermistor connection cable shall be provided with the fan coil unit.

12. Fan speed control shall be user-selectable: high, medium, low, or microprocessor automatic operation during all operating modes.
13. A time delay shall prevent compressor restart in less than 3 minutes.
14. Automatic heating-to-cooling changeover to provide automatic heating and cooling operation. Control shall include deadband to prevent rapid mode cycling.
15. Demand defrost shall be provided and shall minimize defrost cycles by internally adjusting defrost timing based on frost accumulation.

2.3 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

- A. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
- B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 1. Compressor Type: Reciprocating or Scroll.
 2. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 3. Refrigerant Charge: A2L refrigerant, including but not limited to R-454b.
- C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid sub-cooler.
- D. Fan: Aluminum-propeller type, directly connected to motor.
- E. Motor: Permanently lubricated, with integral thermal-overload protection.
- F. Low Ambient Kit: Permits operation down to 0 deg F.
- G. Mounting Base: Polyethylene.
- H. Outdoor Coil: Coil shall be constructed of aluminum fins mechanically bonded to internally enhanced, seamless copper tubes which are cleaned, dehydrated, and sealed.
- I. Outdoor compartment shall be isolated and have an acoustic lining to assure quiet operation.
- J. Refrigeration Components: Refrigerant circuit components shall include brass external liquid line service valve with service gage port connections, suction line service valve with service gage connection port, service gage port connections on compressor suction and discharge lines with Schrader-type fittings with brass caps, accumulator, and bi-flow filter drier.
- K. Controls and Safeties: Operating controls and safeties shall be factory selected, assembled, and tested. The minimum control functions shall include the following:
 1. Controls:
 - a. Time delay restart to prevent compressor reverse rotation on single phase scroll compressors.
 - b. Automatic restart on power failure restoration.
 - c. Safety lockout if any outdoor unit safety is open.
 - d. A time delay control sequence is also provided standard through the fan coil board, thermostat, or controller.
 - e. High-pressure and liquid line low-pressure switches.
 - f. Automatic outdoor-fan motor protection.

- g. Start capacitor and relay (single-phase units without scroll compressors).
- 2. Safeties:
 - a. System diagnostics.
 - b. Compressor motor current and temperature overload protection.
 - c. High pressure relief.
 - d. Outdoor fan failure protection.

L. Electrical Requirements:

- 1. Unit electrical power shall be a single point connection.
- 2. Unit control voltage to the indoor-fan coil shall be 24v.
- 3. All power and control wiring must be installed per NEC and all local building codes.
- 4. Unit shall have high-and low-voltage terminal block connections.

2.4 ACCESSORIES

- A. Programmable Thermostat: Low voltage with sub-base to control compressor and evaporator fan.
- B. Automatic-reset timer to prevent rapid cycling of compressor.
- C. Refrigerant Piping: Refer to Division 23 Refrigerant Piping.
- D. Provide Condensate pump.
- E. BACnet IP controller.
- F. Stop Valves: For systems containing more than 6.6 lbs of refrigerant shall have stop valves installed at:

The Suction inlet of each compressor, compressor unit or condensing unit;
The Discharge of each compressor, compressor unit or condensing unit; and
The Outlet of each liquid receiver.

~~Refrigerant Detector: For Mini Split Units, provide a refrigerant detector equal to Danfoss DST G-Series A2L Refrigerant Detector with UL 60335-2-40 & UL 60335-2-89 Approvals & Certification. Note: coordinate with control subcontractor for integration requirements with the Building Management System prior to purchasing refrigerant detector. Refrigerant Detection systems shall include "self-test".~~

~~(Note: As far as the ASHRAE Standard 15 is concerned, the installed systems should be considered: Non-ducted (mini split systems), occupancy type as per application and high probability systems with A2L Refrigerants. Also, a machinery room is not required due to not exceeding refrigerant quantity limit.)~~

~~(Note: Unless the system exceeds a certain refrigerant quantity for the space it serves, a refrigerant detector may not be required by Code (although it is included in these design documents). For example, if the refrigerant quantities are less than prescribed by ASHRAE 15, a detector may not be required. With that said, the following calculation must also be utilized to make final determination on the Code requirement for a Refrigerant Detector:~~

~~"For commercial public assembly, and larger mercantile occupancies, when the refrigerant charge is of any independent circuit exceeds $0.212 \times LFL$ (lb.) where LFL is in pounds per 1000 cubic feet, unless the concentration of refrigerant in a complete discharge from any independent circuit will not exceed 50% of the RCL.")~~

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install referenced tubing to allow access to unit.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to unit to allow service and maintenance.
- C. Ground equipment according to Division 26 Section "Grounding."
- D. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

3.4 REFRIGERANT SYSTEMS

~~Refrigerant Detector: On detection of refrigerant concentration exceeding 25% of Lower Flammability Limit (LFL), the system shall within 15 seconds of detection:~~

~~Turn on Supply Fan~~

~~Turn off Compressor and all other electrical devices, excluding control power transformers, control system and supply fan~~

~~Exhaust fans shall be "on"~~

~~De-energize any flame producing equipment.~~

~~The System shall continue to operate in alarm mode for at least 5 minutes after the refrigerant detector has sensed a drop in refrigerant concentration below 25% LFL.~~

~~Refrigerant Detection System shall be witnessed and tested prior to Substantial Completion.~~

~~Refrigerant detector shall be located:~~

~~Non-Ducted Systems: Locate the detector within the equipment or a location within 12" of the floor and within a horizontal distance of not more than 3.3 feet with a direct line of site of the unit.~~

- A. Refrigerant Piping shall be installed a minimum of 7.25 feet above finished floor (unless the piping is installed against the ceiling and is allowed by the AHJ).
- B. Labeling:
 - 1. Label AHU & Condenser Section: I.D. Refrigerant Type and include label: "Warning – Risk of Fire. Flammable Refrigerant".
 - 2. Label Refrigerant Piping: Every 20 feet, include the following label: "Warning – Risk of Fire. Flammable Refrigerant".
- C. Installation Identification: Each Refrigerant System erected on the premises shall be provided with a legible permanent sign, securely attached and easily accessible indicating:
 - 1. The Name and Address of the Installer
 - 2. The Refrigerant number and amount of refrigerant
 - 3. The Lubricant identity and amount, and
 - 4. The field test pressure applied.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 81 28

SECTION 23 81 46 – HORIZONTAL PACKAGED WATER-COOLED HEAT PUMP UNITS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.
- B. Division 23, Basic Mechanical Materials and Methods sections apply to work of this section.
- C. Refer to Drawings for Control requirements.

1.2 SUMMARY

- A. This specification includes water-cooled heat pump units, as described herein.
- B. Indoor horizontal, water-cooled, Variable Speed ECM Fan, Building Management System (BMS) controlled cooling and heating packaged unit utilizing two-stage compressor(s). Unit shall be equipped with hot gas reheat and duct mounted electric resistance reheat. Unit shall supply air through ductwork as shown on the contract drawings.

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, dimensions, required clearances, weights, furnished specialties and accessories; and installation and start-up instructions.
- B. Shop Drawings: Submit shop drawings detailing the manufacturer's electrical requirements for power supply wiring for packaged units and auxiliary heating circuits. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- C. Operation and Maintenance Data: Submit maintenance data and parts list for each packaged water-cooled heat pump units, including "trouble-shooting" maintenance guide, servicing guide and preventative maintenance schedule and procedures. Include this data in maintenance manual.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of packaged water-cooled heat pump units, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards: Testing and rating of packaged water-cooled heat pump units of 135,000 BTU/hr capacity or over shall be in accordance with ARI 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment."
- C. Testing and rating of packaged water-cooled heat pump units under 135,000 BTU/hr capacity shall be in accordance with ARI 210 "Standard for Unitary Air-Conditioning Equipment," and provide Certified Rating Seal. Units shall bear Certified Rating Seal.
- D. Refrigerating system construction of packaged water-cooled heat pump units shall be in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration."
- E. Energy Efficiency Ratio (EER) of packaged water-cooled heat pump units shall be equal to or greater than prescribed by ASHRAE 90.1 "Energy Efficient Design of New Buildings Except Low rise Residential Buildings" and as scheduled.
- F. Packaged water-cooled heat pump units shall be listed by UL and have UL label as a unit.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Handle packaged water-cooled heat pump units and components carefully to prevent damage. Replace damaged packaged water-cooled heat pump units or components with new.
- B. Store packaged water-cooled heat pump units and components in clean dry place, off the ground, and protect from weather, water, and physical damage.
- C. Rig packaged water-cooled heat pump units to comply with manufacturer's rigging and installation instructions for unloading packaged water-cooled heat pump units, and moving them to final location.

1.6 SPECIAL WARRANTY

- A. Provide written parts warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, compressors, heat exchangers, refrigeration circuit, refrigerant, control boards, and electronic components with inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period.
- B. Warranty Period: Parts warranty shall extend 5 years from the date of substantial completion.

1.7 MAINTENANCE

- A. Extra Materials: Furnish to Owner, with receipt, the following spare parts for each packaged water-cooled heat pump unit:
 - 1. One set filters for each unit.

PART 2 – PRODUCTS

2.1 PACKAGED WATER-COOLED HEAT PUMP UNITS

- A. Manufacturers: Subject to compliance with requirements, provide packaged water-cooled heat pump, manufactured by one of the following, or pre-approved equal.
 - Carrier
 - ClimateMaster
 - Florida Heat Pump (Bosch)

2.2 EQUIPMENT

General Unit Description:

- A. Equipment shall be reverse cycle heating and cooling type and have an operating range between 25 and 120 degrees entering water temperature. The unit shall be factory assembled, piped, internally wired, fully charged with R-454B refrigerant and oil and test operated at the factory in both cooling and heating mode.
- B. Products shall be designed, rated, and certified in accordance with ETL, CETL, and ISO-AHRI 13256-1. Units shall meet the efficiency standards of the 2023 Florida Building Code – Energy Conservation.
- C. Unit(s) shall consist of heavy gauge, galvanized steel casing with compressor, water-to-refrigerant heat exchanger, air-to-refrigerant heat exchanger, thermal expansion valve, reversing valve, return-air filter, supply air fan motor unit controls.

Cabinet:

- A. Provide unit factory assembled and pre-wired consisting of heavy gage galvanized steel cabinet. Air handling sections shall be lined with ½" thick, 1.5# density cleanable foil faced glass fiber insulation. Compressor compartments shall be lined with ½" thick, 1.5# density sound absorbing glass fiber insulation. The insulation shall be UL listed and meet NFPA-90A and UL 181 Standards.
- B. 1" Discharge duct collar and return air duct collar. Units shall accommodate 2" filters.
- C. Units shall be of Horizontal configuration with the following airflow arrangements:
 - 1. Right inlet/Straight discharge. (Refer to drawings. Field verify fit for final configuration requirements.)
- D. Units shall have the ability to be field convertible from straight to back with no additional parts or modifications.
- E. Units shall have factory installed hanger brackets with EPDM isolation grommets.
- F. Access for inspection and cleaning of the unit drain pan, coils, and fan section shall be provided.

Refrigeration System:

- A. Air-to-Refrigerant Coil: The air-to-refrigerant coil shall consist of copper tubes mechanically bonded into evenly spaced aluminum fins. All coils shall be leak tested to 625 psig and pressure tested to 625 psig at the factory to ensure the pressure integrity. The tubes shall be completely evacuated of air and correctly charged with proper volume of refrigerant prior to shipment. The refrigerant coil distributor assembly shall be of orifice style with round copper distributor tubes. The tubes shall be sized consistently with the capacity of the coil. Suction headers shall be fabricated from rounded copper pipe.

Compressor:

- A. The two-stage scroll compressor(s) shall be internally sprung. The compressor(s) shall have a dual level vibration isolation system. The compressor(s) shall be mounted on EPDM vibration isolation grommets to heavy gauge compressor mounting plate, which is isolated from the cabinet base with EPDM grommets for vibration attenuation. Units shall include a discharge muffler for sound attenuation. Compressor(s) shall have thermal overload protection. Compressor(s) shall be located in an insulated compartment away from air stream to minimize sound transmission.

Refrigerant Circuit:

- A. Within the refrigerant circuit, access ports shall be factory supplied on the high and low pressure sides for refrigerant pressure or temperature testing. A filter drier shall be provided and factory-installed within the refrigeration circuit. Protection against excessive discharge pressure shall be provided by means of a high pressure switch. Protection against a loss of charge shall be provided by low pressure safety switch.
- B. The refrigerant tubing shall be 99% pure copper. This system shall be clean and free from contaminants and conditions such as drilling fragments, dirt, and oil. Provide with extended range insulation; suction side refrigerant piping and water lines internal to the unit shall be insulated with an closed cell insulation.

Refrigerant Metering:

- A. A bi-directional thermal expansion valve (TXV) shall be provided as standard. Capillary tubes are not allowed.

Reversing Valve:

- A. Units shall come standard with a reversing valve for heating and cooling operation. The reversing valve shall be a four-way solenoid-activated refrigerant valve.

Hot Gas Reheat:

- A. Unit shall include modulating hot gas reheat. Control of re-heat shall be accomplished by space mounted humidistat.

Electric Reheat:

- A. Duct mounted electric resistance re-heat shall be shipped loose, as scheduled. Electric reheat coils shall have integral hinged control cabinet with knockouts for power and control conduit connections. Control cabinet shall house primary and secondary limit protection, terminal connections, SCR controller for modulating electric heat, fan relay control, circuit fuses, etc. Assembly shall be UL and CSL listed.

Water-to-Refrigerant Heat Exchanger:

- A. Cupro-Nickel Heat Exchanger: The water-to-refrigerant heat exchanger shall be a high quality co-axial coil for maximum heat transfer. The cupro-nickel coil is deeply fluted to enhance heat transfer and minimize fouling and scaling. The coil has a working pressure of 400 psig on the water side and 660 psig on the refrigerant side.

Refrigerant Detection System:

- A. The refrigerant detection system shall consist of the control module and sensors within the cabinet of the unit. In the event of a refrigerant leak, the control module will disable compressor operation, and continue to run the unit blower to disperse and concentration of leaked refrigerant in compliance with UL 60335-2-40 and UL 60335-2-89 safety standards for mildly flammable refrigerants.
- B. Note: coordinate with control subcontractor for integration requirements with the Building Management System (BMS) prior to purchasing refrigerant detector. Refrigerant Detection systems shall include "self-test".

Electrical:

- A. Unit shall have integral non-fused disconnect switch. All electrical wiring shall enter the unit cabinet at a single location.
- B. The unit control box shall contain all necessary devices to allow heating and cooling operation to occur from a remote mounted BMS zone sensor. These devices shall include, but not limited to:
 - 1. 75 VA transformer
 - 2. 24V compressor contactor
 - 3. A low voltage terminal strip is located inside the control panel behind the service access panel. This terminal strip may be used for low voltage (zone sensor / humidity sensor) connections.

Controls:

- A. Unit controls shall be factory-wired, factory tested, and factory-commissioned. Each WSHP unit shall be controlled by a direct digital controller with WSHP control logic for standalone control or BMS integration via a Multi-protocol interface board with field selectable protocol. Selectable protocols shall include at a minimum: BACnet MS/TP and BACnet IP protocols. Control of the two-speed compressor and variable speed supply air fan motor shall be provided by the unit controller or BMS to optimize energy efficiency and comfort.

- B. The controller shall have the ability to control to setpoints: occupied, occupied standby, occupied bypass, and unoccupied. It shall control multiple units via one humidistat. It shall also provide as a minimum anti-short cycle compressor protection, random start delay, filter maintenance timer, timed override, relay to external damper, isolation valve control, condensate overflow protection, high and low pressure protection, diagnostics, test mode for troubleshooting, dehumidification mode, two-stage compressor control, EC fan control, Hot gas re-heat control, and duct mounted electric re-heat control.
- C. Prior to ordering, coordinate with Siemens for BMS requirements. Include costs for all required control interface cards, hardware, software, control modules, wiring, etc. for a fully operational system.

Supply Air Blower and Motor Assembly:

- A. Blowers shall have inlet rings to allow removal of wheel and motor from one side without removing housing. Units shall have a direct drive centrifugal fan. The fan motor shall be an EC variable speed ball bearing type motor. The EC blower motor shall provide soft-starting functionality, maintain constant CFM over its static operating range, and provide airflow adjustment in 25 CFM increments via its control board. The fan motor shall be isolated from the housing by rubber grommets. The motor shall be permanently lubricated and have thermal overload protection.
- B. Dehumidification mode shall be provided to allow lower airflow in cooling mode for dehumidification. The dehumidification mode may be constant or automatic (humidistat controlled). Airflow/Static pressure rating of the unit shall be based on a wet coil and a clean filter in place.

Drain Pan:

- A. The drain pan shall be constructed of corrosion resistant material and insulated to prevent sweating. Acceptable materials include 304 Stainless Steel. The drain pan shall be fully insulated. The bottom of the drain pan shall be sloped pitch the condensate toward the drain connection to ensure complete condensate drainage when unit is installed level and trapped per manufacturer's installation instructions. The drain pan shall comply with ASHRAE 62 for IAQ conformity. A float switch shall be factory installed on all units as standard.

Filters:

- A. Factory installed filters shall be 2" MERV 8.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which packaged water-cooled heat pump units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION

- A. General: Install packaged water-cooled heat pump units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances. Provide Secondary drain pan.
- B. Electrical Connections: Refer to Division 26 - Electrical Connections for Equipment for final connections to equipment and installation of loose shipped electrical components.
- C. Water Piping: Provide piping as indicated on the drawings. Pipe relief valve outlet to floor drain.

3.3 FACTORY START-UP

- A. Factory start WSHP units and submit reports to Engineer. Coordinate with Controls Contractor and T&B Contractor for initial and final set-up.

3.4 DEMONSTRATION

Operating and Maintenance Training:

- A. Instruct Owner's personnel in operation and maintenance of packaged water-cooled heat pump units. Training shall include start-up and shut-down, servicing and preventative maintenance schedule and procedures, and troubleshooting procedures plus procedures for obtaining repair parts and technical assistance. Review operating and maintenance data contained in the Operating and Maintenance Manuals.
- B. Schedule training with Owner, provide at least 7-day prior notice to the Architect/Engineer.

END OF SECTION 23 81 46

SECTION 23 81 46.01 – VERTICAL PACKAGED WATER-COOLED HEAT PUMP UNITS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.
- B. Division 23, Basic Mechanical Materials and Methods sections apply to work of this section.
- C. Refer to Drawings for Control requirements.

1.2 SUMMARY

- A. This specification includes water-cooled heat pump units, as described herein.
- B. Indoor vertical, water-cooled, Belt driven inverter duty fan motor with VFD, Building Management System (BMS) controlled cooling and heating packaged unit. Unit shall be equipped with duct mounted SCR electric resistance reheat (as scheduled). Unit shall supply air through ductwork as shown on the contract drawings.

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, dimensions, required clearances, weights, furnished specialties and accessories; and installation and start-up instructions.
- B. Shop Drawings: Submit shop drawings detailing the manufacturer's electrical requirements for power supply wiring for packaged units and auxiliary heating circuits. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- C. Operation and Maintenance Data: Submit maintenance data and parts list for each packaged water-cooled heat pump units, including "trouble-shooting" maintenance guide, servicing guide and preventative maintenance schedule and procedures. Include this data in maintenance manual.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of packaged water-cooled heat pump units, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards: Testing and rating of packaged water-cooled heat pump units of 135,000 BTU/hr capacity or over shall be in accordance with ARI 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment."
- C. Testing and rating of packaged water-cooled heat pump units under 135,000 BTU/hr capacity shall be in accordance with ARI 210 "Standard for Unitary Air-Conditioning Equipment," and provide Certified Rating Seal. Units shall bear Certified Rating Seal.
- D. Refrigerating system construction of packaged water-cooled heat pump units shall be in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration."
- E. Energy Efficiency Ratio (EER) of packaged water-cooled heat pump units shall be equal to or greater than prescribed by ASHRAE 90.1 "Energy Efficient Design of New Buildings Except Low rise Residential Buildings" and as scheduled.
- F. Packaged water-cooled heat pump units shall be listed by UL and have UL label as a unit.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Handle packaged water-cooled heat pump units and components carefully to prevent damage. Replace damaged packaged water-cooled heat pump units or components with new.
- B. Store packaged water-cooled heat pump units and components in clean dry place, off the ground, and protect from weather, water, and physical damage.
- C. Rig packaged water-cooled heat pump units to comply with manufacturer's rigging and installation instructions for unloading packaged water-cooled heat pump units, and moving them to final location.

1.6 SPECIAL WARRANTY

- A. Provide written parts warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, compressors, heat exchangers, refrigeration circuit, refrigerant, control boards, and electronic components with inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period.
- B. Warranty Period: Parts warranty shall extend 5 years from the date of substantial completion.

1.7 MAINTENANCE

- A. Extra Materials: Furnish to Owner, with receipt, the following spare parts for each packaged water-cooled heat pump unit:
 - 1. One set of filters for each unit.
 - 2. One set of belts for each.

PART 2 – PRODUCTS

2.1 PACKAGED WATER-COOLED HEAT PUMP UNITS

- A. Manufacturers: Subject to compliance with requirements, provide packaged water-cooled heat pump, manufactured by one of the following, or pre-approved equal.

Carrier
ClimateMaster
Florida Heat Pump (Bosch)

2.2 EQUIPMENT

General Unit Description:

- A. Equipment shall be reverse cycle heating and cooling type and have an operating range between 25 and 120 degrees entering water temperature. The unit shall be factory assembled, piped, internally wired, fully charged with R-454B refrigerant and oil and test operated at the factory in both cooling and heating mode.
- B. Products shall be designed, rated, and certified in accordance with ETL, CETL, and ISO-AHRI 13256-1. Units shall meet the efficiency standards of the 2023 Florida Building Code – Energy Conservation.
- C. Unit(s) shall consist of heavy gauge, galvanized steel casing with compressor, water-to-refrigerant heat exchanger, air-to-refrigerant heat exchanger, thermal expansion valve, reversing valve, return-air filter, supply air fan motor unit controls.

Cabinet:

- A. Provide unit factory assembled and pre-wired consisting of heavy gage galvanized steel cabinet. Air handling sections shall be lined with ½" thick, 1.5# density cleanable foil faced glass fiber insulation. Compressor compartments shall be lined with ½" thick, 1.5# density sound absorbing glass fiber insulation. The insulation shall be UL listed and meet NFPA-90A and UL 181 Standards.
- B. 1" Discharge duct collar and return air duct collar. Units shall accommodate 2" filters.
- C. Units shall be of Vertical configuration with the following airflow arrangements:
 - 1. Front inlet/Top discharge. (Refer to drawings. Field verify fit for final configuration requirements.)
- D. Units shall fit through a standard door opening. Field Verify fit prior to ordering. Break unit down and reassemble in mechanical room as required for installation.
- E. Provide base rails and housekeeping pad high enough for full condensate trap and slope to drain.
- F. Access for inspection and cleaning of the unit drain pan, coils, and fan section shall be provided.

Refrigeration System:

- A. Air-to-Refrigerant Coil: The air-to-refrigerant coil shall consist of copper tubes mechanically bonded into evenly spaced aluminum fins. All coils shall be leak tested to 625 psig and pressure tested to 625 psig at the factory to ensure the pressure integrity. The tubes shall be completely evacuated of air and correctly charged with proper volume of refrigerant prior to shipment. The refrigerant coil distributor assembly shall be of orifice style with round copper distributor tubes. The tubes shall be sized consistently with the capacity of the coil. Suction headers shall be fabricated from rounded copper pipe.

Compressor(s):

- A. The unit shall be equipped with a dual refrigeration circuit. The unit shall cycle compressors in a lead/lag sequence to respond to space capacity demand. The scroll compressor(s) shall be internally sprung. The compressor(s) shall have a dual level vibration isolation system. The compressor(s) shall be mounted on EPDM vibration isolation grommets to heavy gauge compressor mounting plate, which is isolated from the cabinet base with EPDM grommets for vibration attenuation. Units shall include a discharge muffler for sound attenuation. Compressor(s) shall have thermal overload protection. Compressor(s) shall be located in an insulated compartment away from air stream to minimize sound transmission.

Refrigerant Circuit:

- A. Within the refrigerant circuit, access ports shall be factory supplied on the high and low pressure sides for refrigerant pressure or temperature testing. A filter drier shall be provided and factory-installed within the refrigeration circuit. Protection against excessive discharge pressure shall be provided by means of a high pressure switch. Protection against a loss of charge shall be provided by low pressure safety switch.
- B. The refrigerant tubing shall be 99% pure copper. This system shall be clean and free from contaminants and conditions such as drilling fragments, dirt, and oil. Provide with extended range insulation; suction side refrigerant piping and water lines internal to the unit shall be insulated with closed cell insulation.

Refrigerant Metering:

- A. A bi-directional thermal expansion valve (TXV) shall be provided as standard. Capillary tubes are not allowed.

Reversing Valve:

- A. Units shall come standard with a reversing valve for heating and cooling operation. The reversing valve shall be a four-way solenoid-activated refrigerant valve.

Electric Reheat:

- A. Duct mounted electric resistance re-heat shall be shipped loose, as scheduled. Electric reheat coils shall have integral hinged control cabinet with knockouts for power and control conduit connections. Control cabinet shall house primary and secondary limit protection, terminal connections, SCR controller for modulating electric heat, fan relay control, circuit fuses, etc. Assembly shall be UL and CSL listed.

Water-to-Refrigerant Heat Exchanger:

- A. Cupro-Nickel Heat Exchanger: The water-to-refrigerant heat exchanger shall be a high quality co-axial coil for maximum heat transfer. The cupro-nickel coil is deeply fluted to enhance heat transfer and minimize fouling and scaling. The coil has a working pressure of 400 psig on the water side and 660 psig on the refrigerant side.

Refrigerant Detection System:

- A. The refrigerant detection system shall consist of the control module and sensors within the cabinet of the unit. In the event of a refrigerant leak, the control module will disable compressor operation, and continue to run the unit blower to disperse and concentration of leaked refrigerant in compliance with UL 60335-2-40 and UL 60335-2-89 safety standards for mildly flammable refrigerants.
- B. Note: coordinate with control subcontractor for integration requirements with the Building Management System (BMS) prior to purchasing refrigerant detector. Refrigerant Detection systems shall include "self-test".

Electrical:

- A. Unit shall have integral non-fused disconnect switch. All electrical wiring shall enter the unit cabinet at a single location.
- B. The unit control box shall contain all necessary devices to allow heating and cooling operation to occur from a remote mounted BMS zone sensor. These devices shall include, but not limited to:
 - 1. 100 VA transformer
 - 2. 24V compressor contactor
 - 3. A low voltage terminal strip is located inside the control panel behind the service access panel. This terminal strip may be used for low voltage (zone sensor / humidity sensor) connections.

Controls:

- A. Unit controls shall be factory-wired, factory tested, and factory-commissioned. Each WSHP unit shall be controlled by a direct digital controller with WSHP control logic for standalone control or BMS integration via a Multi-protocol interface board with field selectable protocol. Selectable protocols shall include at a minimum: BACnet protocol. Control of the compressor and variable speed supply air fan motor shall be provided by the unit controller or BMS to optimize energy efficiency and comfort.
- B. The controller shall have the ability to control to setpoints: occupied, occupied standby, occupied bypass, and unoccupied. It shall also provide as a minimum anti-short cycle compressor protection, random start delay, filter maintenance timer, timed override, relay to external damper, isolation valve control, condensate overflow protection, high and low pressure protection,

diagnostics, test mode for troubleshooting, dehumidification mode, compressor control, VFD fan control, and duct mounted electric re-heat control.

- C. Prior to ordering, coordinate with Siemens for BMS requirements. Include costs for all required control interface cards, hardware, software, control modules, wiring, etc. for a fully operational system.

Supply Air Blower and Motor Assembly:

- A. Blowers shall have inlet rings to allow removal of wheel and motor from one side without removing housing. Units shall have a belt drive centrifugal fan. The fan motor shall be an inverter duty variable speed type motor. The variable speed blower motor shall provide soft-starting functionality. The fan motor shall be isolated from the housing by rubber grommets. The motor shall be permanently lubricated and have thermal overload protection.

Drain Pan:

- A. The drain pan shall be constructed of corrosion resistant material and insulated to prevent sweating. Acceptable materials include 304 Stainless Steel. The drain pan shall be fully insulated. The bottom of the drain pan shall be sloped pitch the condensate toward the drain connection to ensure complete condensate drainage when unit is installed level and trapped per manufacturer's installation instructions. The drain pan shall comply with ASHRAE 62 for IAQ conformity. A float switch shall be factory installed on all units as standard.

Filters:

- A. Factory installed filters shall be 2" MERV 13.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which packaged water-cooled heat pump units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION

- A. General: Install packaged water-cooled heat pump units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances. Provide Secondary drain pan.
- B. Electrical Connections: Refer to Division 26 - Electrical Connections for Equipment for final connections to equipment and installation of loose shipped electrical components.
- C. Water Piping: Provide piping as indicated on the drawings. Pipe relief valve outlet to floor drain.

3.3 FACTORY START-UP

- A. Factory start WSHP units and submit reports to Engineer. Coordinate with Controls Contractor and T&B Contractor for initial and final set-up.

3.4 DEMONSTRATION

Operating and Maintenance Training:

- A. Instruct Owner's personnel in operation and maintenance of packaged water-cooled heat pump units. Training shall include start-up and shut-down, servicing and preventative maintenance schedule and procedures, and troubleshooting procedures plus procedures for obtaining repair

parts and technical assistance. Review operating and maintenance data contained in the Operating and Maintenance Manuals.

- B. Schedule training with Owner, provide at least 7-day prior notice to the Architect/Engineer.

END OF SECTION 23 81 46.01

SECTION 23 81 46.02 – MODULAR PACKAGED WATER-COOLED HEAT PUMP UNITS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.
- B. Division 23, Basic Mechanical Materials and Methods sections apply to work of this section.
- C. Refer to Drawings for Control requirements.

1.2 SUMMARY

- A. This specification includes modular water-cooled heat pump units, as described herein.
- B. Indoor modular, water-cooled, Variable Speed ECM Fan, Building Management System (BMS) controlled cooling and heating packaged unit utilizing variable capacity compressor(s). Unit shall be equipped with hot gas reheat. Unit shall interface with existing duct mounted SCR electric resistance reheat. Unit shall supply air through ductwork as shown on the contract drawings. Unit shall be broken into modular sections for installation through a standard 36" door opening, and assembled inside the Mechanical Room.

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, dimensions, required clearances, weights, furnished specialties and accessories; and installation and start-up instructions.
- B. Shop Drawings: Submit shop drawings detailing the manufacturer's electrical requirements for power supply wiring for modular units and auxiliary heating circuits. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- C. Operation and Maintenance Data: Submit maintenance data and parts list for each packaged water-cooled heat pump units, including "trouble-shooting" maintenance guide, servicing guide and preventative maintenance schedule and procedures. Include this data in maintenance manual.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of packaged water-cooled heat pump units, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards: Testing and rating of packaged water-cooled heat pump units of 135,000 BTU/hr capacity or over shall be in accordance with ARI 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment."
- C. Refrigerating system construction of packaged water-cooled heat pump units shall be in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration."
- D. Energy Efficiency Ratio (EER) of packaged water-cooled heat pump units shall be equal to or greater than prescribed by ASHRAE 90.1 "Energy Efficient Design of New Buildings Except Low rise Residential Buildings" and as scheduled.
- E. Modular water-cooled heat pump units shall be listed by UL and have UL label as a unit.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Handle packaged water-cooled heat pump units and components carefully to prevent damage. Replace damaged packaged water-cooled heat pump units or components with new.
- B. Store packaged water-cooled heat pump units and components in clean dry place, off the ground, and protect from weather, water, and physical damage.
- C. Rig packaged water-cooled heat pump units to comply with manufacturer's rigging and installation instructions for unloading packaged water-cooled heat pump units, and moving them to final location.

1.6 SPECIAL WARRANTY

- A. Provide written parts warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, compressors, heat exchangers, refrigeration circuit, refrigerant, control boards, and electronic components with inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period.
- B. Warranty Period: Parts and Labor warranty shall extend 5 years from the date of substantial completion.

1.7 MAINTENANCE

- A. Extra Materials: Furnish to Owner, with receipt, the following spare parts for each packaged water-cooled heat pump unit:
 - 1. One set filters for each unit.

PART 2 – PRODUCTS

2.1 MODULAR WATER-COOLED HEAT PUMP UNITS

- A. Manufacturers: Subject to compliance with requirements, provide packaged water-cooled heat pump, manufactured by one of the following, or pre-approved equal.
 - Addison
 - Carrier
 - Desert Aire

2.2 EQUIPMENT

General Unit Description:

- A. Equipment shall be reverse cycle heating and cooling type and have an operating range between 25 and 120 degrees entering water temperature. The unit shall be factory assembled, piped, internally wired, fully charged with R-454B refrigerant and oil and test operated at the factory in both cooling and heating mode.
- B. Products shall be designed, rated, and certified in accordance with ETL, CETL, and ISO-AHRI 13256-1. Units shall meet the efficiency standards of the 2023 Florida Building Code – Energy Conservation.
- C. Unit(s) shall consist of heavy gauge, galvanized steel casing with compressor, water-to-refrigerant heat exchanger, air-to-refrigerant heat exchanger, thermal expansion valve, reversing valve, return-air filter, supply air fan motor unit controls.

Cabinet:

- A. Provide unit factory assembled and pre-wired consisting of heavy gage galvanized steel cabinet. Air handling sections shall be lined with 2" thick, closed cell insulation with R-13 rating. The insulation shall be UL listed and meet NFPA-90A and UL 181 Standards.
- B. 1" Discharge duct collar and return air duct collar. Units shall accommodate 2" filters.
- C. Units shall be of Horizontal configuration with rear inlet and front discharge.
- D. Provide base rails and housekeeping pad high enough for full condensate trap and slope to drain.
- E. Access for inspection and cleaning of the unit drain pan, coils, and fan section shall be provided.

Refrigeration System:

- A. Air-to-Refrigerant Coil: The air-to-refrigerant coil shall consist of copper tubes mechanically bonded into evenly spaced aluminum fins. All coils shall be leak tested to 625 psig and pressure tested to 625 psig at the factory to ensure the pressure integrity. The tubes shall be completely evacuated of air and correctly charged with proper volume of refrigerant prior to shipment. The refrigerant coil distributor assembly shall be of orifice style with round copper distributor tubes. The tubes shall be sized consistently with the capacity of the coil. Suction headers shall be fabricated from rounded copper pipe.

Compressor(s):

- A. The unit shall be equipped with a dual refrigeration circuit. The first (lead) circuit shall be equipped with a variable speed scroll compressor. Lead compressor shall turn down to 58% of it's nominal capacity. The second (lag) circuit shall be a single stage scroll compressor. Compressors shall be internally sprung. The compressor(s) shall have a dual level vibration isolation system. The compressor(s) shall be mounted on EPDM vibration isolation grommets to heavy gauge compressor mounting plate, which is isolated from the cabinet base with EPDM grommets for vibration attenuation. Compressor(s) shall have thermal overload protection. Compressor(s) shall be located in an insulated compartment away from air stream to minimize sound transmission.

Refrigerant Circuit:

- A. Within the refrigerant circuit, access ports shall be factory supplied on the high and low pressure sides for refrigerant pressure or temperature testing. A filter drier shall be provided and factory-installed within the refrigeration circuit. Protection against excessive discharge pressure shall be provided by means of a high pressure switch. Protection against a loss of charge shall be provided by low pressure safety switch.
- B. The refrigerant tubing shall be 99% pure copper. This system shall be clean and free from contaminants and conditions such as drilling fragments, dirt, and oil. Provide with extended range insulation; suction side refrigerant piping and water lines internal to the unit shall be insulated with an closed cell insulation.

Refrigerant Metering:

- A. A bi-directional thermal expansion valve (TXV) shall be provided as standard. Capillary tubes are not allowed.

Reversing Valve:

- A. Units shall come standard with a reversing valve for heating and cooling operation. The reversing valve shall be a four-way solenoid-activated refrigerant valve.

Hot Gas Reheat:

- A. Unit shall include modulating hot gas reheat. Control of re-heat shall be accomplished by space mounted humidistat.

Electric Reheat:

- A. Unit controls shall interface with existing Duct mounted SCR electric resistance re-heat.

Water-to-Refrigerant Heat Exchanger:

- A. Cupro-Nickel Heat Exchanger: The water-to-refrigerant heat exchanger shall be a high quality co-axial coil for maximum heat transfer. The cupro-nickel coil is deeply fluted to enhance heat transfer and minimize fouling and scaling. The coil has a working pressure of 400 psig on the water side and 660 psig on the refrigerant side.

Refrigerant Detection System:

- A. The refrigerant detection system shall consist of the control module and sensors within the cabinet of the unit. In the event of a refrigerant leak, the control module will disable compressor operation, and continue to run the unit blower to disperse and concentration of leaked refrigerant in compliance with UL 60335-2-40 and UL 60335-2-89 safety standards for mildly flammable refrigerants.
- B. Note: coordinate with control subcontractor for integration requirements with the Building Management System (BMS) prior to purchasing refrigerant detector. Refrigerant Detection systems shall include "self-test".

Electrical:

- A. Unit shall have integral non-fused disconnect switch. All electrical wiring shall enter the unit cabinet at a single location.
- B. The unit control box shall contain all necessary devices to allow heating and cooling operation to occur from a remote mounted BMS zone sensor. These devices shall include, but not limited to:
 - 1. Transformer
 - 2. 24V compressor contactor
 - 3. A low voltage terminal strip is located inside the control panel behind the service access panel. This terminal strip may be used for low voltage (zone sensor / humidity sensor) connections.

Controls:

- A. Unit controls shall be factory-wired, factory tested, and factory-commissioned. Each WSHP unit shall be controlled by a direct digital controller with WSHP control logic for standalone control or BMS integration via a Multi-protocol interface board with field selectable protocol. Selectable protocols shall include at a minimum: BACnet protocols. Control of the two compressors and variable speed supply air fan motor shall be provided by the unit controller or BMS to optimize energy efficiency and comfort.
- B. The controller shall have the ability to control to setpoints: occupied, occupied standby, occupied bypass, and unoccupied. It shall control multiple units via one humidistat. It shall also provide as a minimum anti-short cycle compressor protection, random start delay, filter maintenance timer, timed override, relay to external damper, isolation valve control, condensate overflow protection, high and low pressure protection, diagnostics, test mode for troubleshooting, dehumidification mode, two-stage compressor control, EC fan control, Hot gas re-heat control, and duct mounted electric re-heat control.

- C. Prior to ordering, coordinate with Siemens for BMS requirements. Include costs for all required control interface cards, hardware, software, control modules, wiring, etc. for a fully operational system.

Supply Air Blower and Motor Assembly:

- A. Blowers shall have inlet rings to allow removal of wheel and motor from one side without removing housing. Units shall have a direct drive centrifugal fan. The fan motor shall be an EC variable speed ball bearing type motor. The EC blower motor shall provide soft-starting functionality, maintain constant CFM over its static operating range, and provide airflow adjustment in 25 CFM increments via its control board. The fan motor shall be isolated from the housing by rubber grommets. The motor shall be permanently lubricated and have thermal overload protection.
- B. Dehumidification mode shall be provided to allow lower airflow in cooling mode for dehumidification. The dehumidification mode may be constant or automatic (humidistat controlled). Airflow/Static pressure rating of the unit shall be based on a wet coil and a clean filter in place.

Drain Pan:

- A. The drain pan shall be constructed of corrosion resistant material and insulated to prevent sweating. Acceptable materials include 304 Stainless Steel. The drain pan shall be fully insulated. The bottom of the drain pan shall be sloped pitch the condensate toward the drain connection to ensure complete condensate drainage when unit is installed level and trapped per manufacturer's installation instructions. The drain pan shall comply with ASHRAE 62 for IAQ conformity. A float switch shall be factory installed on all units as standard.

Filters:

- A. Factory installed filters shall be 2" MERV 13.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which packaged water-cooled heat pump units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION

- A. General: Install packaged water-cooled heat pump units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances. Provide Secondary drain pan.
- B. Electrical Connections: Refer to Division 26 - Electrical Connections for Equipment for final connections to equipment and installation of loose shipped electrical components.
- C. Water Piping: Provide piping as indicated on the drawings. Pipe relief valve outlet to floor drain.

3.3 FACTORY START-UP

- A. Factory start WSHP units and submit reports to Engineer. Coordinate with Controls Contractor and T&B Contractor for initial and final set-up.

3.4 DEMONSTRATION

Operating and Maintenance Training:

- A. Instruct Owner's personnel in operation and maintenance of packaged water-cooled heat pump units. Training shall include start-up and shut-down, servicing and preventative maintenance schedule and procedures, and troubleshooting procedures plus procedures for obtaining repair parts and technical assistance. Review operating and maintenance data contained in the Operating and Maintenance Manuals.
- B. Schedule training with Owner, provide at least 7-day prior notice to the Architect/Engineer.

END OF SECTION 23 81 46.02

SECTION 23 81 46.03 – PACKAGED WATER-COOLED HEAT PUMP UNITS
PRE-PURCHASED UNIT INSTALLATION SPECIFICATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This specification is for the installation of Owner Pre-purchased horizontal packaged water-cooled heat pump units, as scheduled and described herein.
- B. The Vendor is obligated to transport, deliver, load, unload, and store at Owner's desired location for installation by the Contractor. The Vendor is also obligated to provide all start-up and parts warranty services. The Contractor shall provide Labor Warranty described herein.

1.2 HANDLING

- A. Handle packaged water-cooled heat pump units and components carefully to prevent damage. Replace damaged packaged water-cooled heat pump units or components with new.
- B. Rig packaged water-cooled heat pump units to comply with manufacturer's rigging and installation instructions for unloading packaged water-cooled heat pump units, and moving them to final location.

1.3 SPECIAL WARRANTY

- A. Warranty Period: Vendor supplied Parts warranty shall extend 5 years from the date of substantial completion. Contractor supplied Labor warranty shall extend 5 years from the date of substantial completion.

PART 2 – PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 FACTORY START-UP

- A. Vendor to provide factory start of WSHP units and submit reports to Engineer. Coordinate with Controls Contractor and T&B Contractor for initial and final set-up.

3.2 DEMONSTRATION

Operating and Maintenance Training:

- A. Instruct Owner's personnel in operation and maintenance of packaged water-cooled heat pump units. Training shall include start-up and shut-down, servicing and preventative maintenance schedule and procedures, and troubleshooting procedures plus procedures for obtaining repair parts and technical assistance. Review operating and maintenance data contained in the Operating and Maintenance Manuals.
- B. Schedule training with Owner, provide at least 7-day prior notice to the Architect/Engineer.

END OF SECTION 23 81 46.03