SECTION 23 01 00 - OPERATION AND MAINTENANCE OF HVAC SYSTEMS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Service for heating, ventilating, and air conditioning equipment required for the work as indicated on the drawings, including the items listed in “Related Sections”.

1.14 RELATED SECTIONS

A. Operating manuals: Division 01 and Section 23 01 01.

B. General project warranty: General Conditions.

C. Commissioning: Divisions 01 and 23.

D. Boilers: Section 23 52 16.

E. Unit heaters: Section 23 82 39.

F. Chillers: Section 23 64 19.

G. Condensing units: Section 23 63 13.

H. Pumps: Section 23 21 23.

I. Air-handling units: Section 23 73 22.

J. Ductless split-system units: Section 23 81 27.

K. Variable-refrigerant-flow systems: Section 23 81 28.

L. Fan-coil units: Section 23 82 19.

M. Dedicated outdoor air system units: Section 23 72 00.

N. Packaged rooftop units: Section 23 74 13.

1.26 DESIGN REQUIREMENTS:

A. The products specified, scheduled, and shown on drawings are the basis of the design of this project.

B. For requirements affecting use of optional manufacturers, or substitutions, see Division 01 and Section 23 01 01, HVAC General Provisions; and Section 23 05 00, Common Work Results for HVAC.

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1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings:

1. Refrigeration service organization: Name and address of proposed agency, along with any sub-contractors or factory authorized agencies identified.
2. Burner startup and service organization: Name and address of proposed agency, along with any sub-contractors or factory authorized agencies identified.
3. Proposed service or test agreement of each type included in the project, showing conformance to specifications. Include detailed list of work to be performed at each visit.
4. Sub-contractor requirements: Provide qualifications, factory certifications, training and experience of the individuals that will install, set-up, startup, and repair equipment of systems
5. Copies of all startup, test, service, and maintenance agreements with sub-contractors.
6. For each sub-contractor, provide number of years' experience servicing installed equipment, proof that the company is a factory-authorized installation/service agency, and list of employees that have completed factory training and certification of installed equipment.

C. Certifications:

1. Qualifications of refrigeration installation and service agency demonstrating that the agency is either a vendor-employed factory-trained representative, or a factory employed and trained representative.
2. Qualifications of burner startup and service agency demonstrating that the agency is either a vendor-employed factory-trained representative, or a factory employed and trained representative.
3. Each installation and service organization: A list of at least ten projects, similar to this project in type, size, and components, which have been operating satisfactorily for at least two heating and cooling seasons.
4. Include evidence of each requirement specified in article 1.41, "Qualifications," below.

D. Field test reports:

1. Test and inspection reports for refrigeration equipment, including equipment startup and test reports.
2. Test and inspection reports for burner equipment, including equipment startup and test reports.
3. Besides the number specified in general submittal requirements, submit copies to the Owner and the Commissioning Agent.

1.40 QUALITY ASSURANCE

A. Perform work in accordance with the plumbing, electrical, building, fire and safety codes of the state, county or city in which the work is performed.

B. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1 Energy Efficient Design of New Buildings Except Low-rise Residential Buildings.

D. Burner operation shall meet the requirements for exhaust gases and temperature of the applicable authorities having jurisdiction.

1.41 QUALIFICATIONS OF EACH SERVICE AND MAINTENANCE AGENCY

A. Vendor-employed factory-trained or factory employed and trained representative regularly engaged in performing installation, startup, and service work for equipment and systems of the types included in this project.

B. Located in the Baltimore/Washington, DC, metropolitan area.

C. Staff factory-trained by the manufacturer of the equipment included in this project.

D. Provides emergency service on call 24 hours a day.

E. Maintains an adequate stock of manufacturer's genuine or approved parts to service this equipment.

F. Has service contracts available, which can meet requirements specified for the equipment and systems of this project.

1.50 MECHANICAL SYSTEM MAINTENANCE

A. The project will be constructed in multiple phases, as indicated on the drawings. All equipment installed by the contractor shall be maintained by the contractor until substantial completion of each project phase is awarded. Maintenance log shall be updated weekly and located within the Construction Manager's trailer throughout construction. Maintenance shall be per manufacturer's recommendations for general and preventative maintenance, and shall include but not be limited to adjusting, lubrication, and filter change.

1.91 BURNER STARTUP AND SERVICE

A. Provide startup and service for each burner installed as part of the work, by an agency qualified as described above. Boiler start up shall be performed by boiler factory-authorized technician.

B. Approved agency shall start, adjust, and test the complete burner system, and shall provide service as specified below during the term of the general project correction period.

C. Check all parts of the installation applicable to the burner, and verify that fuel piping installation, wiring, control installation, and appurtenances are in accordance with the recommendations of the burner manufacturer. Upon initial start-up, operate and adjust the burner to obtain the performance specified by the burner manufacturer.

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D. Startup report shall include:

Fuel pressure to nozzle - inches of Hg.
Stack draft - inches wg, positive or negative
Fire box pressure - inches wg, positive or negative
Gross stack temperature - degrees F (maximum allowable 500 degrees F)
Room temperature - degrees F
Net stack temperature - degrees F
C02 in fire box - percent C02
C02 in flue gases - percent C02
Smoke reading on the Bacharach scale
Calculated combustion efficiency

1. Provide readings and calculations for both high and low fire settings, or six progressive sets of readings and calculations for modulating firing controls.
2. Test the operation of the flame safeguard control, all operating and limit controls, and the function of the low water cutoff. In the startup report, certify that these functions have been checked and that operation is satisfactory.

E. After the system has been operating under normal occupancy conditions for at least two weeks but not more than four weeks, repeat the adjustments and tests, and prepare another report including the same information.

F. During the first adjustment session, the Owner's maintenance personnel shall be present, and shall be instructed in the proper operation of the burner and its associated control system.

G. Notify the Architect, Owner's representative and any authority having jurisdiction at least one week prior to the scheduled final startup, so that they may arrange to have representatives present to observe the burner start-up and adjustment.

1.93 REFRIGERATION EQUIPMENT WARRANTY AND SERVICE

A. Manufacturer's authorized and factory-trained startup and service organization will be responsible for starting, adjusting, and servicing the complete refrigeration system during the term of the correction period of this contract.

B. Ascertain that piping installation, wiring, control installation, and appurtenances of each refrigeration unit are in accordance with the recommendations of the manufacturer. Upon initial startup, operate and adjust the unit to obtain the performance specified by the manufacturer.

C. Special warranties shall cover the replacement of all parts and components for no less than the time of the general project correction period, starting from the date of substantial completion.

D. Compressors shall have an additional extended parts-only warranty for a total of five years including the general correction period.

E. Refrigerant circuits of self-contained units shall have an additional extended parts-only warranty for a total of five years including the general correction period.

F. Supply emergency service promptly upon call during correction period with no extra charge to Owner.

G. Maintenance in addition to repair: In addition to the repair service required during the correction period, provide maintenance by the manufacturer's authorized factory-trained local agent including routine calls by a factory trained representative, not less than one call every two months during the cooling season. The planned maintenance program shall include:

1. Inspect complete refrigerant circuit for refrigerant leaks with approved halide or electronic leak detector.
2. Replace defective parts and refrigerant at no addition to the contract sum.
3. Tighten belts, nuts, screws, and terminal wiring connections as required.
4. Clean evaporator-condenser coils as needed.
5. Lubricate moving parts as needed.
6. Adjust, align, and replace belts where needed.
7. Check for oil or refrigerant leaks and correct as necessary.
8. Check for blockage of condensate elimination system and correct as required.
9. Check and record unit starting and running amperage.
10. Check and record power voltage and control voltage.
11. Check and record operating temperatures and pressure. (Pressure not required on hermetic circuits.)
12. Check and record thermostatic expansion valve super heat.
13. Check temperature and pressure controls and adjust as required.
14. Check for proper operation of limit switches and safety controls.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 ELECTRIC WIRING FOR MOTORS, STARTERS, AND CONTROLS

A. Furnish and install and in most cases factory-wire motor starters specified under each technical section in this division. Furnish and install under Division 26 magnetic starters not specifically specified with equipment. Unless specified otherwise, automatic control devices for equipment are furnished with the equipment.

B. Unless explicitly specified otherwise, mount and completely wire under Division 26 all starters and automatic control devices, except those which are factory-mounted on equipment.

C. Unless specified otherwise, motor disconnects, manual starters, pushbutton stations, and pilot lights are specified in Division 26, Electrical. Equipment specified in Division 23 shall be suitable for operation in conjunction therewith.

D. Unless specified otherwise in a particular section, electric motors shall comply with the requirements of Section 23 05 13.

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3.59 IDENTIFICATION

A. Identify equipment as required in Section 23 05 00, Common Work Results for HVAC.

B. Thermometers, gages, and control devices shall be identified.

3.61 TESTING MECHANICAL EQUIPMENT

A. Check and adjust all heating and cooling equipment installed.

B. Operate heating and cooling equipment and check controls including high and low limit controls.

C. Mechanical equipment shall be proven to function properly by actual operation prior to final acceptance.

3.71 EQUIPMENT LUBRICATION

A. Bearings of equipment shall be provided with adequate facilities for lubrication. Oiling devices shall be accessible. Lubricate bearings upon completion of work prior to startup of the equipment. Lubricants shall be as specified by equipment manufacturers.

END OF SECTION

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SECTION 23 01 01 - HVAC GENERAL PROVISIONS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. General provisions and requirements for all HVAC work.

1.14 RELATED SECTIONS

A. Requirements of this section generally supplement requirements of Division 01.

B. Division 01 includes sections specifying requirements for LEED rating, construction waste management, and coordination drawings.

C. Commissioning requirements: Divisions 01 and 23.

1.20 REFERENCES

A. NFPA 10: Portable Fire Extinguishers.

B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.

1.25 SYSTEM DESCRIPTION

A. The full set of Contract Documents applies to work of Division 23.

B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.

C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.

D. Except as required otherwise in Division 01, promptly obtain and pay for, including all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Owner.

E. HVAC work of this project includes, as a brief general description, the following:

1. Four pipe (chiller and boiler) system with fan-coil units, dedicated outdoor air system, roof-top air-handling units, and variable refrigerant flow systems.
2. The project includes commissioning under the direction of a Commissioning Agent (CxA).
3. The project will be LEED certified.

F. See Division 01 for requirements related to LEED certification, commissioning, Owner's occupancy of the premises, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

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1.26 PRODUCT OPTIONS

A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Division 23 specifications.

B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in the article "Substitutions," below for substitutions.

C. Products specified by reference standards or by description only: Any product meeting those standards or description.

D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance.

1. Where other acceptable manufacturers are named, Contractor may provide products of those named manufacturers only, which meet the specifications.
2. Where specification permits "equal" products, without naming other acceptable manufacturers, Contractor may use products of any manufacturer, which meet the specifications.

E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

1.27 SUBSTITUTIONS

A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 23 specifications.

B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.

C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.

D. A request constitutes a representation that the Bidder or Contractor:

1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
2. Will provide the same warranty for the substitution as for the specified product.
3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to Owner.
4. Waives claims for additional costs or time extension which may subsequently become apparent.
5. Will reimburse Owner for review or redesign services associated with re-approval by authorities.

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E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.

F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

1.28 MATERIALS AND EQUIPMENT

A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project and of representative manufacture. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.

B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.

C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.

D. Terms have the following meanings:

1. Furnish: Supply item
2. Install: Mount and connect item
3. Provide: Furnish and install.

E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturers' instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the Architect.

F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.

G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the Architect will determine sizes to be utilized.

H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the Architect of said uncertainty, doubt, or conflict and obtain a decision as to the intent before starting any work which may be affected by this decision.

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1.29 COORDINATION

A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the Architect and await a written decision.

B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate HVAC work so that work of each trade is completed before other construction begins which would obstruct it.

C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.

D. Coordinate location and elevation of all piping, ductwork, light fixtures, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the Architect prior to initiation of work. Correct improperly coordinated installation at no additional cost.

E. The Contractors' assistants shall include a competent foreman, who shall be on the premises at all times to check, lay out, coordinate and superintend the installation of work. The foreman shall establish all grades and lines relative to the work before starting, and be responsible for the accuracy thereof.

F. Coordination drawings: Refer to Division 01 and "Submittals" paragraph below.

1.30 SUBMITTALS

A. Manufacturers' and subcontractors' lists:

1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.

B. Shop drawings and product data:

1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of shop drawings and product data for every item of equipment. Shop drawings or product data will not be considered until manufacturers' lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in

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sufficient detail and scope to verify compliance with requirements of the contract documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.

a. For roof-mounted equipment, submit manufacturer's certified drawings and other coordination drawings as required so that openings can be framed through the roof in accordance with structural requirements.

3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
4. All exclusively electrical items furnished as items associated with mechanical items but not specifically described in the mechanical item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the mechanical item by identification specification paragraph.
5. Product data sheets shall be 8.5-inches by 11-inches cut sheets for operating and maintenance manual.
6. Include layout drawings for the entire mechanical systems including air-handling units, fan-coil units, energy recovery units, chillers, boilers, pumps, VRF terminal units, miscellaneous mechanical equipment, ductwork, piping, control components, and other appurtenances. Coordinate and illustrate layout of mechanical systems with building components, ceilings, structure, fire alarm system, fire suppression system, plumbing systems, electrical power, lighting, communication systems, and other appurtenances. Do not begin installation of mechanical systems until drawings have been reviewed and accepted by the Architect and Owner.
7. All project submittals shall be submitted during the first phase of construction.

C. Submit at least three copies of the results of every test required under any section in this division.

D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.

1. Include project name, address, name and phone number of owner's representative, and project type and size.

E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Architect prior to final acceptance of the work.

1.34 SPECIALIST

A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract,

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installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

1.35 CONTRACT CLOSEOUT SUBMITTALS

A. Project record documents:

1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:

    a. Contract drawings.
    b. Specifications.
    c. Addenda.
    d. Change orders and other modifications to the Contract.
    e. Reviewed shop drawings, product data, and samples.

2. Maintain record documents separate from documents used for construction.
3. Record information concurrent with construction progress.
4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:

    a. Manufacturer's name and product model and number.
    b. Product options, substitutions, or alternates utilized.
    c. Changes made by addenda and modifications.

5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:

    a. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
    b. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
    c. Field changes of dimension and detail.
    d. Details not on original Contract Drawings.

6. Submit documents as specified in Division 01.

B. Operation and maintenance data:

1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
2. Lubrication charts: Prepare lubrication charts for each piece of mechanical equipment that requires grease or oil.

    a. Include the following:

1) Types of lubricants required.
2) Locations of lubrication points.
3) Frequency of lubrication.

b. Provide one extra set of lubrication charts mounted in plastic covers, besides those required in Operating and Maintenance Manuals.

3. Binders: Three-ring binders with vinyl-covered hard covers. Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
4. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS," and title of project. Print on spine of binder "O & M INSTRUCTIONS." If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.
5. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
6. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
7. Part 1: Directory, listing names, addresses, and telephone numbers of mechanical engineers; Contractor; mechanical subcontractors; and major mechanical equipment suppliers.
8. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:

a. Significant design criteria, including pump and fan curves and similar performance charts.
b. List of equipment, including operating weight of each piece.
c. Parts list for each component, including recommended spare parts list.
d. Operating instructions.
e. Maintenance instructions for equipment and systems.
f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
g. Valve charts, including locations of flow fittings.
h. New burner installations: Include firing rate, nozzle size, and fuel pressure.

9. Part 3: Project documents and certificates, including the following:

a. Shop drawings and product data.
b. Air and water balance reports.
c. Photocopies of certificates.
d. Photocopies of warranties and guarantees.
e. Test reports: Copies of the results of all tests required under all sections of specifications.
f. Confirmation that all commissioning action items have been completed.

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10. Submit three copies of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer's and Commissioning Agent's comments. Revise content of documents as required prior to final submittal.
11. Submit final volumes revised, within ten days after final inspection.
12. Submit DVD optical disc storage media specified in Section 23 05 00.
13. Provide a spreadsheet using Microsoft Excel indicating each piece of mechanical equipment provided for this project as well as service information including but not limited to:

    a. Equipment Designation
    b. Associated Equipment
    c. Location
    d. Area Served
    e. Manufacturer
    f. Model Number
    g. Serial Number
    h. Year Built
    i. Heating Capacity
    j. Heating Source (Hot Water, or Electric)
    k. Heating Water Flow Rate
    l. Cooling Total Capacity
    m. Cooling Sensible Capacity
    n. Cooling Source (Chilled Water or DX)
    o. Chilled Water Flow Rate
    p. Refrigerant Type
    q. Refrigerant Charge
    r. Heating Source (Hot Water, Gas, or Electric)
    s. CFM for Each Fan
    t. External Static Pressure for Each Fan
    u. Total Static Pressure for Each Fan
    v. Horsepower for Each Fan
    w. Fan Type for Each Fan
    x. Drive Type for Each Fan
    y. Wheel Diameter for Each Fan
    z. RPM for Each Fan
    aa. Belt Size and Quantity for Each Fan
    bb. Filter Type, Size, and Quantity for Each Filter Bank
    cc. kW
    dd. HP
    ee. Watts
    ff. MCA
    gg. MOP
    hh. MFS
    ii. FLA
    jj. Voltage/Phase
    kk. Any additional information requested by HCPSS project manager.

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C. Submit a draft copy in electronic format using Microsoft Excel which includes information for one piece of each type of equipment. Submit to the Architect and HCPSS for review and approval prior to completing the spreadsheet. Upon approval, submit the completed document again for review and approval prior to submitting the finalized version.

1.42 REGULATORY REQUIREMENTS

A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.

B. Provide, without extra charge, any additional materials and labor which may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.

C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.

1. The plumbing, mechanical, electrical, building, fire, and safety codes of the state and county or city in which the work is being performed.
2. The National Electric Code, NFPA 70 (NEC).
3. The National Fire Protection Association Code. (NFPA).
4. International Energy Conservation, Fire, Fuel Gas, Mechanical, and Plumbing Codes (ICC).

1.43 REFERENCE STANDARDS

A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless specified otherwise in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply. Products shall be certified by manufacturers to meet the requirements of referenced standards.

1. Federal Specifications (FS)
2. Military Specification (MS)
3. Military Standards (Mil. Std.)
4. Air Conditioning and Refrigeration Institute (ARI)
5. Air Movement and Control Association (AMCA)
6. Associated Air Balance Council (AABC)
7. American Association State Highway and Transportation Officials (AASHTO)
8. American National Standards Institute (ANSI)
9. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
10. ASME International (ASME)
11. American Society for Testing and Materials (ASTM)
12. American Society of Sanitary Engineering (ASSE)
13. American Water Works Association (AWWA)
14. International Code Council (ICC)
15. Manufacturer's Standardization Society of the Valve and Fittings Industry Inc. (MSS)

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16. National Electrical Code, NFPA 70 (NEC)
17. National Electrical Manufacturer's Association (NEMA)
18. National Fire Protection Association (NFPA)
19. National Fuel Gas Code, NFPA 54
20. National Sanitary Foundation (NSF)
21. National Standard Plumbing Code (NSPC)
22. The Occupational Safety and Health Act (OSHA)
23. Piping and Drainage Institute (PDI)
24. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)
25. Underwriters Laboratory Inc. (UL)
26. Maryland Occupational Safety and Health Act (MOSHA)

1.53 TEMPORARY STORAGE

A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.

B. Area shall be maintained and shall be returned to original condition at the completion of the project.

1.54 PROTECTION

A. Control dust resulting from construction work to prevent its spread beyond the immediate work area, and to avoid creation of a nuisance.

1. Do not use water to control dust. Use drop cloths or other suitable barriers.
2. In areas where dirt or dust is produced as a result of the work, sweep daily, or more often as required.
3. Provide walk-off mats at entries and replace them at regular intervals.
4. Construct dust partitions, where indicated on the drawings or as required.
5. Protect areas occupied by Owner's personnel or equipment.
6. Seal off all return air registers and other mechanical systems to prevent dust from entering.

B. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.

1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
2. Protect finished work from damage, defacement, staining, or scratching.
3. Protect finishes from cleaning agents, or grinding and finishing equipment.
4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
5. Coordinate installations and temporarily remove items to avoid damage from finishing work.

C. Repair all damage or soiling to the complete satisfaction of the Architect; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract Sum.

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D. Protect work stored in place and supplies stored in the building.

1. Store materials and products, subject to damage from moisture, in dry locations. If necessary, protect in wraps or covers.
2. Store plastics, other materials, and products subject to damage from heat or cold at manufacturer's recommended temperatures.

E. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

1.55 FIRE PROTECTION

A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.

B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

1.60 PROJECT CONDITIONS

A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting, drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.

B. If, in the course of the work, workers encounter a material they suspect to present some hazard:

1. Promptly notify the Architect in writing.
2. Do not perform any work which would disturb the suspected material until written instructions have been received.

1.80 WARRANTY

A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties specified in individual sections.

B. During the correction period, the Contractor shall promptly correct any work found to be not in accordance with the requirements of the Contract Documents, on receipt of written notice from the Owner. Except as otherwise required in General Conditions and Division 01, the correction period is two years after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.

C. When use of the permanent equipment has been permitted for temporary heating or ventilation of the building, the warranty and correction periods shall nevertheless begin at the time of substantial completion, unless another date of acceptance has been agreed to by the Owner.

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D. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.

E. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.

F. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.11 CUTTING AND PATCHING

A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.

B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of pipes, ducts and appurtenances. Close superfluous openings and remove all debris caused by work of this division.

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C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the Architect.

D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.

E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

3.14 TEMPORARY FACILITIES

A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.

3.40 PROGRESS MEETINGS

A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or Architect finds them necessary or advantageous to progress of work.

B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, Architect and Owner shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

3.82 COMMISSIONING

A. Comply with requirements of “Commissioning” in Part 1 above.

END OF SECTION

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SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Basic material and equipment required for the piping work as indicated on the drawings and specified in Division 23.

B. Other requirements applicable to more than one section of Division 23.

C. Identification of HVAC systems and equipment.

1.14 RELATED SECTIONS

A. Division 01 includes sections specifying requirements for LEED rating, and construction waste management.

B. Commissioning requirements: Divisions 01 and 23.

C. Project and special warranties: Division 01 and Section 23 01 01.

D. Operation and Maintenance Manuals: Division 01 and Section 23 01 01.

E. Painting: Division 09.

1.21 DEFINITIONS

A. Project correction period: A period after Substantial Completion of the work during which the Contractor shall correct every part of the work found to be not in accordance with the requirements of the contract documents, promptly after receipt of written notice.

B. Qualified testing agency: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual sections; and where required by authorities having jurisdiction, that is acceptable to authorities.

1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.

C. DN: Dimension Nominale, nominal pipe size in millimeters, in accordance with the metric system for construction, Systeme Internationale (SI).

D. NPS: Nominal pipe size in inches, in accordance with standard U.S. designations for manufactured pipe. Pipe sizes do not change when projects are designed and built in metric units; each size has a consistent name (nominal dimension) in each system.

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1.26 DESIGN REQUIREMENTS

A. The drawings and system performances have been designed based on using the particular manufacturer's products specified and scheduled on the drawings.

B. Products of other manufacturers that are listed under the article "Acceptable Manufacturers," or permitted as "equal," are permitted provided:

1. Product shall meet the specifications.
2. Contractor shall make, without addition to the contract sum, all adjustments for deviations so that the final installation is complete and functions as the design basis product is intended.

C. Do not propose products with dimensions or other characteristics different from the design basis product that render their use impractical, or cause functional fit, access, or connection problems.

D. The contract drawings are generally diagrammatic and do not indicate all fittings or offsets in pipe, all access panels, or other specialties required.

1. Install pipe exposed to view parallel with the lines of the building and as close to walls, columns, and ceilings as may be practical, maintaining proper clearances for access at all parts requiring servicing.
2. Install pipe a sufficient distance from other work to permit a clearance of not less than 0.5 inch (15 mm) between its finished covering and adjacent work.
3. No pipe shall be run below the head of a window or door.

a. Equipment, ducts, and pipes installed in areas without a suspended ceiling shall be as tight to structure as possible, but at least above a height of 6'-8", unless otherwise noted.

4. Pull boxes and other appurtenances which require operation or maintenance shall be easily accessible. Do not cut or form handholes for operation or maintenance of appliances through walls or ceilings.

1.30 SUBMITTALS

A. Comply with Division 01 and Section 23 01 01.

B. Shop drawings:

1. Showing proposed expansion design.
2. Schedule of welding and brazing procedures proposed for each piping system included in the project.

C. LEED submittal:

1. Product data for Credit EQ 3.1 and 5: For filter media installed during construction and prior to occupancy, documentation indicating MERV rating.

2. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For adhesives and sealants, include printed statement of VOC content.
3. Product data for Credit EQ 4.2: For mastics, paints and coatings applied within the building waterproofing envelope, documentation including printed statement of VOC content in g/L.
4. Product data for Indoor Environmental Quality (IEQ) Credit 4.4: For wood product such as plywood equipment backboards, include printed statement of non-urea-formaldehyde component present in material.

D. Certifications: Proof of operator and testing agency personnel qualifications as required for welding and brazing in the article "Quality Assurance" below.

E. Test reports: Field test results for each piping system as specified in Part 3 below.

1.40 QUALITY ASSURANCE

A. Provide materials and perform work in accordance with the plumbing, mechanical, electrical, building, fire, health and safety, and other applicable codes and regulations of the state, county or city in which the work is performed.

B. Welding procedures and operator qualifications for structural welding: AWS D1.1, Structural Welding Code Steel, electric arc process.

C. Welding, brazing, and soldering procedures and operator qualifications for building systems piping:

1. AWS D10.9, Qualification of Welding Procedures and Welders for Piping and Tubing.
2. ASME B31.9, Building Services Piping.
3. Copper Development Association "Copper Tube Handbook."
4. Safe Drinking Water Act.

D. Qualifications of independent testing laboratory personnel:

1. Welding inspectors: AWS QC1, Certification of Welding Inspectors.

E. Electrical control panels, equipment, materials and devices provided or installed as work of Division 23 shall bear UL label or, if UL label is not available, the item shall be tested and labeled by a qualified testing agency, acceptable to authorities having jurisdiction, and in accordance with NFPA 70 (NEC). Provide testing, if required, without addition to the contract sum.

F. Qualifications of DVD documentation technician: For video documentation specified in "Operating Instructions (Demonstration)," employ persons knowledgeable in DVD optical storage media format for video and audio production and editing.

G. The project shall be LEED certified. See requirements specified in Division 01 and individual sections for LEED requirements, waste and air quality control.

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H. Adhesives, sealants, mastics, primers, paints and coatings applied within the building waterproofing envelope: Comply with low-emitting requirement in Section 01 61 16.

I. Products shall contain no urea-formaldehyde content.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

PART 2 - PRODUCTS

2.10 MATERIALS

A. General piping techniques, testing, identification, painting, and operating instructions specified in this section apply to products specified in other sections of Division 23.

B. Weldolets and thredolets: Fittings designed for installing branches on piping, with either welded or threaded connection to branch; conforming to ASTM A 234.

C. Solder: Free of lead, antimony, and zinc and meeting the requirements of ASTM B 32. No solder containing lead is permitted.

1. Tin 95.5 percent, copper 4 percent, and silver 0.5 percent; equal to “Silvabrite 100” manufactured by Engelhard Corporation.
2. Tin, copper, bismuth, and silver; equal to "Oatey Silver" manufactured by Oatey.

D. Flux: Meeting the requirements of ASTM B 813 and NSF 61 certified, equal to Oatey H-20^{95}.

E. Pipe jointing compound:

1. Polytetrafluoroethylene (PTFE) pipe thread tape, "Teflon."
2. Pipe cement and oil.
3. For gas service: As specified in Section 23 11 23, Natural-Gas Piping.

F. Wood-preservative-treated lumber: Treated by pressure process, AWPA C2, with chemicals acceptable to authorities having jurisdiction, and marked with treatment quality mark of an inspection agency approved by ALSC Board of Review.

1. Application: Treat items indicated on the drawings, and the following:

a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.
b. Wood sills, sleepers, blocking, and similar concealed members in contact with masonry or concrete.
c. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
d. Wood floor plates that are installed over concrete slabs-on-grade.

2.21 IDENTIFICATION DEVICES AND MATERIALS

A. Stenciling materials:

1. Stencils: Manufactured standard stencils prepared for required applications, conforming to ANSI A13.1 for color and size of legend letters, including arrows showing direction of flow.
2. Paint: Exterior type enamel, colors conforming to ANSI A13.1, or black.

B. Equipment identification tags:

1. Laminated plastic with adhesive back, white core and black outer layers, which, when engraved, will produce white letters and numerals on a black background.
2. Tags installed on curved surfaces shall be aluminum or brass.

C. Valve tags: Brass, 1.5 inch (40 mm) in diameter with black-filled numbers not less than 0.25 inch (6 mm) high, complete with brass attachment chains.

D. Ceiling identification tags: Laminated plastic with adhesive back, engraved black letters on white background, minimum 0.5 inch (15 mm) wide and length as required for 0.375 inch (10 mm) high letters for name of concealed device and number.

2.23 DATE-SENSITIVE EQUIPMENT

A. Date-sensitive equipment: Systems, equipment, or components which use or process date and time data in order to perform their functions.

B. Each item of date-sensitive equipment used in the project shall be warranted by the manufacturer to properly function and correctly use or process all time-related data for all dates and times which occur during a reasonable life expectancy of the equipment.

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PART 3 - EXECUTION

3.03 INSTALLATION OF PRODUCTS AND EQUIPMENT

A. Manufacturers' instructions: Except as modified by drawings or specifications, install products and equipment in accordance with manufacturers' instructions and recommendations applicable to the project conditions.

1. Immediately notify Architect if a difference or discrepancy is found between manufacturers' instructions and the drawings or specifications.

B. Installation: Above-ceiling equipment and devices shall be installed as low as possible to facilitate maintenance.

3.22 PIPE INSTALLATION

A. Remove burrs resulting from cutting pipe or from any other operation.

B. Threaded connections:

1. Cut threads full and clean.
2. Apply specified pipe jointing compound or tape on male threads only.
3. Where piping is installed in crawl spaces and tunnels, cover exposed threads with either bituminous protective coating or rust-inhibitive paint. Apply after joints have been assembled and tested.

C. Thoroughly clean pipe and fittings before they are installed, and keep them clean until the acceptance of the completed work. Cap or plug the ends of the lines so as to prevent earth and other debris from entering during construction.

D. Provide for expansion and contraction of piping and connections so that no strain or breakage will occur. Provide anchors and guides of approved design where shown on drawings and where necessary to allow for proper expansion and contraction. At the time of installation, expansion loops shall be cold sprung to one-half of the calculated expansion.

E. Provide for draining all parts of water piping systems and apparatus by installing a valved hose connection at every low point.

F. Black steel piping NPS 2.5 (DN 65) and larger shall be welded; NPS 2 (DN 50) and smaller shall be threaded, except as required otherwise in a particular section.

G. Do not weld galvanized piping.

H. Use welding fittings, tees, wyes, reducers, eccentric reducers, and caps as required. Branches at least two nominal pipe sizes less than the main may be made with "Weldolets" or "Thredolets" installed with full size opening in larger pipe and in accordance with manufacturer's printed instructions. Flanges shall be welded neck or slip-on pattern of class to suit the valves or equipment connections. Flanges shall have machine bolts with hex nuts and washers.

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I. Each connection from risers to equipment shall contain at least three elbows or expansion joints. Connections shall be so arranged that movement in piping due to expansion and contraction will not be transmitted to the equipment.

J. Install unions and flanges in the piping at each item of equipment, control valve, and appliance, so as to provide easy removal of the equipment, valve, or appliance, and to provide for easy removal of coils.

K. Pitch water piping so that air in the system can be properly vented. Provide stop valves where necessary to isolate parts of system for repairs without draining the entire system.

L. Special techniques: Follow the techniques for soldering and brazing pipe, fittings, and valves as recommended by the manufacturer.

3.23 COPPER TUBING FOR WATER INSTALLATION

A. Solder joints for copper tubing: Clean ends of tubing and inside of fitting ends thoroughly with emery cloth before applying flux.

B. Make flare joints in copper tubing with proper size flaring tool and in accordance with manufacturer's recommendations.

C. Provide isolation fittings between copper and steel piping to prevent electrolysis.

D. Cut pipe with a tubing cutter or fine-tooth saw. Cuts made with a saw shall be true and square, and the end shall be filed smooth with a fine-tooth file. Remove all marks and burrs with sandpaper.

3.25 INTERFACE WITH OTHER PRODUCTS

A. Where it is necessary to run pipes through walls, provide finished, permanent, waterproof installation complete with inserts, sleeves, supports or hangers, seals, and other appurtenances as required. Do not pierce, cut, or notch any footing or other structural member.

B. Waterproofing and dampproofing of the building shall be unharmed by the installation of the work. Where pipe has to pierce waterproofing or dampproofing, including outside walls, the penetration shall be made watertight. Waterproofing damaged or destroyed shall be repaired or replaced with new waterproofing.

3.59 IDENTIFICATION

A. General: Do not apply identification until insulation and finish painting work is complete.

B. Equipment:

1. Stencil equipment with minimum two-inch (50-mm) -high letters or provide identification tags. Clearly identify function, equipment served, and area served.

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2. Firmly fasten each identification tag to its appropriate piece of equipment with drive screws, sheet metal screws, or rivets. Do not interfere with operation of, or damage the item being marked.

C. Piping:

1. Mark by stenciling.
2. Mark to identify service with arrows showing direction of flow. Apply markings near building walls where pipes enter or leave an accessible space and in intermediate locations so that markings are no more than 30 feet (9 m) apart. They shall be readily visible to a person standing on the floor.
3. Fully identify all piping installed as work of the project.
4. Mark pipe with letters of height and with colors as required by OSHA and conforming to ANSI A13.1.
5. Identify every thermometer, gage, and control device.
6. Provide valve tags for all valves except stop valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.

D. Stencil ductwork after insulation is applied, if required, with minimum two-inch (50-mm)-high letters, clearly identifying service (supply, return, exhaust) and showing direction of flow with arrows. Mark ducts near the building walls where they enter or leave a space, and at intervals of not more than 30 feet (9 m). Identification shall be visible to a person standing on the floor.

E. Ceiling identification tags: Provide on the access door or, in suspended ceilings, on the ceiling support adjacent to the unit.

1. Valves: Identify with the same number shown on the valve tag.
2. Terminal units above ceilings: Identify with unit description and number.

3.61 PIPING TESTS

A. Notify Owner at least one day prior to the actual test.

B. Test before pipes are concealed or insulated. Test the piping in sections as the work progresses, so as not to delay progress of the building construction. Furnish pumps and gages required for testing.

C. Conduct piping tests before connecting equipment that would be subject to damage from the test pressure. Replace piping or fittings found defective with new material.

D. Bracing and supporting: Adequately brace and support piping during the test, so that no movement, displacement, or damage results from the application of the test pressure.

E. Refrigerant piping: Test as specified in Section 23 23 00.

F. Test the piping systems for not less than four hours to fulfill the conditions in the Piping Systems Test Schedule at the end of this section.

G. Documentation of tests: Prepare a test report for each portion of piping tested, identified by service, material, location, and pipe size. Submit four copies of test documentation for distribution. Include these items:

1. Date of test.
2. Starting and completion times.
3. Initial test pressure.
4. Final test pressure.
5. Problems or leaks detected.
6. Corrective actions taken.
7. Record of successful completion of testing.
8. Name, title, and signature of person conducting test.

3.75 CLEANING AND PAINTING

A. Cleaning: Clean all piping and equipment. Where items are to be painted, clean ready for painting.

B. Painting: Coordinate painting with requirements of Division 09. Paint the items identified below to be painted. Use paint materials and systems specified in Division 09.

C. Items to be painted:

1. Items identified below to have protective coating.
2. Items furnished with manufacturer's prime coat.
3. Mechanical rooms:

    a. Non-galvanized hangers and supports.

4. Piping and ductwork exposed in finished spaces, insulated and uninsulated.
5. Inside ducts behind registers, grilles, and diffusers.

D. Items not to be painted: Copper, stainless steel, and equipment furnished with manufacturer's finish.

E. Paint systems in mechanical rooms: Paint piping using colors in accordance with ANSI A13.1.

1. Galvanized steel: One coat of primer recommended for galvanized surfaces and one coat of glossy alkyd enamel.
2. Ferrous metal: One coat of primer recommended for ferrous metal and one coat of glossy alkyd enamel.
3. Items protected with bituminous coating or rust-inhibitive primer: Finish coat of compatible glossy enamel.

F. Paint systems for exposed piping and ductwork: Primer compatible with the substrate, whether steel, galvanized steel, insulation jacket, or other material; one coat or two, if required to cover, to match adjacent surfaces in color and texture.

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G. Painting inside ducts behind registers, grilles, and diffusers: Matte black, compatible with substrate and suitable for the temperatures at which the duct will operate, extending from the duct opening to a depth such that no unpainted surface will be visible to a person standing on the floor or adjacent balconies.

3.81 OPERATING INSTRUCTIONS (DEMONSTRATION)

A. Furnish the necessary technicians, skilled workers, and helpers to operate all the HVAC systems and equipment of the entire project for one 8-hour day.

B. Where specified in technical sections, provide longer periods required for specialized equipment.

C. Instruct the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of all systems and equipment.

1. Instructions by manufacturer's technical representative for each type of equipment shall include the performance of the recommended preventive maintenance procedures for that equipment.

D. The Operating and Maintenance Manual shall be available at the time of the instructions, for use by instructors and Owner personnel.

E. Record each instruction session only in DVD media format (video and audio format), including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVDs with each Operating and Maintenance Manual.

F. Schedule the general and specialized instruction periods for a time agreed upon by the Owner, Architect, and Commissioning Agent. Demonstrations shall not occur during school hours of operation. Schedule sessions starting at 7:00 am, or starting after school.

3.90 SCHEDULES

A. Piping Systems Test Schedule:

(See Schedule, next page)

SYSTEM	TEST PRESSURE PSIG (kPa)	ALLOWABLE DROP	MEDIUM
Heating water	125 (860)	None	Water
Chilled water	125 (860)	None	Water
Fuel gas	100 (690)	None	*Air

* If pressure drops, locate leaks with soap and water solution

END OF SECTION

SECTION 23 05 01 - EXCAVATION AND FILL FOR HVAC WORK

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Trenching, backfilling, and compacting for HVAC work underground inside the building and extending five feet beyond exterior building walls, and outside the building as shown on drawings.

1.14 RELATED SECTIONS

A. Cutting and patching: Division 01 and Section 23 01 01.

B. Piping: Sections 23 21 13 and 23 21 15.

1.20 REFERENCES

A. ASTM D 1557: Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbs/cu ft (2700 kN-m/cu m).

1.30 SUBMITTALS

A. General: Submit in accordance with Division 01 and Section 23 01 01.

B. Shop drawings: At the same scale as the contract drawings, showing field verified locations of utilities, and proposed detailed trenching plan.

C. Product data:

1. Warning tape

D. Certifications: Test reports showing that compaction meets specified requirements.

PART 2 - PRODUCTS

2.10 MATERIALS

A. Backfill: Earth materials, free from perceptible amounts of wood, debris, or topsoil, free of frost at the time of placement, and not containing marl or other elements which tend to stay in a plastic state.

B. Underground warning tape: Polyethylene 0.004 inch (0.102 mm) thick for metallic lines, and for non-metallic lines polyethylene both sides with metallic lining, six inches (152 mm) wide.

1. Colors: In accordance with APWA and AASHTO standards.
2. Markings: Repeated continuously along the entire length, legend appropriate for line being identified.

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2.12 EQUIPMENT

A. Mechanical tampers for compacting backfill: Capable of exerting a blow equal to 250 pounds per square foot (12 kPa) of area of the tamping face.

PART 3 - EXECUTION

3.05 PREPARATION

A. Contact local utility company underground information service (BGE Miss Utility) before beginning excavation outside buildings.

B. The general locations of underground utilities are indicated on the drawings and are not to be assumed to be accurate or complete. Before beginning work, field check the area with the most accurate instruments available, such as Fisher Labs' Pipe and Cable Locators.

3.20 INSTALLATION

A. Perform all excavating, cutting of paved areas, trenching, sheeting, shoring, backfilling, and compacting required for the proper installation of the work. Repair of pavement is specified in Division 32.

B. Where obstructions are encountered, obtain written approval and make necessary changes in line, grade or location.

C. Protect existing utilities from damage during excavation and backfilling. Repair damaged new or existing work at no addition to the contract sum. Bracing, shoring and other protection of existing utilities is part of this work.

D. Do not damage or remove existing shrubs or trees including their root systems, without prior notification to the Architect.

E. Note the depths of footings. In cases where piping is in close proximity to or below footings and where the natural earth under footings is disturbed, after the line is installed the voids shall be filled up to bottoms of such footings with solid concrete.

3.24 CUTTING

A. Cut concrete and asphalt concrete with masonry saw prior to breaking it into smaller pieces for removal.

B. Cut sidewalks perpendicular to the length at the closest existing joint that is a minimum of 24 inches back from either side of the top of the new trench.

3.25 TRENCHING

A. Excavations inside the building shall be carefully planned. Stockpile excavated earth so as not to interfere with other construction. Dig trenches to the proper depths, providing extra depressions where required for hubs of pipes.

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B. Excavations outside the building shall generally follow the routes indicated on the drawings. Stockpile topsoil separately for later replacement. Excavations shall be of sufficient depths to provide, unless indicated otherwise on the drawings, a minimum cover as follows:

1. Water piping: 42 inches (1067 mm).
2. Fuel piping: 30 inches (762 mm).

C. Trenches shall be of necessary depth and width for the proper laying of pipe with a minimum of 8 inches (205 mm) on each side of the joint.

1. The sides shall be as nearly vertical as practicable. Unless local regulations are more strict, trenches 4 ft. (1220 mm) and deeper shall have shored sides as required by OSHA trenching regulations.
2. The bottoms of trenches shall be accurately graded to provide uniform bearing and support for each section of pipe on undisturbed soil at every point along its entire length, except for bell holes and for the proper sealing of the pipe joints.
3. No greater length of trench shall be left open, in advance of the completed structure placed in it, than can be completed in that day's operation.
4. Except where rock is encountered, do not excavate below the depths required. Where rock excavation is required, excavate to a depth of at least 6 inches (150 mm) below the trench depth and fill the overdepth with compacted crusher run or bank run stone or sand. Unauthorized overdepths in excavation shall be backfilled with crushed stone, slag or gravel, thoroughly compacted.
5. Whenever wet or otherwise unstable soil is encountered, it shall be removed to the depth and extent directed, and the trench backfilled to the proper grade with crushed stone, slag or gravel.

D. Should springs be encountered within the work area, or soft soil conditions at the elevations required for load bearing, immediately notify the Architect and do not place any portion of the work on such surfaces until instructions are received.

E. Furnish and maintain pumps, flumes, gutters, and appurtenances if required to keep the excavations free from water. Water shall be directed to a point remote from building operations, shown on the approved shop drawing.

3.26 BACKFILL

A. Place no backfill until the adjacent construction or the utility to be covered has been inspected, tested, and approved.

B. Installing underground warning tape: Install in backfill above exterior buried lines not encased in concrete. Select legend and color appropriate for type of line. Install metallic lined tape for non-metallic lines. Install approximately 12 inches (305 mm) below grade.

C. HVAC systems backfill:

1. Backfill and compact in six-inch (150-mm) layers up to spring line of the pipe. The installations shall then be inspected and tested.

2. Following inspection, backfill in six-inch (150-mm) layers, each compacted, until the pipe has a cover of not less than one foot (305 mm). Place the remainder of the backfill material in the trench in eight-inch (200-mm) compacted layers.
3. Excavations improperly backfilled shall be reopened, then refilled and compacted to the required grade and compaction, and smoothed off.
4. Open trenches across roadways or other areas to be paved shall be backfilled as specified above, except that the entire depth of trench shall be backfilled in six-inch (150-mm) layers, and each layer shall be mechanically compacted.
5. Completed work shall have uniform graded surface, in accordance with the surface and grade indicated on the drawings.

3.27 COMPACTION

A. Test in accordance with the requirements of ASTM D 1557.

B. Compact under slabs, roads, and sidewalks to a 95 percent density.

C. Compact unpaved areas to a 90 percent density.

D. Backfill and compact trench in unpaved areas to within 4 inches (102 mm) of existing grade. Furnish and install compacted select topsoil for the final layer to finish even with existing grade. Remove surplus earth and rake unpaved areas for final planting.

E. Take particular care in compaction of earth under joints of HVAC piping.

END OF SECTION

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SECTION 23 05 02 - SLEEVES AND PLATES FOR HVAC PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Sleeves and escutcheon plates for piping systems.

B. Mechanical seals for piping penetrations.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Sleeves, plates, sealants, and mechanical penetration seals.

PART 2 - PRODUCTS

2.10 SLEEVES, PLATES, AND ACCESSORIES

A. Steel sleeves: Schedule 40 black steel pipe, ASTM A 53.

B. Copper sleeves: Type L, ASTM B 88 hard drawn.

C. Cast-iron sleeves: Extra heavy, equal to product of U.S. Pipe Co. with waterstop and ends as shown on the drawings.

D. Sealing compound in walls and floors: Equal to the following:

1. Bare and insulated pipes carrying fluids 150 degrees F (65 degrees C) and below: Sika Corporation “Sikaflex – 1a.” Use a primer for applications required by the manufacturer.
2. Bare and insulated piping carrying fluids 151 degrees F (66 degrees C) and above: Dow Corning Corporation “795 Silicone.” Use a primer for applications required by the manufacturer.

E. Floor, wall and ceiling plates: Stamped or cast brass, hinged type as pipe size requires. Plates shall have chrome finish.

F. Mechanical penetration seals: Equal to PSI “Link-Seal Modular Seals” or Calpico Sealing Link “LINX”. Seals shall be modular mechanical type, consisting of interlocking synthetic links shaped to continuously fill the annular space between the pipe and wall opening. Bolt and nut fasteners for the seals shall be stainless steel for units used in penetrations below grade.

PART 3 - EXECUTION

3.20 INSTALLING SLEEVES

A. Install sleeves for piping, or piping with insulation continuous through sleeve, passing through walls, partitions, beams, or slabs.

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1. Exception: Where steel pipe penetrates a steel beam that is not part of a fire- or smoke-rated assembly, no sleeve is required.

B. Do not cut, drill, or burn structural steel for installation of piping without specific instructions from the Architect.

C. Locations in nonfire-rated construction:

1. Install steel sleeves for penetrations of steel, iron, and insulated piping.
2. Install copper sleeves for penetrations of uninsulated copper tubing and piping.

D. Locations in floors and fire-rated construction: Sleeves used in piping penetrations through fire-rated construction shall be an acceptable component of the through-penetration firestop assembly as specified in Section 23 05 07, Firestopping for HVAC Work.

1. Where firestop assembly is UL listed, sleeve material shall be as directed in the listing.
2. Where other specified approval and acceptance is required, sleeve shall be as described in the approved assembly.

E. Install sleeves through walls and partitions flush with finished surfaces.

F. Sleeves through floors shall extend 0.375 inch (10 mm) above top of finished floor and be finished neat and level. Sleeves through mechanical or equipment room floors shall extend one inch (25 mm) above finished floor. Provide projecting sleeves with anchor clips to prevent them from being loosened and knocked down in the floor construction.

G. Sleeves for penetrations in kitchen and food service areas shall finish 0.375 inch (10 mm) above floor or flush with wall surfaces and be neatly pointed up to fit snugly against floor or wall materials. Seal space between pipe and sleeve with waterproof sealant or fire barrier as required, and finish even with wall or floor with a light pouring of molten lead.

H. Sleeves for insulated piping with vapor barrier shall be large enough to pass piping and insulation.

I. Seal spaces between sleeves and pipe, or pipe insulation, in nonrated walls, with mineral wool.

J. Penetrations in exterior masonry or concrete walls and foundations:

1. Sleeves: Cast iron, or in cast concrete may be core drilled.
2. Above grade: Mechanical penetration seal, at outside face of wall.
3. Below grade: Mechanical penetration seals, at outside and inside faces of wall.

3.25 INSTALLING PLATES

A. Piping passing through interior walls, partitions, floors, and ceilings in exposed locations shall be fitted with wall, floor, and ceiling plates of size and depth to conceal sleeves. Secure plates firmly in place with set screws.

B. Do not install floor or wall plates on pipes in the kitchen and food service areas.

END OF SECTION

SECTION 23 05 03 - ACCESS DOORS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Access doors for concealed HVAC specialties requiring maintenance or manual operation.

1.14 RELATED SECTIONS

A. Valves: Section 23 05 23.

B. Specialties: Section 23 05 08.

C. Duct access doors: Section 23 33 00.

D. Controls: Sections 23 09 01 through 23 09 23.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Each type of access door.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Wall and ceiling access doors:

1. Acudor Products Inc.
2. Cesco Products Company
3. Karp Associates, Inc.
4. Milcor, Inc.
5. Zurn Industries

2.21 WALL AND CEILING ACCESS DOORS

A. Doors: Provide Milcor model listed, or similar type and equal quality by another acceptable manufacturer.

B. Types:

1. Fire-rated where occurring in fire-rated walls.
2. Style AP where occurring in acoustical plastered surfaces.
3. Style K where occurring in hard plastered surfaces.
4. Style M stainless steel where occurring in masonry or ceramic tile surfaces.
5. Style DW where occurring in drywall construction.

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C. Sizes: As required for access to the particular device, but no less than 16 by 16 inches (405 by 405 mm).

D. Finish: Brushed stainless steel.

E. Recessed door panels for concealed type doors: Types:

1. Style AP: Acoustical plaster applied into recessed door panel for flush finish.
2. Style AT: Matching acoustical tile applied into recessed door panel for flush finish.
3. Style ATR: Matching material applied into recessed door panel for flush finish.
4. Style DWR: Drywall panel applied into recessed door panel for flush finish.

2.70 LABELS

A. For access doors to fire protection devices: OSHA and NFPA approved, describing the fire protection device within.

B. Minimum lettering size: 0.5 inch (13 mm) high.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Provide access doors in walls and inaccessible ceilings for concealed damper operators, duct access doors, valves, and other concealed specialties and appliances that require manual operation or maintenance.

B. Select appropriate size door for each particular application.

END OF SECTION

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SECTION 23 05 04 - HVAC DEMOLITION

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Extent and location of demolition are shown on the drawings.

B. Work includes salvage of items identified on the drawings.

1.14 RELATED SECTIONS

A. Demolition: Division 02.

B. Asbestos removal: Division 02.

1.40 QUALITY ASSURANCE

A. Demolition shall be carried out as expeditiously as possible in accordance with accepted practice and applicable building code provisions.

1.60 PROJECT CONDITIONS

A. If, in the course of the work, workers encounter a material they suspect to be asbestos, to contain lead or PCBs, or to present some other hazard:

1. Promptly notify the Architect in writing.
2. Do not perform any work which would disturb the suspected material until written instructions have been received.

B. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.

C. Locate, identify, and protect mechanical and electrical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.20 DEMOLITION

A. Comply with demolition and disposal requirements of Division 02.

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B. Perform removal work neatly with the least possible disturbance to the building.

C. Provide temporary barriers, danger signals, and appurtenances for protection of personnel and equipment during removal operations.

D. Demolish, remove, demount, and disconnect inactive and obsolete piping, fittings and specialties, equipment, ductwork, controls, fixtures, and insulation.

1. Piping and ducts embedded in floors, walls, and ceilings may be abandoned in place if they do not interfere with new installations. Cut back to at least one inch below finished surface.
2. Remove materials above accessible ceilings.
3. Drain and cap items to remain behind finished surfaces.
4. Patch and repair surface materials as required in Division 01 and Section 23 01 01 article, “Cutting and Patching.”

E. Remove anchors, bolts, and fasteners associated with piping and equipment to be removed.

3.21 ITEMS FOR SALVAGE

A. Items to be salvaged shall be identified by HCPSS staff during construction.

B. Remove items to be salvaged in a manner to prevent damage. Pack or crate if required to protect the items from damage in storage.

D. Items to be salvaged: Identify contents of crates. Repair items damaged during removal or replace with new to match existing. Deliver to location where directed.

3.22 DISPOSAL

A. Dispose of equipment and materials removed, and rubbish and waste material, as work progresses. Do not allow demolition debris to accumulate on site. Remove products of demolition from the building daily.

3.23 PROTECTION

A. Provide adequate and positive protection to existing building and equipment that is to remain, particularly to prevent entry of either dust or water. Ensure weathertightness at all times. Keep standby patching materials on hand to patch and maintain protection as required.

END OF SECTION

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SECTION 23 05 05 - EQUIPMENT CONNECTIONS FOR HVAC

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Equipment connections for HVAC and Owner-provided equipment.

1.14 RELATED SECTIONS

A. Piping connections: Section 23 05 00.

B. Lists of accessories: Suppliers of equipment specified in other divisions.

C. Wiring connections: Section 26 05 21.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Any product required for connection but not specified in other sections.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Connect to HVAC equipment. Install valves, balancing cocks, thermometer wells, gage tappings, control valves, air vents, strainers, and appurtenances as shown on diagrams on drawings and specified under other sections of the specifications.

B. Connect to owner-supplied equipment requiring water, gas, or other piping connections, that is specified, furnished and set in place in other divisions or listed on the drawings.

C. Provide water supply shutoff valves, gas shutoff valves, and unions at each item of equipment. Where exposed adjacent to chromium-finished piping, the water shutoff valves shall be chromium plated.

END OF SECTION

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SECTION 23 05 06 - CURBS AND FLASHINGS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Curbs, rails, and flashing devices for HVAC items and equipment penetrating roof and mounted on roof.

B. Sound deadening materials for curbs supporting equipment.

1.14 RELATED SECTIONS

A. Rough carpentry: Division 06.

B. Condensing units: Section 23 63 13.

C. Air-handling units: Section 23 73 22.

D. Dedicated outdoor air system units: Section 23 72 00.

E. Fans: Section 23 34 00.

F. Ductless split-system units: Section 23 81 27.

G. Ductwork: Section 23 31 13.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings: Roof curbs and rails, showing compatibility with roof membrane, insulation, and slope, and configuration for the supported equipment.

1. If curbs are provided by curb manufacturer, coordinate with approved shop drawings provided as specified in related equipment sections, to determine configuration of equipment requiring curb support.

C. Product data: Each type of manufactured unit, accessory, and accessory material.

D. Certifications: For sound deadening materials, statement signed by the Architect stating that he or she has inspected the installation of sound deadening materials in the roof curb(s) for rooftop unit(s) which include compressors and that the installation is in accordance with the specifications and drawings.

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1.40 QUALITY ASSURANCE

A. Curbs and rails may be the product of the manufacturer of the equipment they support, or of a roof curb and support manufacturer, provided they are equal to the products of the named manufacturers and meet this specification.

1.70 SEQUENCING

A. Coordinate installation of rooftop equipment and supports with roof structure and membrane. Loads and penetrations shall not exceed or damage structural capacity or weathertightness.

PART 2 - PRODUCTS

2.10 MATERIALS

A. Wood-preservative-treated lumber: As specified in Division 06 and in Section 23 05 00.

1. Application: Treat items indicated on the drawings, and the following:

a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.

B. Sound control accessory materials:

1. Sealant: One-part nonsag urethane sealant, equal to Sika Corp. “Sikaflex-1a,” Sonneborn “Sonolastic NP1,” or Tremco “Dymonic.”

a. Bond breaker: Polyethylene, or as recommended by sealant manufacturer.

2. Exterior gypsum soffit board: 0.5-inch-thick.
3. Embedding compound: As recommended by gypsum board manufacturer.
4. Acoustical lining: ASTM C 1071, Type II, rigid, 2 inches thick, ASTM C 423 (Type A mounting) NRC at least 0.95.

2.21 PENETRATIONS OF GROUPS OF PIPES

A. Provide a curb and cover as detailed on drawings.

2.22 CURBS AND RAILS

A. Basis-of-design product: Subject to compliance with requirements, provide the specified product or comparable product by one of the following:

1. Curbs Plus, Inc.
2. Pate Co.
3. Roof Products & Systems (RPS) Corp.
4. ThyCurb Division, ThyBar Corp.

B. Fabricate each curb and rail in accordance with certified equipment drawings supplied by the equipment manufacturer, and with details on the drawings. Select style and configuration as required by roof membrane, insulation, and slope.

1. Height: At least 12 inches (305 mm) above top of insulation, except as otherwise shown on drawings.

a. Fans ventilating kitchen hoods: At least 24 inches (610 mm), or more if required to place discharge of fan 40 inches (1016 mm) above roof surface.

2. Steel: 18 gage, galvanized.
3. Construction: Monolithic, with all welded components, fully mitered corners, factory-attached wood nailer, and steel counterflashing.
4. Insulation: Fiberglass board, 3 lbs (48 kg/m^3) density, 1.5 inches (38 mm) thick.

a. Protective liner: On curbs serving duct systems made of aluminum, black steel, or stainless steel, or paint spray booth exhaust, provide liner of the same metal as the duct.

C. Curbs for condensing units 5 tons and smaller: Equal to Pate pedestal curb with solid top and "Dektite" flashing system, size to fit each unit.

1. Top: Plywood of adequate thickness and reinforcement to support unit, covered with no less than 18 gage galvanized steel counterflashing cap.
2. Pipe and conduit flashings: EPDM with ribbed aluminum base with mounting holes for screws, designed for field mounting on curb.

a. Number: One for each pipe and conduit to the supported unit.
b. Size: To suit pipe and conduit required for the unit.

2.72 ROOFTOP PIPE SUPPORT SYSTEM

A. Equal to Caddy "Erico Pipe Pier," UV-protected, closed -cell polyethylene foam block 10.5 by 4 inches, to which is bonded 10.5-inch pipe strut.

B. Provide manufacturer's standard pipe clamps and accessories designed for strut system, as required for size, material, and configuration of air-conditioning condensate lines across roof.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

A. Flashing of roofing felts into clamping devices of sleeves through roof, and flashing and counterflashing of pipe curb assemblies and of roof rails and curbs shall be as specified under Division 07.

B. Securely attach curb to roof construction with a 6-inch-(150-mm) wide wood frame the thickness of the roof insulation, with countersunk flat-head 0.375-inch (10-mm) diameter cadmium-plated through bolts with washer and double nuts on underside of structural framing around roof opening. Secure curb to wood frame with No. 10 cadmium-plated wood screws.

1. Place bolts and screws on maximum 12-inch (305-mm) centers, with no fewer than two for each side of rail, curb, or frame.

C. Where dissimilar metals would come in contact with each other, coat them with bituminous protective coating or other coating compatible with adjacent materials.

3.21 INSTALLING ACCESSORY SOUND-DEADENING MATERIALS

A. Inside the perimeter of the curb, cover roof deck with gypsum board fit in tightly, joints and voids filled in with embedding compound, and edges sealed.

B. Over gypsum board, install two layers of acoustical lining. Install one layer of gypsum board between the two layers of acoustical lining, and one over the top layer of acoustical lining. Fill joints and voids and seal edges of each layer of gypsum board.

C. Applying sealant:

1. Clean surfaces and install bond breaker.
2. Install sealant to a maximum depth of 0.5 inch, minimum depth 0.25 inch. Sealant is moisture-cured; assure adequate exposure to air.

D. Protect sound-deadening materials from weather until equipment has been installed and flashed weathertight.

3.22 INSTALLING ROOFTOP PIPE SUPPORT SYSTEM

A. Where air-conditioning condensate lines cross roof from equipment to drain, support on rooftop support system.

B. Use clamps and fasteners compatible with piping.

C. Follow manufacturer’s instructions.

3.60 FIELD QUALITY CONTROL

A. Notify the Architect at least two days in advance of the time when the installation of sound-deadening materials will be complete. Do not cover the work until the Architect has inspected it and signed the certificate required in the article “Submittals” in Part 1 above, stating that the installation of sound deadening is in accordance with the specifications and drawings.

END OF SECTION

SECTION 23 05 07 - FIRESTOPPING FOR HVAC WORK

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Through-penetration firestopping in fire-rated construction.

B. Through-penetration smoke-stopping in smoke partitions.

1.14 RELATED SECTIONS

A. Sections specifying requirements for LEED rating are specified in Division 01.

B. Sleeves and plates: Section 23 05 02.

C. Ductwork: Section 23 31 13.

1.20 REFERENCES

A. Underwriters Laboratories

1. UL Fire Resistance Directory
2. UL 1479: Through Penetration Firestops.

B. American Society for Testing and Materials Standards:

1. ASTM E 814: Standard Test Method for Fire Tests of Through-Penetration Firestops.

1.21 DEFINITIONS

A. Assembly: Particular arrangement of materials specific to given type of construction described in referenced documents.

B. Barriers: Time-rated fire walls, smoke barrier walls, time-rated ceiling/floor assemblies and structural floors.

C. Firestopping: Methods and materials applied in penetrations and unprotected openings to limit spread of heat, fire, gasses and smoke.

D. Penetration: Opening or foreign materials passing through or into barrier or structural floor such that full thickness of rated materials is not obtained.

E. Sleeve: Metal fabrication or pipe section extending through thickness of barrier and used to permanently guard penetration. Sleeves are described as part of penetrating system in other sections and may or may not be required.

F. System: Specific products and applications, classified and numbered by the rating agency to close specific barrier penetrations.

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1.25 SYSTEM DESCRIPTION

A. Design requirements

1. Fire-rated construction: Maintain barrier and structural floor fire resistant ratings including resistance to cold smoke at all penetrations.
2. Smoke barrier construction: Maintain barrier and structural floor resistance to cold smoke at all penetrations.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. LEED submittal:

1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For penetration firestopping, including printed statement of VOC content and chemical components.

C. Product data: Manufacturer's specifications and technical data including the following:

1. Detailed specification of construction and fabrication.
2. Manufacturer's installation instructions.

D. Shop drawings: Submit firestop assemblies and devices for all openings and through penetrations in fire-rated construction. Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, plus the following specific requirements.

1. Details of each proposed assembly identifying intended products and applicable rating agency classification.
2. Manufacturer or manufacturer's representative shall provide qualified engineering judgments and drawings relating to conditions where rated assemblies do not exist.

E. Quality control submittals:

1. Statement of qualifications.

F. Applicators' qualifications statement:

1. List past projects indicating required experience.

G. Certifications: Letters or forms showing acceptance by local authorities for systems without acceptance by a rating agency.

1.40 QUALITY ASSURANCE

A. Products and assemblies shall be tested and labeled by an independent, nationally recognized testing and labeling authority.

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B. Comply with requirements for LEED certification specified in Division 01.

C. Installer's qualification: Firm experienced in installation or application of systems similar in complexity to those required for this project, plus the following:

1. Acceptable to or licensed by manufacturer, state, or local authority where applicable.
2. At least 2 years experience with systems.
3. Successfully completed at least 5 projects of comparable scale, using these systems.

D. Local and state regulatory requirements: Obtain acceptance for proposed assemblies not conforming to specific rating agency classifications or rated assemblies.

E. Materials shall have been tested to provide fire rating at least equal to that of the construction in which they are to be installed.

F. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.

1.50 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:

1. Deliver products in original unopened packaging with legible manufacturer's identification.
2. Coordinate delivery with scheduled installation date, allow minimum storage at site.

B. Storage and protection: Store materials in a clean, dry, ventilated location. Protect from soiling, abuse, moisture and freezing when required. Follow manufacturer's instructions.

1.60 PROJECT CONDITIONS

A. Existing conditions:

1. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.
2. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.

B. Environmental requirements:

1. Furnish adequate ventilation if using solvent.
2. Furnish forced-air ventilation during installation if required by manufacturer.
3. Keep flammable materials away from sparks or flame.
4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.
5. Comply with manufacturing recommendations for temperature and humidity conditions before, during and after installation of firestopping.

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1.80 WARRANTY

A. General project warranty and correction period, as required in general conditions and Division 01, requires repair or replacement of materials or systems which fail in joint adhesion, co-adhesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, or general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers and products: Those listed in the UL Fire Resistance Directory for the UL System involved, or rated for the application by Warnock Hersey or by another acceptable rating agency.

2.20 THROUGH-PENETRATION FIRESTOPPING OF FIRE-RATED CONSTRUCTION

A. Provide systems or devices listed and labeled by a rating agency, and conforming to the construction type, penetrant type, annular space requirements and fire rating involved in each separate instance. The system shall be symmetrical for wall applications. Systems or devices shall be asbestos-free.

1. Additional requirements: Withstand the passage of cold smoke either as an inherent property of the system or by the use of a separate product included as a part of the rated system or device, and designed to perform this function.

2.22 SMOKE-STOPPING AT SMOKE PARTITIONS

A. Through-penetration smoke-stopping: Any system complying with the requirements for through-penetration firestopping in fire-rated construction is acceptable, provided that the system includes the specified smoke seal or will provide a smoke seal. The length of time of the fire resistance may be disregarded.

2.70 ACCESSORIES

A. Fill, void or cavity materials and forming materials: Classified for firestopping use, or included in a rated firestopping assembly, by a rating agency.

PART 3 - EXECUTION

3.02 EXAMINATION

A. Verification of conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.

1. Verify barrier penetrations are properly sized and in suitable condition for application of materials.

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2. Do not proceed until unsatisfactory conditions have been corrected.

3.05 PREPARATION

A. Clean surfaces to be in contact with penetration seal materials, of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.

3.20 INSTALLATION

A. Provide firestop devices or assemblies for every opening and penetration in floors or fire-rated construction.

B. Install penetration seal materials in accordance with printed instructions of the rating agency and in accordance with manufacturer's instruction.

C. Ensure an effective smoke barrier in each sealed penetration. Install smoke stopping as specified for firestopping.

D. Protect materials from damage on surfaces subject to traffic.

E. Where large openings are created in walls or floors to permit installation of pipes, ducts, or other items, close unused portions of opening with firestopping material tested for the application.

3.60 FIELD QUALITY CONTROL

A. Examine penetration seals to ensure proper installation before concealing or enclosing them.

B. Keep areas of work accessible until inspection and acceptance by applicable authorities.

C. Before substantial completion, patch and repair firestopping cut or penetrated by other construction work.

3.70 ADJUSTING AND CLEANING

A. Clean up spills of liquid components.

B. Neatly cut and trim materials as required.

C. Remove equipment, materials and debris, leaving area in undamaged, clean condition.

END OF SECTION

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SECTION 23 05 08 - HVAC PIPING SPECIALTIES

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Specialties for piping systems.

1.14 RELATED SECTIONS

A. Piping: Sections 23 11 23 and 23 21 13.

B. Access doors: Section 23 05 03.

C. Expansion tanks and air separators: Section 23 05 09.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: For each specialty included in the work. Include rated capacities of selected equipment and manufacturer's installation instructions where applicable. Indicate materials, finishes, dimensions, required clearances, methods of assembly of components; and piping and wiring connections.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Flexible connections, NPS 2.5 through 12:

1. Amber/Booth
2. Dunlop, Inc.
3. Garlock Mechanical Packing Division
4. Mason Industries, Inc.
5. Metraflex
6. US Hose Corporation/Senior Flexonics

B. Gaskets:

1. Garlock Mechanical Packing Division
2. Manville

C. Dielectric nipples:

1. Anvil International
2. Elster Perfection
3. Precision Plumbing Products, Inc.
4. Sioux Chief Manufacturing Company, Inc.

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5. Victaulic Company of America

D. Water strainers:

1. Keckley
2. Mueller Steam Specialty
3. Spirax Sarco Inc.
4. Tate Andale, Inc. “Guardian”
5. Watts Industries, Inc.

E. High-capacity automatic air vents:

1. Amtrol Inc.
2. Hoffman Specialty Div. of ITT Industries
3. Spirax Sarco Inc.
4. Spirotherm, Inc.
5. Taco, Inc.

F. Automatic air vents:

1. Hoffman Specialty Div. of ITT Industries
2. ITT Bell and Gossett
3. Spirax Sarco Inc.
4. Spirotherm, Inc.
5. Taco Inc.

G. Manual air vents:

1. ITT Bell and Gossett
2. Taco, Inc.

H. Chemical feeder:

1. Neptune Chemical Pump Company
2. Vulcan Laboratories Inc.

2.21 FLEXIBLE CONNECTIONS, WATER

A Flexible connections NPS 1.5 through 12 (DN 40 through 300) for base-mounted pumps: Equal to Mason Industries, Inc. Type SFEJ. Units shall have Class 150 flanged ends with multi-layered kevlar tire cord fabric reinforced with peroxide cured EPDM cover, liner and fabric frictioning. Connectors shall be installed with control rods designed with 1/2 inch (12 mm) thick neoprene washer bushings large enough in diameter to withstand the thrust at 1000 psi (70 kg/cm^2) maximum on the washer area. Bursting pressure shall be a minimum of three times Operating Pressures. Allowable movements and pressures shall be in accordance with the following:

Pipe Size NPS (DN)	Length Face to Face Inches (mm)	Axial Compression Inches (mm)	Axial Elongation Inches (mm)	Transverse Movement Inches (mm)	Angular Deflection Degrees (Rad)	Operating Pressures Psi (Bar) at Operating Temperatures 170F(77C)	250F(121C)
1.5 (40)	4.0 (102)	0.625 (16)	0.5 (12)	0.375 (9.5)	21 (0.37)	250 (17)	215 (14)
2 (50)					20 (0.35)		
2.5 (65)					19 (0.33)		
3 (75)					18 (0.31)		
4 (100)					17 (0.30)		
5 (125)					16 (0.28)		

B. Flexible connections NPS 2 (DN 50) and smaller: Equal to Senior Flexonics Series BSN, stainless steel with threaded ends in steel pipe and Series BRC, bronze with solder ends in copper pipe.

C. Flexible connections NPS 2.5 through 12 (DN 65 through 300): Equal to Metraflex Company Type MLP. Units shall have 150 psi flanged ends with corrugated Type 321 stainless-steel inner tube and stainless-steel wire braid outer shield.

2.24 GASKETS, UNIONS, AND DIELECTRIC NIPPLES

A. Gaskets for flanged joints: Cross-laminated long fiber composition suitable for service, temperature, pressure and liquid with which they come in contact.

B. Unions NPS 2 (DN 50) and smaller: Malleable iron, Class 150, ASME B16.39, equal to Anvil International with ground bronze seats, or soldered type brass unions of equal quality.

C. Dielectric nipples:

1. General: Completely isolate dissimilar metals so that electric current is below 1 percent of the galvanic current which would exist with metal-to-metal contact. Gaskets approved for the medium carried by the piping system.
2. Dielectric nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain or threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 degrees F (107 degrees C).
3. Grooved piping: "Dielectric Waterway Fittings" equal to Victaulic Co. "Clearflow" steel threaded ends or thread to Victaulic groove with opaque, high-temperature thermoplastic copolymer liner designed for use at temperatures up to 225 degrees F (107 degrees C) and pressure up to 300 psi (2068 kPa). Complete with ring groove to lock steel casing to plastic liner.

2.25 WATER SPECIALTIES

A. Y-type strainers:

1. Equal to Spirax Sarco Model IT threaded or Model CI flanged.
2. For use in copper piping: Spirax Sarco Model BT threaded.

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3. Screens in Y-type strainers: Stainless-steel having maximum 0.045-inch (1.2-mm) perforations.

B. High-capacity automatic air vent: For releasing air from hot or cold water lines. Float-operated type with minimum 7 cfm (3.3 L/s) capacity.

1. Materials: Cast-iron body and cover; stainless-steel valve pin and seat, and float; gasket conforming to ASTM F 104; high-strength steel cap screws.
2. Operating limits: Maximum pressure 250 psig (1725 kPa); maximum temperature 300 degrees F (149 degrees C); hydrostatic pressure to 350 psig (2415 kPa).

C. Automatic air vent: Water vent designed for use on high pressure hot or cold water mains. Includes safety drain connection for discharging moisture entrained in the vented air. Tapped at top for 1/8-inch IPS (DN 6) built-in check valve.

1. Materials: Cast brass body.
2. Operating limits: Maximum operating pressure 150 psi (1035 kPa); hydrostatic pressure to 450 psi (3105 kPa).

D. Manual air vent: 150 psig (1035 kPa) working pressure, 212 degrees F (100 degrees C) maximum operating temperature.

E. Pressure relief valves: ASME rated, NB approved, automatic reseating type conforming to ANSI Z21.22.

1. Provide straight pressure type where installed in pipe lines and for protection of coils and cold water vessels.
2. Provide combination pressure and temperature type where installed for hot water tanks and vessels.

2.27 CHEMICAL FEEDER

A. Five gallon capacity, cast-iron or welded-steel body, rated for pressure of 200 psi, complete with capped filling opening, connections, inlet, outlet and drain valves, and accessories, as detailed on the drawings.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

A. Plastic piping specialties are not permitted in HVAC system ceiling plenums or shafts used to convey building HVAC air distribution.

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3.21 INSTALLING FLEXIBLE CONNECTIONS

A. Make connections to base-mounted heating and chilled water pumps and to air-handling units with flexible connections, unless coils in air-handling units are otherwise isolated. Flexible connections may also be used in connections to other equipment to provide for proper alignment of piping with connection flange on equipment. Piping on house side of flexible connections shall be securely anchored.

3.23 INSTALLING GASKETS, FITTINGS, AND DIELECTRIC NIPPLES

A. Gaskets shall be installed in accordance with manufacturer's recommendations.

B. Pipe connections to fixtures, control valves, equipment and appliances shall be provided with unions or flanges so that the units may be disconnected and replaced without damage to the pipe.

C. Provide dielectric nipples between copper and steel piping NPS 0.5 through 2.5 (DN 15 through 65).

3.24 INSTALLING WATER SPECIALTIES

A. Provide specialties for each piping system and for heat transfer elements, as indicated.

B. Install valves, Y-type strainers, balancing fittings, vacuum breakers, and appurtenances for unit heaters, heating and cooling coils, and heating and cooling elements.

C. Automatic fill for the hydronic systems shall be as diagramed on the drawings. The pressure-relief valves shall be line size and adjusted to the pressures indicated on the drawings.

D. In hydronic systems, provide automatic air vents where indicated and at each high point in piping. Provide 0.375-inch (DN 10) copper tubing from each automatic vent to discharge into main relief lines which discharge into nearest service tank or floor drain. Provide high-capacity type near expansion tank or air separation tank and where indicated. Install manual air vents at each terminal unit.

E. Install relief valves for devices where required by governing codes. Relief valve discharge shall be piped as indicated or to the nearest floor drain or to within six inches of the floor beside unit.

3.26 INSTALLING CHEMICAL FEEDER

A. Install on steel angle supports, complete with connections and accessories, as shown on the drawings. Assure that cap is in place and operable.

END OF SECTION

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SECTION 23 05 09 - HVAC EXPANSION SYSTEM

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Precharged bladder-type expansion tank and tangential air separator with vent.

B. Buffer tank.

1.14 RELATED SECTIONS

A. Piping: Section 23 21 13.

B. Supports: Section 23 05 29.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Each type of expansion system or tank, including each relief and air separation device and all accessories.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide the specified and scheduled products or comparable products by one of the following:

1. Expansion and buffer tanks:

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc
    c. Bell and Gossett Domestic Pump Div of ITT
    d. Taco
    e. Wessels

2. Tangential air separators:

    a. Amtrol, Inc
    b. Bell and Gossett Domestic Pump Div of ITT
    c. Patterson
    d. Taco

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2.31 BLADDER-TYPE EXPANSION TANK

A. Pressurized bladder-type tank, Taco CA or CBX model number scheduled on the drawings, containing impermeable bladder which separates the air cushion from the system water. Operating temperature: 240 degrees F maximum. Precharge to system fill pressure.

B. Shell: Welded steel, constructed, tested and stamped in accordance with ASME BPV for Unfired Pressure Vessels for a working pressure of 125 psi (860 kPa), Lined with protective coating.

C. Bladder: Butyl rubber, flexible but not stretchable under working conditions, removable for inspection.

D. Size and capacity: Shown on the drawings.

E. Supports: For horizontal or vertical support on concrete equipment foundation, as diagramed on the drawings.

2.32 BUFFER TANK

A. Buffer tank, Taco BTL model number scheduled on the drawings. Operating temperature: 240 degrees F maximum.

B. Shell: Welded steel, constructed and tested in accordance with ASME Code Section VIII, Division 1. Unfired pressure vessels for a working pressure of 125 psi (860 kPa).

C. Size and capacity: Shown on the drawings.

D. Supports: For vertical support on concrete equipment foundation, as diagrammed on the drawings.

E. Provide factory installed insulation on each tank.

1. For chilled water: 1-inch armaflex.

2.34 TANGENTIAL SEPARATOR

A. Air separator: Amtrol, Bell & Gossett, or Taco tangential type, designed to eliminate free and entrained air from the system.

B. Construction: Welded black steel, ASME constructed and labeled for 125 psig (860 kPa) working pressure.

1. Connections:

a. NPS 2 (DN 50) and smaller: Threaded.
b. NPS 2.5 (DN 65) and larger: Flanged.

2. Air-removing element: Perforated stainless-steel air collector tube.
3. Size: Line size unless otherwise noted on the drawings.

2.36 AUTOMATIC AIR VENT

A. As specified in Section 23 05 08, HVAC Piping Specialties. Float type vent, size and capacity recommended by manufacturer for tank and system.

PART 3 - EXECUTION

3.21 INSTALLING EXPANSION AND BUFFER TANKS

A. Follow manufacturer's instructions and recommendations.

B. Install piping, air separation apparatus, and vents as diagramed on drawings.

C. Install supports as shown on drawings.

3.23 INSTALLING TANGENTIAL AIR SEPARATOR

A. Suspend from overhead hanger.

B. Provide automatic air vent and install drain pipes between vent and floor drain.

1. Discharge piping from automatic air vent shall be piped to glycol feeder reservoir.

C. Make automatic fill connection from cold water main to system, as shown on diagrams.

3.75 CLEANING

A. Remove and clean air separator air-removing element after 24 hours operation, and after 30 days operation.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

END OF SECTION

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SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Unless otherwise specified in a particular section or required for a particular application, motors shall conform to the following requirements, whether factory-installed or field-installed.

1.13 PRODUCT FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Motor capacitors: Section 26 05 21, Wiring Connections.

1.14 RELATED WORK SPECIFIED ELSEWHERE

A. Pumps: Sections 23 21 23.

B. Chillers: Section 23 64 19.

C. Condensing units: Section 23 63 13.

D. Air-handling units: Section 23 73 22.

E. Unit heaters: Section 23 82 39.

F. Dedicated outdoor air system units: Section 23 72 00.

G. Fans: Section 23 34 00.

H. Ductless split-systems: Section 23 81 27.

I. Fan-coil units: Section 23 82 19.

J. Variable frequency drives: Section 26 29 23.

K. Variable-refrigerant-flow systems: Section 23 81 28.

L. Packaged rooftop units: Section 23 74 13.

1.20 REFERENCES

A. NEMA MG 1: Motors and Generators.

B. NEMA MG 10: Energy Management Guide for Selection and Use of Polyphase Motors.

C. NEMA MG 11: Energy Management Guide for Selection and Use of Single-Phase Motors.

D. UL 508: Industrial Control Equipment.

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1.21 DEFINITIONS

A. Energy efficient motor: Motor meeting the nominal and minimum efficiency levels listed for its horsepower and speed in Table 12-10 of NEMA MG 1.

B. Nominal efficiency: Efficiency as defined in Table 12-8, Efficiency Levels, in NEMA MG 1, and identified on the motor nameplate.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data:

1. Motors and drives not provided with equipment: Show nameplate data and ratings; characteristics; mounting arrangements; size and location of winding termination lugs, conduit entry, and grounding lugs, and coatings.
2. Motor capacitors.

C. Wiring diagrams required for the proper installation of mechanical equipment.

D. Submit product data which verifies compliance with ASHRAE 90.1 or provide certified performance ratings by a qualified independent testing agency.

E. Certifications:

1. Actual motor power factor for each motor, certified test results for each motor proposed for use on this project.
2. Field test showing corrected power factor, if required.
3. Motors controlled by variable frequency controllers: Certification that motor meets specified requirements.

1.40 QUALITY ASSURANCE

A. Actual motor power factor shall be tested and certified by an independent testing laboratory.

B. Where power factor is field tested as required in “Power Factor” in Part 2 below, specialist performing tests shall be acceptable to the local authorities having jurisdiction.

C. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

D. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

1.44 REGULATORY REQUIREMENTS

A. Motors shall conform to the requirements of NEMA MG1 and applicable portions of the National Electric Code (NEC, NFPA 70).

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PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Motors:

1. Baldor Electric Co.
2. Marathon
3. Rockwell
4. Siemens
5. A.O. Smith
6. Toshiba International

B. Motor capacitors:

1. ABB Power Distribution
2. Commonwealth Sprague
3. General Electric

2.20 BASIC MOTOR REQUIREMENTS

A. Capacity: Each motor shall have sufficient capacity and torque to start, accelerate, and operate the machine it drives without exceeding the motor nameplate rating at the speed specified, or at any speed and load which may be obtained by the drive actually furnished.

B. Starting: Each automatically controlled motor shall be capable of starting as frequently as the control sequence may demand. Motors not automatically controlled shall be capable of making no fewer than 4 starts per hour.

C. Loads: Belt-connected motors shall be equipped with shafts and bearings designed to withstand both the normal connected loads of the drive furnished, and momentary loads imposed during acceleration.

D. Ratings: Motors shall be rated for continuous duty at 100 percent of rated capacity, and temperature rise shall be based on ambient temperature of 40 degrees C.

E. Phase: Unless otherwise indicated, motors one-half horsepower and larger shall be polyphase and motors smaller than one-half horsepower shall be single-phase motors.

F. Motor construction:

1. Motors for fans, air handling units, dedicated outdoor air system units and pumps, unless specified otherwise in the equipment section, shall be open drip-proof NEMA design B construction.

G. Efficiency: The term “energy efficient” is defined in the article “Definitions” in Part 1 above.

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1. Single-phase motors, alternating-current fractional horsepower, rated 1/20 to 1 horsepower, 250 volts or less: NEMA MG 11, types and efficiencies selected for their applications.
2. Polyphase motors, medium alternating-current, squirrel-cage, 1 to 500 horsepower, 600 volts or less: NEMA MG 10, energy-efficient types selected for their application. Nominal full-load efficiencies shall meet or exceed ratings of Table 12-10 of NEMA MG 1.
3. Motors for packaged hermetic and semi-hermetic refrigeration compressors need not comply with these efficiency requirements but they shall comply with the requirements indicated for power factor and power consumption.

2.21 SINGLE-PHASE MOTORS

A. Permanent split-capacitor split-phase with rheostat type speed control, or electronically commutated motor (ECM) type.

B. Bearings: Sealed, prelubricated ball-bearing type.

2.22 POLYPHASE MOTORS

A. NEMA MG1 Design B.

B. Stator: Copper windings.

C. Rotor: Squirrel cage.

D. Bearings: Doubly shielded, prelubricated ball bearings suitable for radial and thrust loading of connected equipment.

E. Temperature rise shall not exceed insulation rating.

F. Insulation: Class F.

G. Motors used with inrush controllers: Match wiring requirements for indicated controller with required motor leads brought to motor terminal box to suit control method.

H. Horsepower/frame relationship: NEMA Standard for T frame motors.

I. Motor frame and endshields: Cast iron.

J. Conduit box: Either steel or aluminum, diagonally split and rotatable in 90-degree increments, with grounding provision.

K. Finishes:

1. External hardware: Plated to resist corrosion.
2. External paint: Industrial enamel.

L. Nameplates: Stainless steel or aluminum, and stamped in accordance with NEMA MG1. Nameplate information shall include the nominal efficiency value in accordance with NEMA MG1 and the manufacturer's minimum guaranteed efficiency value.

2.23 ELECTRONICALLY COMMUTATED MOTOR (ECM)

A. Brushless DC type motor with permanently lubricated heavy-duty ball bearings, electronic commutation, and designed for synchronous rotation.

B. Operated by an integrated controller/inverter, the motor speed shall be controllable down to 20 percent of full speed and 85 percent efficient at all speeds.

2.25 MOTORS CONTROLLED BY VARIABLE FREQUENCY DRIVES

A. Specifically constructed and warranted by the manufacturer to meet the voltage requirements of NEMA MG 1, Part 31.4.4.2.

B. Temperature rise: Match rating for Class B insulation.

C. Insulation: Class B or F (TEFC), or Class F (ODP).

D. Bearing protection: Conductive shaft grounding ring, equal to Aegis SGR by Electro Static Technology, to transmit induced current from shaft to motor frame without harming bearings.

2.26 POWER FACTOR

A. Power factor for three-phase motors 10 HP and larger and packaged equipment systems totaling 10 HP and larger as noted below shall be not less than 90 percent at full rated load. Test, certify, and submit certified reports for each motor as required in "Submittals" and "Quality Assurance" in Part 1 above.

1. Should the Contractor propose to provide motors with less than 90 percent power factor, provide power-factor-correcting, automatically discharging type motor capacitors. The corrected power factor of the motor-capacitor combination shall be equal to or greater than 90 percent. Submit certified test results.
2. Motor capacitor: Designed for installation at the load side of motor starters; insulated, impregnated component unit completely enclosed in a grounded steel case with welded and ground seams. Where installed on outdoor equipment, case shall be weatherproof. Provide each unit with a flexible cable for connection to the starter or motor terminals. The capacitor shall be suitable for use in areas with ambient temperatures ranging from minus 10 degrees F to 115 degrees F.

B. Where motors totaling 10 HP and larger are part of packaged equipment system, such as packaged air-conditioning unit or air-conditioning condensing unit, the overall power factor for the entire system package shall be no less than 90 percent. Provide capacitors and appurtenances required to accomplish this power factor as part of the packaged equipment, or furnish separately and wire as work of equipment installation. Capacitors shall be stepped, deenergized, or cycled when the unit is deenergized or the load is varied, to maintain 90 percent power factor.

1. Capacitors provided as part of packaged equipment: If the installation of the capacitors voids the UL label, unit shall be tested. Actual power factor shall be factory-tested and certified test results included in submittals.
2. Capacitors provided separately and wired as work of equipment installation: Unit shall then be field tested to verify actual power factor. Submit field test reports.
3. Tests shall be performed by an electrical testing specialist and in accordance with NFPA 70 (NEC) testing brochure.

C. Motors and packaged equipment systems equipped with variable frequency drives shall not receive power factor correcting capacitors.

2.27 MOTOR DRIVES

A. Motors for belt-driven units shall have adjustable variably pitched cast-iron sheaves to allow a 10 percent increase or reduction in speed for units less than 30 HP and fixed sheaves for units 30 HP and larger. Belts shall be sized for minimum 150 percent BHP. Provide OSHA- and MOSHA-approved type belt guards. Include one change in drive sheave for each unit if necessary to obtain required air quantities and static pressure.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Mount direct-connected motors securely and in accurate alignment. The drive shall be free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.

B. Provide each belt-connected motor with a securely mounted adjustable base to permit installation and adjustment of belts.

C. Mount capacitors shipped separately beside motor connection box as required. Connect in accordance with the requirements of Division 26, Electrical.

1. Test units at full rated load after the installation of the motor capacitors, and submit reports.

D. Provide additional drive and belt changes where required to meet requirements of testing and balancing specified in Section 23 05 93, Testing, Adjusting and Balancing.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

END OF SECTION

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SECTION 23 05 19 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Meters and gages for HVAC systems.

1.14 RELATED SECTIONS

A. Pipe installation and testing: Section 23 05 00.

B. Valve tags and charts: Section 23 05 23.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings: Meter and gage schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gage.

C. Product data: For each type of meter, gage, device, and fitting specified.

1. Scale range.
2. Ratings.
3. Calibrated performance curves.
4. Kit for pressure-temperature connections.

D. Show flow measurement locations on valve charts specified in Section 23 05 23, General-Duty Valves for HVAC Piping.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Meters and gages:

1. AMETEK; U.S. Gage
2. Ashcroft; Dresser Instrument
3. Miljoco Corporation
4. Taco, Inc.
5. H.O. Trerice Co.
6. Weiss Instruments
7. Weksler; Dresser Instrument
8. Onicon (DDC flow meters)

B. Pressure-temperature connections:

1. Miljoco Corporation

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2. Peterson Equipment Company
3. Sisco
4. Texas Fairfax Company
5. H.O. Trerice Co.
6. Utilities Materials and Controls, Inc.
7. Weiss Instruments

2.11 THERMOMETERS

A. General: Industrial, adjustable angle type, accurate to within plus or minus one percent of range span, baked enamel finish, blue reading organic liquid tube, glass or clear acrylic plastic window, dust and moisture tight.

1. Scale size: 9 inches (230 mm).
2. Graduation: To the scale shown on the drawings or of a scale so that the normal working temperature of the system is near the mid-point of the scale.
3. Case: Cast aluminum.

B. Pipe-mounted thermometers: Brass well, separable sockets.

1. Where mounted in insulated piping, thermometers shall have six-inch (150-mm) stem length and sockets with 2.5-inch (64-mm) lagging extension necks. Where mounted in uninsulated piping, they shall have 3.5-inch (89-mm) stem lengths and sockets without lagging extension.
2. Where thermometer wells only are required, provide separable socket with 2.5-inch (64-mm) lagging extension, fitted with attached chain and cap.

C. Duct-mounted thermometers: Perforated aluminum stem, length maximum 24 inches (610 mm) or of length to have end of bulb near center of duct. Provide union flange fitting where stem passes through duct side or unit casing. Provide lagging extension flange on insulated ductwork.

2.12 PRESSURE GAGES

A. Pressure gages shall be accurate to within plus or minus one percent of range span, silver brazed bronze bourdon-tube system, bronze movement, aluminum dial with white background, black graduations and numerals and adjustable pointer, bottom connected.

1. Dial diameter: 6 inches (150 mm).
2. Those installed adjacent to pumps or in pulsating locations shall be provided with pulsating dampeners or snubbers.
3. Case: Cast aluminum or glass filled nylon.

B. Graduation: To the scale shown on drawings, or so pointer is nearly straight up at system normal working pressure.

C. Gages shall be straight pressure type, except gages on suction side of pumps and inlet side of suction strainers shall be compound type.

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D. Gage cock (pressure gage isolation valve):

1. Ball valve: Bronze, three-piece body, full port, with Type 316 stainless steel trim, 150 psi (1034 kPa) saturated steam, 600 psi (4137 kPa) non-shock cold water, oil, or gas, equal to Nibco 595.

E. Pressure gage for fuel gas service: ASME B40.1, Grade A phosphor-bronze Bourdon-tube pressure gage, with bottom connection, designed for pressure 10 psi (69 kPa) and less with 1/10 of 1 psi increments; equal to Trerice No. 760B.

1. Case: Drawn steel or brass, with 2.5-inch (64-mm) diameter glass lens.
2. Connector: Brass, 0.25-inch (DN 8) NPS.
3. Scale: White coated aluminum, with black graduations and markings.
4. Accuracy: Plus or minus 1.6 percent of range.

2.13 COMBINATION PRESSURE-TEMPERATURE CONNECTIONS

A. Combination pressure-temperature connections: Equal to UMAC Universal Lancaster Test Plugs, Peterson “Pete’s Plug,” Sisco, Fairfax P/T Plugs, H.O. Trerice test plugs, or Miljoco test plugs. Plugs shall have self-closing valve which will operate at a temperature up to 300 degrees F (149 degrees C). Body and cap shall be brass, and shall receive either a temperature or pressure probe. Provide with a kit including gages and thermometers in a protective case.

2.20 ELECTROMAGNETIC DDC FLOW METER FOR CHILLED WATER AND HEATING WATER

A. Inline insertion electromagnetic flow-detecting meter coupled to a wall-mounted remote meter controller, equal to Onicon F-3100 Series. Fully digital measurements for volumetric flow, totalized flow, and flow velocity via correlation transit-time mode. Suitable for chilled water and heating water conditions and pipe sizes and wall thicknesses as shown on the drawings.

B. Construction: Carbon-steel body with AISI Type 304 stainless-steel internal flow tube and ANSI Class 150 raised-faced flanged end connections.

C. Controller: NEMA 250 reinforced nylon enclosure, 64- by 128-pixel backlit 2-line alphanumeric LCD graphic display. Complete with cabling to interconnect meters, transmitters, and temperature sensors to controllers.

D. Process liquids:

1. Chilled water from 35 to 80 degrees F and 0 to 200 psig.
2. Heating water from 80 to 150 degrees F and 0 to 200 psig.

E. Temperature transducer: Clamp-on or wetted surface type equal to GE GS868. Provided in thermowells, multiple-wire RTD platinum transducer compatible with flow meter, its controller, and liquid operating conditions.

1. Accuracy: Plus or minus 2 percent.
2. Output: Conditioned pulse and analog 4 to 20 mA current signal.

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3. Sizes: NPS 1-1/2 to 14 (DN 40 to 350).

F. Pressure transmitters: Wetted surface type equal to GE GS868. Provided in thermowells, multiple-wire transmitter compatible with flow meter, its controller, and liquid operating conditions.

1. Accuracy: Plus or minus 2 percent.
2. Output: Conditioned pulse and analog 4 to 20 mA current signal.
3. Sizes: NPS 1-1/2 to 14 (DN 40 to 350).

G. Input-outputs: Meters capable of providing the following flow and energy measurements:

1. Chilled water and heating water:

a. Water temperature, conductivity, and pressure.
b. Water flow in feet per second (m/s), BTU per hour (kW/hour), and gallons per minute (l/s).
c. Totalized flow in the above units.

H. Velocity accuracy: Plus or minus 0.4 percent of range from 3.3 to 33 feet/second (1.0 to 10.1 m/s).

I. Velocity range: Minus 40 to 40 feet/second (minus 12.2 to 12.2 m/s).

J. Communication: Provide BACnet communications card for DCS data transfer.

K. Power: 120 Vac, single phase, 60 Hertz, 35 mA maximum.

L. Output: Conditioned pulse and analog 4 to 20 mA current signals.

M. Sizes: NPS 1 (DN 25) for maximum 85 gpm (5.4 l/s) to NPS 12 (DN 300) for maximum 11,000 gpm (694 l/s).

PART 3 - EXECUTION

3.21 INSTALLING THERMOMETERS

A. Pipe line thermometers shall be installed as indicated on the drawings. Thermometers shall be readable from the floor level.

B. Duct thermometers for air handling units shall be located as follows, except thermometers are not required if air system is not ducted:

1. Roof-top air-handling units: (2 per unit)

a. RA duct: rigid bulb, plus 30 to 180 degrees F (minus 1.1 to plus 82.2 degrees C).
b. Discharge duct: rigid bulb, plus 30 to 180 degrees F (minus 1.1 to plus 82.2 degrees C).

2. Dedicated outdoor air system units: (2 per unit)

    a. CA discharge duct: rigid bulb; minus 20 to plus 130 degrees F (minus 28.9 to plus 54.4 degrees C).
    b. Exhaust air inlet duct: rigid bulb; minus 20 to plus 130 degrees F (minus 28.9 to plus 54.4 degrees C).

C. Furnish and deliver to Owner at final inspection, three additional pipe line thermometers as above specified, with 6-inch (152-mm) stem lengths, for use in the thermometer wells. Range shall be 0 to plus 100 degrees F.

3.22 INSTALLING PRESSURE GAGES

A. Gages shall be readable from the floor level.

B. Each gage connection shall have a gage cock. Connections to pipe lines shall be 0.5 inch (DN 15), with 0.5 inch (DN 15) by 0.25 inch (DN 8) reducer for valve, the assembly of sufficient length to clear insulation.

C. Where gage cocks only are called for on drawings, provide the 0.5-inch (DN 15) connections to pipe line with reducer and the gage cock.

D. Provide one compound and one straight pressure gage of appropriate scale to Owner at final inspection.

3.23 INSTALLING COMBINATION PRESSURE-TEMPERATURE CONNECTIONS

A. Option: Provide combination pressure-temperature connections, complete with kits, where thermometer wells or gage cocks only are called for on the drawings.

3.24 INSTALLING DDC FLOW METERS

A. Install a DDC flow meter as indicated on drawings. When locating the fittings, assure that sufficient straight run of pipe is provided both upstream and downstream from fittings as recommended by the manufacturer for accurate readings. Size of fittings shall be same as pipe size.

1. Provide each fitting with an identification tag as specified for valve tags, giving station identification number, pipe size, meter scale and required flow in gpm (l/s).
2. Show flow meter locations on valve charts specified in Section 23 05 23.
3. Calibrate flow meter during balancing.
4. Provide connection to the building automation system.

END OF SECTION

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SECTION 23 05 23 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Valves for various piping systems.

B. Chainwheel operators.

1.14 RELATED SECTIONS

A. Piping installation and testing: Section 23 05 00.

B. Piping systems: Section 23 21 13.

C. Automatically operating valves: Section 23 05 08.

D. Access doors: Section 23 05 03.

E. Valves for fuel gas system: Section 23 11 23.

1.20 REFERENCES

A. ASME B16.10: Face-to-Face and End-to-End Dimensions of Valves.

B. ASME B16.34: Valves - Flanged, Threaded, and Welding End.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: For each type of valve. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.

C. Maintenance data: For inclusion in operation and maintenance manual specified in Division 01 and Section 23 0101. Include manufacturer's instructions for adjusting, servicing, disassembling, and repairing.

D. Valve charts: Furnish valve charts typed on 8.5 by 11-inch (216 by 279-mm) bond paper, showing locations of all manual and automatic control valves, and flow meters. Include:

1. Number
2. Location
3. Service
4. Function
5. Area served

E. Valve numbering system shall be approved by the Owner prior to final submittal. Place one copy of approved chart in a plastic envelope and mount on wall where directed. Provide another copy for each of the Operating and Maintenance Manuals.

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1.40 QUALITY ASSURANCE

A. Ferrous valves shall conform to ASME B16.10 and B16.34 for dimension and design criteria.

B. Copper alloy valves (brass and bronze) shall have no more than 15 percent zinc in the alloy.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Ball valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:

1. Apollo Valves
2. Milwaukee Valve Co.
3. NIBCO
4. Stockham Valve & Fittings
5. Victaulic Company of America
6. Walworth Co.
7. Watts Regulator Co.

B. High-performance butterfly valves: Subject to compliance with requirements, provide the specified high performance Bray valve, or comparable product by one of the following:

1. Bray Controls; a division of Bray International, Inc.
2. NIBCO
3. DeZurik
4. Jamesbury; a subsidiary of Metso Corporation
5. Victaulic Company of America

C. Check valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:

1. Combination Pump and Valve Co.
2. Mueller Steam Specialty
3. NIBCO
4. Victaulic Company of America

D. Balancing valves: Subject to compliance with requirements, provide specified venturi ball valve (readable) by Flo-Pac or NuTech Hydronic Specialty Products, or comparable product by one of the following:

1. Flow Design
2. Gerand Engineering
3. Griswold Controls
4. Pro Hydronic Specialties
5. Taco
6. Tour & Andersson
7. For sizes specified to be high performance butterfly valves with memory stop and venturi flow-measuring assembly, include specified high performance butterfly valve.

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E. Drain valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:

1. Apollo Valves
2. Milwaukee Valve Co.
3. NIBCO
4. Stockham Valve & Fittings
5. Victaulic Company of America
6. Walworth Co.
7. Watts Regulator Co.

2.20 VALVES

A. Ball valves:

1. Valves NPS 2 (DN 50) and smaller: Class 150 SWP, bronze, two-piece body, full port, TFE seats and seals, stainless-steel ball and stem. Extension handle for use in insulated piping. NIBCO T-585-70-66 or S-585-70-66, threaded or soldered ends.

a. Valves NPS 2.5 to 3 (DN 65 to 80): Conventional port, NIBCO T-580-70-66 or S-580-70-66, threaded or soldered ends.

B. High performance butterfly valves, NPS 2.5 (DN 65) and larger: High-performance lug body.

1. Class 150 suitable for use with ASME B16.5 Class 150 flanges.
2. Bidirectional service at 200 psi (1379 kPa) and maintain bubble-tight rating according to ANSI/FCI 70-2 Class VI or API 598 shutoff against 270 psi operating at cold working temperatures.
3. Body: Carbon steel, for flanged connection with alignment bolts, holes, or guides.
4. Seat: Single-piece, reinforced, PTFE, suitable for continuous operation at 121 degrees C, field-replaceable.
5. Bearings: Stainless-steel, PTFE-backed, self-lubricating.
6. Stem seals: PTFE.
7. Shaft: Type 316 stainless steel, including shaft seat, retaining ring, and fasteners. Double offset shall reduce torque on seat.
8. Disk: Type 316 stainless steel.
9. Operator:

a. NPS 6 (DN 150) and smaller: Ten-position leverlock handle.
b. NPS 8 to 10 (DN 200 to 250): Gear operator (30 to 1 gear reduction).
c. NPS 12 (DN 300): Gear operator (50 to 1 gear reduction).
d. NPS 14 (DN 350) and larger: Gear operator (80 to 1 gear reduction).

10. Provide 2-inch minimum extension handle where required in insulated piping.
11. Where used for balancing, provide memory stop.

C. Center-guided, spring-loaded silent-action type check valves:

1. Valves NPS 2 (DN 50) and smaller: Class 125, bronze body, Teflon disk, Teflon seat ring, stainless-steel stem and spring, NIBCO Fig. S-480Y or T-480-Y, threaded or soldered ends.

2. Valves NPS 2.5 (DN 65) through NPS 10 (DN 250): Class 125, cast-iron body, bronze trim, stainless-steel spring, NIBCO Fig. W-910, wafer style.
3. Valves NPS 12 (DN 300) and larger: Class 125, cast-iron body, stainless-steel spring, NIBCO Fig. F-910, flanged.

D. Swing check valves:

1. Valves NPS 2 (DN 50) and smaller: Class 125, bronze, PTFE seat, renewable disks, Y pattern, horizontal swing, NIBCO T-413-Y or S-413-Y, threaded or soldered ends.
2. Valves NPS 2.5 (DN 65) and larger: Class 125, IBBM, bolted bonnet, renewable seat and disk, horizontal swing NIBCO Fig. F-918-B, flanged ends.

E. Balancing valves:

1. NPS 2 (DN 50) and smaller: Venturi ball valve (readable valve) with threaded or soldered ends, Flo-Pac or Nutech Hydronic Specialty Products Model MB, Taco “Accu-Flo (ACUF),” Gerand “Balvalve-Venturi (BV),” Tour & Andersson STAD Series, Griswold Controls “QuickSet,” FlowDesign Model UA or Pro Hydronic Specialties Model CBV.

   a. Materials: Brass and bronze body, chrome-plated brass ball, PTFE seats and stem packing.
   b. Ratings: Entire assembly 250 psi, 250 degrees F (1725 kPa, 121 degrees C).
   c. Flow element: Low-loss, high-signal venturi section with schrader or quick-connect pressure-ports, reliability one to ten and accuracy 2 percent.
   d. Stem: Blowout-proof.
   e. Memory stop: On valve section, adjustable, with extended handle.
   f. Bellows type meter gage kit with case, provide one for use on the entire project.

2. NPS 2.5 (DN 65) and larger: High-performance Butterfly valve with memory stop coupled with a venturi flow-measuring assembly.

   a. Materials: carbon steel, ASTM.
   b. Ratings: 250 psig at 250 degrees F (1725 kPa, 121 degrees C).
   c. Venturi type flow element: Low-loss, high-signal venturi with schrader or quick-connect pressure ports, accuracy plus or minus 3 percent FS.
   d. Provide Owner, one bellows-type meter gage kit with case for use on the entire project.

2.21 DRAIN VALVES

A. Two-piece full-port ball valve, NPS 0.75 (DN 20), 600 psi (4137 kPa) CWP, 400 deg F (204 deg C) maximum operating temperature, bronze body, PTFE seats and seals, chrome-plated brass ball, threaded hose outlet with brass cap and chain, lever handle. Provide extension handle where used in insulated piping. NIBCO T-585-70-HC or S-585-70-HC; threaded or soldered inlet.

1. Provide a removable handle where valve is accessible to the general public.

2.70 CHAINWHEEL OPERATORS

A. Manufacturers:

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries, Inc.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Sprocket rim with chain guides: Ductile iron or cast iron, of type and size required for valve. Include zinc coating.
2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
3. Chain: Hot-dip, galvanized steel of size required to fit sprocket rim.

C. Chain storage canisters: Non-corrosive canisters for storage of overhead chains, allow for chain loop release in a single downward movement.

1. Canisters: Plastic, safety yellow or orange color, with perforated bottom for drainage and integral release handle, quick-release hooking mechanism and retention lanyard.
2. Attach to each overhead chain loop with 6 feet minimum clearance below canister.
3. Equal to Roto Hammer, Model CHAW “Chain Away.”

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

A. Install valves to be readily accessible for operation and maintenance, and with ample clearance for turning handles or operators.

B. For valves in inaccessible locations, provide access doors as specified in a related section.

C. Identify valves as specified in Section 23 05 00, Common Work Results for HVAC.

1. Provide tags for all valves except stop valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.
2. Provide ceiling identification tags where valves are above an accessible suspended ceiling. Number shall correspond to tag number.

D. Install chainwheel operators on valves NPS 4 (DN 100) and larger and more than 7 feet (2150 mm) above floor. Extend chains to 6 feet (1850 mm) above finished floor elevation.

3.21 INSTALLING SHUTOFF AND BALANCING VALVES

A. Install shutoff and balancing valves where indicated. Generally, install balancing valves in return lines of heating and cooling coils and elements, and shutoff valves in supply lines.

B. Shutoff valves for water piping systems shall be as follows:

1. Sizes NPS 3 (DN 75) and smaller: Ball valves.
2. Sizes NPS 4 (DN 100) and larger: High-performance butterfly valves.

C. Balancing valves: Locate valve to provide 5 pipe diameters straight inlet and 2 pipe diameters straight outlet.

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3.22 INSTALLING CHECK VALVES

A. Provide center-guided, spring-loaded silent-action type check valves in pumped lines, lines subject to pump pressure, and vertical lines.

B. Provide swing-type check valves in gravity lines or horizontal domestic water lines, lines subject to pump pressure, and vertical lines.

3.24 INSTALLING DRAIN VALVES

A. Install drain valves, NPS 0.75 (DN 20) or size indicated on the drawings, at every low point of a water system, and where indicated.

END OF SECTION

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SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Supports for piping systems and equipment.

B. Equipment foundations.

C. Pipe guides and anchors.

D. Accessories.

1.14 RELATED SECTIONS

A. Vibration control supports: Section 23 05 48.

B. Duct supports: Section 23 31 13.

C. Rooftop pipe support systems: Section 23 05 06.

1.20 REFERENCES

A. ASME B31.9: Building Services Piping.

B. MSS SP-58: Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.21 DEFINITIONS

A. Definitions are from MSS SP-58, “Classification of Piping Systems.”

B. Hot Systems: Maximum operating (service) temperatures 120 degrees F (49 degrees C) and above.

C. Ambient Systems: Maximum operating temperatures 60 to 119 degrees F (16 to 48 degrees C).

D. Cold Systems: Maximum operating temperatures 59 degrees F (15 degrees C) and below.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Provide manufacturer’s literature showing compliance with specifications for each type of hanger and manufactured support, including fasteners and accessory materials.

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1.40 QUALITY ASSURANCE

A. Hangers, supports, guides, and anchors shall comply with the requirements of:

1. MSS SP-58.
2. ASME B31.9.

B. Qualifications of welders: As specified in Section 23 05 00, Common Work Results for HVAC.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Hangers

1. Anvil International
2. Carpenter and Paterson, Inc.
3. National Pipe Hanger Corporation
4. PHD Manufacturing, Inc.
5. PHP Systems/Design

B. Support systems

1. Anvil International
2. PHD Manufacturing, Inc.
3. PHP Systems/Design
4. Unistrut
5. Cooper (refrigerant piping)

C. Thermal hanger shields

1. Carpenter and Patterson, Inc.
2. Pipe Shields, Inc.
3. Rilco Manufacturing Co., Inc.

D. Pipe guides

1. Adesco
2. Carpenter and Paterson, Inc.
3. Metraflex Company

E. Anchors

1. Carpenter and Paterson, Inc.
2. Metraflex Company

2.10 CONCRETE

A. Concrete shall be no less than 3000-lb (25,000 kPa) strength.

B. Reinforcement: 6 by 6 inch (150 by 150 mm) welded steel wire fabric, ASTM A 185.

2.11 GROUT

A. Non-shrink grout: Premixed, consisting of non-metallic aggregate, cement, and water-reducing and plasticizing agents; capable of developing minimum compressive strength of 7,000 psi (48,000 kPa) in 28 days.

1. Sonneborn-Rexnord “Sonogrout”
2. L&M Construction Chemical Company “Crystex”
3. US Grout Corporation “Five-Star Grout”

2.20 HANGERS AND SUPPORTS

A. Types are identified by MSS type numbers in the article Installing “Pipe Hangers and Supports” below.

B. Materials for hangers and clamps:

1. For uninsulated copper pipe: Copper plated.
2. For uninsulated steel pipe and all insulated pipe: Galvanized or factory-painted.
3. For refrigerant piping: Clamp inserts, equal to Cooper "B-Line" armafix clamps, suitable for hanger or channel supports.

C. Insulating-insert materials and protection shields:

1. Insulation-insert material for cold piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa); or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier. Insert thickness shall match adjacent piping insulation thickness.
2. Insulation-insert material for hot piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa); ASTM C 552, Type II cellular glass with 100-psig (688-kPa); or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength. Insert thickness shall match adjacent piping insulation thickness.
3. Insert and shield shall cover entire circumference of pipe.
4. Insert length: Extend 2 inches (50 mm) beyond shield.

D. Pipe covering protection saddle: Steel, meeting requirements of MSS SP-58 Type 39, with insulating material located in the space between saddle and pipe.

E. Hanger rod nuts and washers shall be zinc-plated. Hanger rods shall be solid steel, all threaded, and zinc-plated.

F. Channel: Slotted cold-rolled steel, equal to Power Engineering Company PS 150 S, 12 gage with 0.406- by 3-inch (10 by 76-mm) slots on 4-inch (102-mm) centers.

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G. Wall- and floor-mounted supports: Structural support system equal to Power Engineering Company “Power Strut.”

H. Structural shapes: ASTM A 36.

I. Steel pipe: ASTM A 53, Grade B, Type E (electric resistance welded), Schedule 40, black and galvanized steel.

J. Threaded rod: MSS SP-58.

2.22 FASTENERS

A. Fasteners to concrete: Self-drilling type expansion shields or machine bolt drop-in anchors for drilled holes, equal to ITT Phillips Anchors “Red Head.” Fasteners to ceilings shall be vibration and shock resistant. Load applied to fasteners shall not exceed 25 percent of manufacturer’s stated load capacity in 3500 psi (24,000 kPa) concrete.

B. Fasteners to drywall or cavity wall construction: Equal to ITT Phillips Anchors “Red Head” toggle bolts, with hollow wall drive anchors or nylon anchors as required.

C. Fasteners to wood construction: Lag bolts.

D. Bolts, nuts, and washers: ASTM A 307, or ASTM A 325 where high strength is required.

2.23 PIPE GUIDES

A. Pipe alignment guides shall be equal to Carpenter and Paterson Figure 1007 heavy-duty insulating type, consisting of a spider and a housing sleeve, constructed of minimum 0.375-inch-thick (9.5-mm) steel.

2.24 PIPE ANCHORS

A. Anchors shall be fabricated from structural steel conforming to ASTM A 36 as detailed on the drawings; shall conform to applicable ASME codes; and shall be capable of withstanding the forces imposed by the system on anchor points.

B. Anchor pipe shoes: Gusseted, equal to Carpenter and Paterson figure 1120.

PART 3 - EXECUTION

3.20 INSTALLING PIPE HANGERS AND SUPPORTS

A. Types and locations, refer to MSS SP-58:

Type 1: Clevis hanger:

1. Non-steam Hot Systems NPS 0.5 (DN 15) through NPS 8 (DN 200).
2. Ambient Systems and Cold Systems of all sizes.

Type 8: Riser clamp, steel for steel or cast-iron risers and stacks, copper plated for copper risers and stacks.

Type 10: Copper-plated adjustable swivel ring for uninsulated copper piping NPS 0.5 (DN 15) through NPS 4 (DN 100). Use Type 1 for insulated pipe.

Type 18: Malleable iron concrete inserts for supporting hangers from concrete structure.

Type 20: Side beam clamp for attaching hanger rods to structural beams. Use proper size clamp to suit beam flange.

Type 23: C clamp for beams with maximum flange thickness of 0.75 inch (19 mm); for use with single pipes NPS 2 (DN 50) and smaller.

Type 33: Heavy welded steel bracket capable of supporting up to 3,000 lbs (1360 kg), with a Type 9 or Type 1 hanger, for piping along walls.

Type 37: Adjustable pipe stanchion saddle with U-bolt and floor flange anchored to floor, for piping NPS 2 to 12 (DN 50 to 300) supported from floor.

Type 40: Pipe-covering protection shield of proper size to fit insulation, between hanger and insulation:

1. Include structural insulation insert between protection shield and pipe for piping NPS 2.5 (DN 65) and larger.
2. Option: Instead of protection shield and structural insert, provide thermal hanger shield.

B. Trapeze piping supports:

1. Field-fabricated from ASTM A 36 steel shapes.
2. Weld steel according to AWS D-1.1.
3. Size threaded rods in accordance with MSS SP-58.
4. Design trapeze support assembly based on supported load plus a 50 percent safety factor.

C. For hangers requiring vibration control, see Section 23 05 48.

D. Hanger rod sizes:

PIPE SIZE NPS (DN)	ROD SIZE Inches (mm)
Up to 2 (Up to 50)	0.375 (10)
2.5 to 3.5 (65 to 90)	0.5 (15)
4 and 5 (100 to 125)	0.625 (16)

E. Horizontal piping generally shall be supported from above.

1. Attaching to walls: Use two 0.375-inch (9.5-mm) screw-type fasteners for attaching brackets and three 0.5-inch (13-mm) bolt-type fasteners for attaching structural supports.
2. Attaching to existing construction: Where necessary to obtain suitable strength for load on concrete slabs or planks, bolt sections of structural channels to slab or planks, using two or more expansion shields as above, and attach hanger rod to the channel.

    a. Steel joists: Provide structural channels between panel points of at least two joists.
    b. Concrete slabs: Use expansion shields and steel bolt or rod.

3. Attaching to bar joists:

    a. Pipes NPS 2.5 (DN 65) and smaller running parallel with joist: Hanger rods welded to top chord of joist at panel points.
    b. Pipes NPS 2.5 (DN 65) and smaller running perpendicular to joist: Support from every other joist by method of hanging as described above.
    c. Pipes NPS 3 (DN 80) and larger running parallel with joist: Support from a length of structural channel or angle welded to the top cords of at least two joists at panel points.
    d. Pipes NPS 3 (DN 80) and larger running perpendicular to joist: Support from every joist by hanger rods welded to top chord of joist at panel points.
    e. Where large numbers of pipes are grouped together, their individual hangers shall be staggered so as to distribute the load among the available joists.

4. Attaching to concrete slab: Secure hanger rods to malleable iron inserts properly spaced and set on the forms before concrete is poured.
5. Attaching to steel decks: Attach hanger rods to the hanger tabs on underside of deck, or pass them through the steel deck and secure on top side with nut, locknut and plate washer.

    a. Plate washers: 4 by 8 inches by 0.125 inch thick (100 mm by 200 mm by 6 mm) for 0.375-inch and 0.5-inch (10 mm and 15 mm) rods; 6 by 12 inches by 0.187 inch (150 by 305 by 5 mm) thick for 0.625-inch (16-mm) and larger rods.
    b. Top of hanger assembly shall be concealed in the concrete fill which will be placed over the deck.

F. Hangers and supports shall be spaced as follows:

1. Copper pipe:

    a. NPS 1.25 (DN 32) and smaller: At least every 6 feet (1.8 m).
    b. NPS 1.5 and 2 (DN 40 and 50): At least every 8 feet (2.4 m).
    c. NPS 2.5 (DN 65) and larger: At least every 10 feet (3 m).

2. Steel pipe:

    a. NPS 1 (DN 25) and smaller: At least every 6 feet (1.8 m).
    b. NPS 1.25 and 1.5 (DN 32 and 40): At least every 9 feet (2.7 m).
    c. NPS 2 to 6 (DN 50 to 150): At least every 10 feet (3 m).
    d. NPS 8 to 12 (DN 200 to 300): At least every 14 feet (4.3 m).

e. NPS 14 (DN 350) and over: At least every 20 feet (6.1 m).

3. Trapeze hangers:

a. Spacing shall not exceed the requirements for the smallest pipe in the rack.

G. Provide additional hangers or supports for concentrated loads such as flanges, valves, expansion compensators, fittings, and other specialties.

H. Provide hangers as required for insulated piping systems. Coordinate selection of hangers and supports with requirements and selected options for insulation continuous through hanger or butted to each side. Provide pipe covering protection shield and structural insulation insert where insulation is continuous through hangers or supports.

I. Provide pipe risers through floor slabs with riser clamps.

J. Support banks of pipes along the wall on a structural support system.

3.21 INSTALLING EQUIPMENT FOUNDATIONS AND SUPPORTS

A. Provide four-inch (100-mm) -high concrete foundations (housekeeping pads) or as indicated on drawings, reinforced with welded-wire fabric, for floor-mounted equipment and where indicated. Anchor concrete foundations by dowels inserted into the floor slab.

B. Unless otherwise specified, provide concrete foundations, bolts, sleeves, and appurtenances as work of the section where the supported equipment is specified and in accordance with the requirements of Division 03.

C. Equipment shall be properly aligned and leveled, and grouted where necessary. Support piping independently of equipment and so as not to cause a strain or thrust.

D. Coordinate exact size, configuration and location of equipment, foundations, and supports using approved shop drawings of equipment.

3.22 INSTALLING PIPE GUIDES

A. Install guides where indicated on the drawings and where required to properly guide piping at expansion loops and joints.

B. Install guides at distances recommended by the manufacturer, in accordance with MSS SP-58, And where indicated on the drawings.

C. Guides do not support piping and do not serve as hangers or supports in determining spacing of hangers and supports.

3.23 INSTALLING ANCHORS

A. Provide anchors where indicated or required by good piping practice to control pipe movement.

B. Furnish and install heavy structural angle irons, channels, and wide flange beams as required for suitable anchor supports and bracing for the piping. Arrange anchor supports to suit field conditions, to be adequate for the required duty, and to transmit the thrust loads to the building structural system or floor slabs.

1. Black steel pipes shall be welded to the supports for anchoring.
2. Galvanized and copper pipes shall be attached to the supports by pipe clamps. Clamps for copper pipes shall be copper-plated or pipe shall be wrapped with lead sleeves.

END OF SECTION

SECTION 23 05 33 - HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Electric heat tracing cable for protecting piping from freezing.

1.20 REFERENCES

A. NFPA 70 (NEC) Article 427, Fixed Electric Heating Equipment for Pipelines and Vessels.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Heat tracing cable and accessories.

1.40 QUALITY ASSURANCE

A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. The following listed manufacturers provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 23 01 01.

1. Chromalox
2. Delta-Therm
3. Easy Heat, Inc.
4. Pentair Thermal Management
5. Thermon

2.20 ELECTRIC HEAT TRACING SYSTEMS

A. Provide tracing for outdoor winterized piping indicated on the drawings and listed in Part 3 below. Systems shall meet requirements of the National Electrical Code (NEC) (NFPA 70), Section 427.

B. Heating cable: Flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conductive inner core material between two parallel copper bus wires, designed to be cut to length at the job site and for wrapping around valves or complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.

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1. Provide end seals for ends of circuits. Wires at the ends of circuits shall not be tied together.
2. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 36 degrees F (4 degrees C) minimum during winter outdoor design temperature, but not less than the following:

    a. NPS 3 (DN 75) pipe and smaller (with 2-inch (50-mm) insulation): 4 watts per foot of pipe.
    b. NPS 4 (DN 100) pipe and larger (with 2-inch (50-mm) insulation): 8 watts per foot of pipe.

C. Electrical heat tracing accessories:

1. Power supply connection fittings and stainless steel mounting brackets. Provide stainless steel worm gear clamp to fasten bracket to pipe.
2. 0.5-inch (13-mm)-wide fiberglass reinforced pressure-sensitive cloth tape to fasten cable to pipe at 12-inch (305-mm) intervals.
3. Pipe surface temperature control thermostat: Cast aluminum, NEMA 4 (watertight) enclosure, 0.5-inch (13-mm) NPT conduit hub, SPST switch rated for 20 amps at system voltage, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature.
4. Signs: Manufacturer's standard meeting NEC requirements, stamped "ELECTRIC TRACED" located on the insulation jacket at 10-foot (3-m) intervals along the pipe on alternating sides.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Cables shall be secured to pipes with tape under the insulation in accordance with the manufacturers' recommendations.

B. Provide heat cable on the following locations:

1. Exterior piping aboveground and underground to below the frost line:

    a. Chilled water to and from chiller.

2. Interior piping where indicated on drawings:

    a. Drain to evaporator units in freezer.

END OF SECTION

SECTION 23 05 48 - VIBRATION CONTROL SUPPORTS FOR HVAC

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Vibration control supports for HVAC equipment.

1.14 RELATED SECTIONS

A. Hangers and supports: Section 23 05 29.

B. Flexible pipe connections: Section 23 05 08.

C. Flexible duct connections: Section 23 33 00.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: For each type of vibration control support included in the work.

1. For Specification D hanger, include scaled drawing showing degrees of hanger rod swing.

C. Shop drawings: Custom-fabricated supports.

1.40 QUALITY ASSURANCE

A. The vibration isolation materials manufacturer shall be responsible for the proper selection of springs to accomplish the specified minimum static deflections for all spring and pad type isolators based on the weight distribution of equipment to be isolated.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide the specified Mason Industries product, or comparable product by one of the following:

1. Amber/Booth Company, Inc.
2. Kinetics Noise Control
3. Mason Industries
4. Vibro-Acoustics
5. Vibration Eliminator Company, Inc.
6. Vibration Mountings and Controls, Inc.

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2.20 VIBRATION CONTROL SUPPORTS

A. Provide engineered supports for equipment and locations shown on drawings and specified in Part 3 below. The units shall prevent the transmission of vibration and mechanically transmitted sound to the building structure.

1. Select units in accordance with the weight distribution of the equipment, so as to produce reasonably uniform deflection. Deflections shall be as specified.
2. Units installed on exterior shall be galvanized.

B. Specification A: Equal to Mason Industries ND, double-deflection neoprene type. All metal surfaces shall be covered with neoprene and have friction pads both top and bottom. Provide bolt holes for mounting. Provide steel rails where necessary to compensate for equipment overhang.

C. Specification B: Equal to Mason Industries SLFH, free-standing spring isolators, laterally stable without housing, and with 0.5-inch-(13-mm) thick neoprene pads between baseplate and support.
1. Mountings shall have leveling bolts rigidly bolted to equipment.
2. Springs: Spring diameters shall not be less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal of 50 percent of the rated deflection.

D. Specification C: Equal to Mason Industries SLRW, galvanized spring type with neoprene pad top and bottom and with a housing that includes vertical resilient limit stops to prevent spring from extending when weight is removed. The housing shall serve as blocking during erection and the shims shall be removed after spring adjustment.

1. Obtain data from the manufacturer of the supported equipment, and select springs individually to provide equal deflection with uneven point loading of the equipment.

E. Specification D: Equal to Mason Industries Type 30N hangers, combination spring and minimum 0.3-inch (8-mm) deflection neoprene in series.

1. Neoprene element: Molded with a rod isolation bushing that passes through the hanger box.
2. Spring diameters and hanger box lower hole sizes: Large enough to permit the hanger rod to swing through a 30-degree arc before contacting the edges of the hole.
3. Springs shall have a minimum additional travel to solid equal to 50 percent of rated deflection.

F. Specification E: Equal to Mason Industries Type PC30N, same as Specification D, except with adjustment to transfer load to spring while holding supported object at fixed elevation. Include spring deflection indicator.

G. Specification W: Fifty-durometer neoprene waffle pads made from identical rubber grids molded back to back. The interconnections form suction pockets for gripping smooth steel as well as rough surfaces. The square waffle pattern is laid out on 0.5-inch (13-mm) centers to facilitate cutting pads to size in the field without the need for measuring.

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H. Specification X: Equal to Mason Industries WB, horizontal thrust restraint, consisting of a spring element in series with a neoprene pad as described in Specification B with the same deflection specified for the mountings or hangers.

1. Spring element: Contained within a steel frame and designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 0.25 inch (6 mm) movement at start and stop.
2. Furnish the assembly with one rod and angle brackets for attachment to both the equipment and ductwork or the equipment and the structure.
3. Horizontal restraints: Attached at the centerline of thrust and symmetrically on either side of the unit.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

A. Adjust vibration control supports as recommended by manufacturer to eliminate transmission of vibration to building structure or other systems.

B. Replace springs that become permanently deformed with new springs.

C. Provide 0.25-inch (6-mm) structural plate sized as required between isolator and equipment.

3.21 FAN VIBRATION CONTROL

A. Suspended from structure: Provide Specification D hanger, selected for weight, with minimum 1.0 inch static deflection.

3.22 AIR-HANDLING UNIT VIBRATION CONTROL

A. Isolators for air handling units may be provided as part of the unit (internal isolation) as specified in the section, Air Handling Units with Coils, but shall meet the requirements of this section.

B. On roofs: Provide number of Specification B mountings, having at least 1.75 inch (45 mm) static deflection, required to properly support unit and its accessories as recommended by the air-handling unit manufacturer.

1. Unit with fan section isolated from coil and filter section:

a. Provide the Specification B mounting under fan and motor only, bolted to equipment support (housekeeping pad).
b. Provide Specification X mounts on each side between fan and coil section to control fan section thrust upon fan start-up.

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3.25 COMPRESSOR VIBRATION CONTROL

A. Roof-mounted air-cooled condensing units with compressors: Specification C isolators with at least 1.5 inch static deflection and Specification W neoprene pads. Mount and set on equipment support curbs. Coordinate size and location of curbs with equipment manufacturer.

3.27 CHILLER VIBRATION CONTROL

A. Chillers mounted on slab on earth: Specification A with 0.35 inch static deflection.

3.29 VIBRATION CONTROLS ON PIPING

A. Floor-mounted piping to pump: Specification A or B vibration isolator consistent with mounting of nearest isolated equipment.

B. Piping: Provide Specification E vibration control supports in first three hangers at both the suction and discharge of pumps, chillers, compressors, and condensing units, and for the first three hangers on pipes connected to air handling units. The static deflection shall be the same as specified for the mountings under the connected equipment.

1. If piping is connected to equipment mounted on slab on grade and hangs from structure under occupied spaces, the first three hangers shall have at least 0.75 inch (19 mm) deflection for pipe sizes up to and including NPS 3 (DN 80), 1.5 inch (38 mm) deflection for pipe sizes up to and including NPS 6 (DN 150) and 2.5 inch (64 mm) deflection thereafter.
2. Other hangers and mounts shall have a minimum spring deflection of 0.75 inch (19 mm).
3. Locate vibration control supports in hanger rods as close to the overhead supports as practical. On supports with double rods, use two vibration control supports.

END OF SECTION

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SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. The Owner shall engage and the Architect shall approve an independent balancing and testing subcontractor.

B. This section includes testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:

1. Balancing airflow and water flow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
2. Adjusting total HVAC systems to provide indicated quantities.
3. Measuring electrical performance of HVAC equipment.
4. Setting quantitative performance of HVAC equipment.
5. Verifying that automatic control devices are functioning properly.
6. Reporting results of the activities and procedures specified in this section.

1.14 RELATED SECTIONS

A. Testing and adjusting requirements unique to particular systems and equipment are included in the sections that specify those systems and equipment.

B. Field quality-control testing to verify that workmanship quality for system and equipment installation is specified in system and equipment sections.

C. General commissioning requirements: Section 01 80 00.

D. Commissioning FPT: Section 01 80 10.

E. Commissioning requirements: Divisions 01 and 23.

F. Duct accessories (balancing point stations): Section 23 33 00.

1.27 PERFORMANCE REQUIREMENTS

A. Select and obtain approval of the testing and balancing subcontractor at the earliest possible time and before beginning ductwork installation.

B. The testing and balancing subcontractor shall visit the job site periodically, beginning with the initial stages of construction of the mechanical systems, and shall ensure that the necessary devices are properly installed so that specified testing and balancing can be performed.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

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B. Submit qualifications of testing and balancing subcontractor, as required in article “Quality Assurance” below.

C. At the completion of each individual phase of construction, submit electronic interim (pencil copy) balance reports for each system within that phase and any previous phases that were rebalanced. Submit copies to the Engineer and Commissioning Agent for review.

D. At the completion of all phases of construction, submit final certified balance reports for all systems.

E. Submit copies of final repots and certificates as part of the Contract Closeout Submittal Operation and Maintenance Manuals.

1.40 QUALITY ASSURANCE

A. Testing and balancing subcontractor qualifications:

1. Current certified member of the Associated Air Balance Council, or certified by National Environmental Balancing Bureau for air and hydronic systems testing and balancing.
2. Has successfully completed at least five projects of similar size and scope.
3. Not affiliated with any other subcontractor participating in this project. Work performed by the subcontractor shall be limited to testing, adjusting, and balancing HVAC systems.

B. Testing and balancing work shall comply with one of the following standards:

1. National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems, published by the Associated Air Balance Council.
2. Procedural Standards for Testing Adjusting Balancing of Environmental Systems, published by the National Environmental Balancing Bureau.

PART 2 - PRODUCTS

2.30 EQUIPMENT

A. Instruments: NIST traceable electronic type, approved and properly calibrated.

PART 3 - EXECUTION

3.02 VERIFICATION OF CONDITIONS

A. Before beginning balancing, ascertain that systems are ready. Verify that system is complete with fans, pumps, ducts, pipes, dampers, and valves in place and operational for balancing. Verify that filters for regular service are in place, as required in Section 23 41 00, Particulate Air Filtration.

3.05 PREPARATION

A. Witness air duct leakage tests required in Section 23 31 13, Metal Ducts, and advise and approve the methods and instruments used.

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B. Using bench-calibrated instruments, field-calibrate pressure gages and dial-type duct thermometers.

C. Air flow measuring devices shall be field-calibrated in cooperation with the controls contractor prior to executing system air balance.

3.21 BALANCING OF SYSTEMS, GENERAL

A. Tabulate settings of temperature control devices and ascertain that thermostats, controllers, and valves are set at specified or approved positions. Verify and certify that the sequence of operation for each system is as shown on drawings, specified, or approved.

B. Provide all labor and devices necessary for the testing and balancing work.

C. The project will be constructed in multiple phases, as indicated on the drawings. Each system shall be tested, adjusted and balanced at the completion of its particular phase. Where required, systems installed in previous phases shall be adjusted and rebalanced to provide appropriate flows.

D. Existing to remain systems shall be tested, adjusted and balanced to the same requirements of new.

E. Coordinate with the mechanical contractor to correct system or equipment deficiencies and to re-sheave fans to complete balancing.

3.22 AIR SYSTEMS BALANCING

A. Balance all air distribution, supply, return, exhaust, and outdoor air systems and equipment.

B. Test and adjust fans to deliver design airflow at lowest possible speed. Adjust air-handling equipment to deliver the required air volumes. Note that air quantities scheduled on drawings do not include allowances for duct leakage. Preliminary adjustments of fan speed should be slightly in excess of scheduled airflow delivery. Make adjustments by adjusting adjustable sheaves, changing sheaves and associated belts, changing wiring connections of motors, or adjusting speed controller.

C. Test and adjust system to design airflow requirements to the greatest extent possible. Manual volume dampers in ducts shall be adjusted to obtain required airflow rates at grilles, registers, and diffusers. Dampers integral to airflow devices should be fully open or minimally closed for airflow fine adjustments.

D. Make pitot tube traverse of main supply, return, and outdoor air ducts to obtain total airflow for fan or air-handling unit.

E. Adjust rooms or zones to design airflow (supply, return, and exhaust).

F. Adjust general HVAC systems to design airflow within the following tolerances:

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1. Total system supply, return, and exhaust: (design to plus 10 percent).
2. Outdoor air: (minus 5 percent to plus 5 percent).
3. Total supply, return, and exhaust for a room or space: (minus 5 percent to plus 5 percent).
4. Grilles, registers, and diffusers:

    a. One per room or space: (minus 5 percent to plus 5 percent).
    b. Two or more per room or space: (minus 10 percent to plus 10 percent).

G. Grilles, registers, and diffusers:

1. Identify each grille, register, and diffuser as to location and area. List manufacturer, type, and size.
2. Identify type of testing equipment used.
3. Test and adjust each grille, register, and diffuser to design airflow. List (design-actual) cfm (cubic meters per minute) and (design-actual) velocity in fpm (meters per second) when applicable.
4. Adjust diffusers, grilles, and registers to minimize drafts. Adjust blades in supply diffuser straightening grids to assure uniform air distribution across diffuser.
5. Adjust linear slot diffusers to provide throw direction as indicated on the drawings. Unless otherwise noted, discharge pattern shall be horizontal. Where two-way throw is indicated, divide the number of slots equally for each direction.

H. Test and record the following data, as applicable, for air-handling equipment:

1. Manufacturer and model number.
2. Total airflow (design-actual).
3. Return air airflow (design-actual).
4. Outdoor air airflow (design-actual).
5. Total and external static pressure (design-actual). Include static pressure at suction, discharge, and between unit coil and filter components.
6. Entering air temperatures (db heating, db and wb cooling).
7. Leaving air temperatures (db heating, db and wb cooling).
8. Motor horsepower (rated-actual).
9. Voltage and phase (rated-actual).
10. Fan speed, rpm (rated-actual).
11. Amperage (rated-actual).

I. In cooperation with the control manufacturer’s representative, set adjustments of automatically operated dampers to operate as specified.

3.24 HYDRONIC SYSTEMS BALANCING

A. Balance all hydronic piping systems.

B. Adjust flow rates for constant-speed pumps that are not controlled by variable frequency drives using the balancing valve in the pump discharge. Valves at variable flow pumps controlled by variable frequency drives shall be fully open with no adjustment made to the variable frequency drive.

C. Adjust and balance the following items listed under the various systems in accordance with the specified standards.

1. Domestic hot water system:

a. Pump
b. Return piping for flow to every branch

2. Chilled water system:

a. Pump
b. Chiller
c. Roof-top air-handling unit cooling coil
d. Dedicated outdoor air system unit cooling coil

3. Heating system:

a. Pump
b. Convector
c. Unit heater
d. Finned pipe radiation
e. Dedicated outdoor air system unit heating coil.
f. Roof-top air-handling unit heating coil
g. Reheat coil
h. Cabinet unit heater

D. After the above items have been adjusted and balanced, submit a certified report listing the specification requirements and the operating conditions of these items as follows:

1. Pump:

a. Flow - gpm
b. Suction pressure
c. Discharge pressure
d. Pressure differential
e. Total dynamic head
f. Motor - HP voltage, hertz, phase, design full load amps
g. Motor - operating line voltage and amperage, overload heater ratings.

2. Chilled water coil:

a. Flow - gpm
b. Entering air - D.B.
c. Entering air - W.B.
d. Leaving air - D.B.
e. Leaving air - W.B.
f. Entering water temperature
g. Leaving water temperature
h. Pressure drop across coil

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i. Outdoor air temperature - D.B.
j. Outdoor air temperature - W.B.

3. DX coil:

a. Suction pressure
b. Suction line temperature
c. Entering air - D.B.
d. Entering air - W.B.
e. Leaving air - D.B.
f. Leaving air - W.B.
g. Outdoor air temperature - D.B.
h. Outdoor air temperature - W.B.

4. Heating water coil (such as coils in AHU's and DOAS units, unit heaters, convectors, finned tube, and reheat coils):

a. Flow - gpm
b. Entering water temperature
c. Leaving water temperature
d. Entering air - D.B.
e. Leaving air - D.B.

5. Chiller and boilers:

a. Flow - gpm
b. Entering water temperature
c. Leaving water temperature
d. Pressure drop across equipment
e. Motor - HP voltage, hertz, phase, design full load amps.
f. Motor - operating amps & volts - install overload heater rating

6. Piping system:

a. Flow - gpm reading of flow meter in various systems: See drawings for locations.

3.26 MARKING OF SETTINGS

A. Following final balance procedures, permanently mark the settings of valves, splitters, dampers, and other adjustment devices so that adjustment can be restored if disturbed at any time. Set memory stops on balancing valves. Return and make required adjustments after submittal and approval of the Certified Balance Report.

END OF SECTION

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SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Definitions and general requirements applicable to the insulation systems specified in "Related Sections."

1.14 RELATED SECTIONS

A. Pipe insulation: Section 23 07 19.

B. Duct insulation: Section 23 07 13.

C. Equipment insulation: Section 23 07 16.

1.20 DEFINITIONS

A. Ceiling space: The space between the ceiling and the floor of an air-conditioned space above.

B. Roof space: The space between the ceiling and the roof, where building insulation is located at the roof level or the space between the ceiling and the floor of a non-air conditioned space above.

C. Attic space: The space between the ceiling and the roof, where building insulation is located at the ceiling level.

D. Air-conditioned areas or spaces: Areas or spaces where the occupied room temperature is maintained between 65 and 80 degrees F (18.3 and 26.7 degrees C).

E. Concealed insulation shall include work:

1. Above ceilings.
2. Where furred in and in pipe chases.

F. Exposed insulation shall include work:

1. In all rooms and areas.
2. In mechanical equipment rooms or spaces.
3. In storage rooms.

1.40 QUALITY ASSURANCE

A. Perform work in strict accordance with the building, fire and safety codes of the state, county or city in which the work is performed.

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B. Insulation, including fittings and butt strips, jackets, facings, and accessories such as adhesives, mastics, cements, tapes and cloth, shall have a fire and smoke hazard rating and label as tested by ASTM E84, NFPA 255, and UL 723, not exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50.

C. All insulation and accessories shall be free of asbestos.

1.50 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation and accessory products in manufacturers' wrapping or cartons, identified on the exterior and bearing labels showing conformance to flame and smoke rating requirements.

PART 2 - PRODUCTS

2.10 MATERIALS

A. Refer to sections listed in "Related Sections."

PART 3 - EXECUTION

Not Used.

END OF SECTION

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SECTION 23 07 13 - DUCT INSULATION

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Insulation applied to ducts.

B. Work of this section includes:

1. Insulation for new ductwork installed under this contract.
2. Patching existing insulation where removed to make connections to existing ductwork.
3. Patching existing insulation damaged during demolition and construction.

1.14 RELATED SECTIONS

A. Section specifying requirements for LEED rating is specified in Division 01.

B. Painting: Division 09.

C. Definitions of concealed, exposed, and other terms: Section 23 07 00.

B. Acoustical duct liner: Section 23 31 13.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. LEED submittal:

1. Product data for credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.

C. Material list: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.

D. Product data: Sufficient to show that the product meets the specified requirements for materials, composition, and performance.

1.40 QUALITY ASSURANCE

A. Meet requirements specified in Section 23 07 00.

B. Comply with requirements for LEED certification specified in Division 01.

C. Installer qualifications: Firm with at least 5 years successful installation experience with mechanical insulation. Work shall be performed by mechanics skilled in this trade.

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1.50 DELIVERY, STORAGE, AND HANDLING

A. Meet requirements specified in Section 23 07 00.

B. Store rigid insulation products so as to protect them from breakage.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article “Product Options” in Section 23 01 01.

B. Insulation and accessories:

1. Armstrong World Industries.
2. CertainTeed Corporation.
3. Childers.
4. Foster.
5. Johns Manville.
6. Knauf Fiber Glass Gmbh.
7. Owens-Corning.

2.10 MATERIALS

A. Flexible fiberglass insulation: ASTM C 553, Type I, K-factor of 0.27 at 75 degrees F (0.037 at 24 degrees C) mean temperature, of thicknesses specified in Part 3 below, nominal density at least 1 lb per cubic foot (16 kg per cubic meter), with vapor-barrier jacket of reinforced kraft and aluminum foil.

B. Rigid fiberglass insulation: ASTM C 612, Types IA-IB, nominal density at least 6 lbs per cubic foot, with K-factor of 0.22 at 75 degrees F (0.032 at 24 degrees C) mean temperature, of thicknesses specified in Part 3 below, with factory-applied jacket composed of a reinforced white kraft and aluminum-foil laminate with the white kraft facing out, equal to CertainTeed CertaPro Commercial Board CB 600.

C. Canvas: Eight ounces/sq. yd. (270 g/sq. m.), fire-retardant treated. Provide washable, abrasion-resistant finish coating equal to Foster “Sealfas” 30-36.

D. Adhesives for duct insulation inside buildings: Recommended by insulation manufacturer for the application, equal to Foster Products 85-60.

E. Vapor barrier coating: Equal to Foster 30-65.

F. Adhesive fasteners: Equal to Duro Dyne perforated base adhesive hanger (PBH). Minimum 12-gauge zinc-plated steel pin with 2 inch by 2 inch, 28 gauge galvanized base and retaining washer. Pin length as required. Comply with ASTM-A591 and SMACNA HVAC Duct Construction for Mechanical Fasteners.

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G. Glass cloth and tape: MIL-C-20079. Tape: Type II, Class 3, 4.5 ounces/sq. yd. (150 g/sq. m.) Cloth: Type I, Class 1, untreated.

H. Self-adhesive tape: Manufacturer's standard tape of material matching insulation jacket, with peelable backing and pressure-sensitive adhesive.

I. Mastic for ductwork exposed to weather: Equal to Foster 30-90 mastic/coating.

J. Elastomeric sheet roofing:

1. Membrane: 0.045-inch-thick (1-mm-thick) reinforced EPDM.
2. Seaming materials: Recommended by membrane manufacturer.
3. Flexible counterflashing: Uncured EPDM, by manufacturer of roofing membrane and recommended for use with it.
4. Color: Black.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Apply insulation in a neat and workmanlike manner and in accordance with manufacturer's printed instructions. Butt joints tightly and apply a brush coat of adhesive to laps and joint strips. Seal laps, pulling jacketing tight and smooth. Tape joints with self-adhesive tape matching the service jacket.

B. Tape and seal terminations of insulation to prevent "dusting".

C. Cut ends of mechanical fasteners.

3.21 INSULATION INSIDE BUILDINGS

A. Concealed ducts: Flexible fiberglass insulation. Adhere with adhesive in sufficient quantities to prevent sagging. On ducts more than 30 inches (762 mm) wide, secure insulation on the underside with mechanical fasteners on 18 inch-(457-mm) maximum centers. Butt insulation with facing overlapping at least 2 inches (50 mm) and sealed with vapor-barrier adhesive. Adhesive must cover full 2-inch (50-mm) overlap to form an airtight seal. Seal breaks and punctures with vapor-barrier tape and same type of adhesive.

B. Exposed ducts: Rigid fiberglass insulation, fastened with mechanical fasteners. Fasteners shall be spaced 12 to 18 inches (305 to 457 mm) on center with a minimum of two rows per side of duct. Secure insulation in place with washers firmly embedded in insulation.

1. Install corner beads on external corners.
2. Seal joints. Apply canvas jacket. Cover with two coats of lagging adhesive, ready for painting. Fastener caps shall match the jacket.

C. For curved surfaces, such as exposed elbows, score or cut insulating board in narrow strips as necessary for snug and neat fit.

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D. Ductwork which need not be insulated:

1. Cooling systems:

a. Insulated flexible supply ducts where installed in:

(1) Ceiling spaces of air-conditioned spaces.
(2) Return air plenums, whether ceiling or roof spaces, of air-conditioned spaces.

b. Supply ducts where exposed in areas they serve.
c. Insulated flexible return ducts, except in attic spaces.
d. Return ducts in ceiling spaces of air-conditioned areas. Note that insulation is required for return ducts in roof spaces.
e. Return ducts exposed in areas they serve.

2. Heating systems:

a. Insulated flexible supply ducts, except in attic spaces.
b. Supply ducts exposed in areas they serve.
c. Return ducts, except in attic spaces.
d. Transfer ducts, except in attic spaces.

3.22 INSULATION THICKNESS

A. Outdoor air ducts: 1.5 inches (40 mm). Where necessary to conceal the standing seams and reinforcing angles on exposed ducts, 2 inches (50 mm).

B. Exhaust air ducts to roof ventilators or to exterior openings: 1.5 inches (40 mm), starting at connection to roof curb or opening and running back to ATC dampers but not less than 10 feet (3 m).

C. Exhaust ducts from air-conditioned areas, in roof or attic space: 1.5 inches (40 mm).

D. Ductwork which transmits combination cooled and heated air or untempered ventilating air shall be insulated as specified below for cooling systems.

E. Conditioned or supply air ducts from dedicated outdoor air systems shall be insulated as specified for supply air ducts.

F. Return or exhaust air ducts from dedicated outdoor air systems shall be insulated as specified for return air ducts.

G. Cooling systems:

1. Supply air ducts: 1.5 inches (38 mm). Where necessary to conceal the standing seams and reinforcing angles on exposed ducts, 2 inches (50 mm).

a. Exception: Lined or unlined supply ducts in attic spaces: 2 inches (50 mm).

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2. Return air ducts: 1.5 inches (40 mm). Where necessary to conceal standing seams and reinforcing angles on exposed ducts, 2 inches (50 mm).

    a. Exceptions:

        (1) Return ducts in attic spaces: 2 inches (50 mm).
        (2) Lined or insulated flexible return ducts in attic spaces: Externally insulated with 1.5-inch (40-mm) thick insulation.

3. Transfer ducts shall be insulated as specified for return ducts.

H. Heating systems:

1. Supply air ducts: 1.5 inches (40 mm). Where necessary to conceal the standing seams and reinforcing angles on exposed ducts, 2 inches (50 mm).

    a. Exception: Supply ducts in attic spaces: 2 inches (50 mm).

2. Return ducts in attic spaces: 2 inches (50 mm).
3. Transfer ducts shall be insulated as specified for return ducts.

3.23 INSTALLATION ON DUCTWORK EXPOSED TO WEATHER

A. Insulate exterior ductwork, whether lined or unlined, with rigid insulation 2 inches (50 mm) thick, except do not insulate discharge ducts from exhaust fans or outdoor air (fresh air) ducts.

B. Over standing seams and reinforcing angles, install thickness to cover protrusions at least 0.5 inch (13 mm).

C. Taper insulation on top of duct from center to each side, to slope no less than 1:12.

D. Mechanically fasten, with washers firmly embedded in insulation. Install fasteners in rows, no more than 18 inches (460 mm) on centers. Install rows no more than 18 inches (460 mm) apart, but no fewer than two rows each on top, bottom, and each side.

E. Install corner beads on external corners.

F. Where insulated duct penetrates walls, fully flash top, bottom, and sides.

G. Finish: Cover insulated ducts with elastomeric sheet roofing membrane, fully adhered to fiberglass insulation.

1. Apply adhesive at rate recommended by membrane manufacturer, to insulation and to membrane.
2. Overlap edges and ends minimum 3 inches (75 mm). Splice and seal in accordance with membrane manufacturer’s installation instructions.
3. Roll surfaces, following membrane manufacturer’s installation instructions.

END OF SECTION

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SECTION 23 07 16 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Equipment insulation as scheduled at end of section.

B. Work of this section includes:

1. Insulation for new ductwork installed under this contract.
2. Patching existing insulation where removed to make connections to existing ductwork.
3. Patching existing insulation damaged during demolition and construction.

1.14 RELATED SECTIONS

A. Section specifying requirements for LEED rating is specified in Division 01.

B. Definitions and general insulation requirements: Section 23 07 00.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. LEED submittal:

1. Product data for credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.

C. Material list: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.

D. Samples required only upon request.

E. Manufacturer's installation instructions and system recommendations.

1.40 QUALITY ASSURANCE

A. Meet requirements specified in Section 23 07 00.

B. Comply with requirements for LEED certification specified in Division 01.

C. Installer qualifications: Firm with at least 5 years successful installation experience with mechanical insulation. Work shall be performed by mechanics skilled in this trade.

1.50 DELIVERY, STORAGE, AND HANDLING

A. Meet requirements specified in Section 23 07 00.

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PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article “Product Options” in Section 23 01 01.

B. Insulation and accessories:

1. Armacell
2. CertainTeed Corporation.
3. Childers.
4. Foster.
5. Johns Manville
6. Knauf Fiber Glass GmbH.
7. Owens-Corning.

2.10 EQUIPMENT INSULATION

A. Insulation types refer to the Equipment Insulation Schedule at the end of the section. Thicknesses are scheduled.

B. Type A, insulation for heated surfaces up to 400 degrees F (295 degrees C), flat and curved 24 inches (610 mm) or more in diameter: ASTM C 612, Class 1 rigid fiberglass equipment insulation, K factor 0.26 at 75 degrees F (0.036 at 24 degrees C) mean temperature, density 6 lbs per cubic foot (96 kg per cubic meter). For surfaces less than 24 inches (610 mm) diameter, and pump casings, use segmented sections.

C. Type B, insulation for cooled surfaces: Flexible elastomeric insulation, ASTM C 534, Type II, with vapor barrier facing.

D. Insulating and finishing cement: Mineral fiber cement with a hydraulic-setting binder, conforming to ASTM C 449.

E. Insulation compounds: Provide adhesives, cements, sealers, mastics, and protective finishes recommended by manufacturers of insulation for each particular application.

F. Insulation accessories: Provide staples, bands, wire, wire mesh, tape, corner angles, anchors, and stud pins recommended by manufacturer of insulation for each particular application.

G. Jacket material: Pre-sized glass cloth, not less than 7.8 ounces per sq. yd (271g per sq. m).

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PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

A. Insulate equipment as specified, except equipment with factory-applied insulation. Follow manufacturer's instructions.

B. Provide removable insulation sections to cover parts of equipment which must be opened or removed periodically for maintenance, such as vessel covers, fasteners, flanges, pump casings and strainers, frames, and accessories. On large vessels, provide additional external support.

1. On hot equipment, insulate equipment surface, leaving flanges, bolts, and other accessories exposed.
2. On cold equipment, or equipment used for both heating and cooling, insulate flanges and accessories, and make insulation separately removable.

C. Maintain the integrity of vapor barriers.

D. Do not insulate boiler manholes, handholes, cleanouts, ASME stamp, or manufacturer's nameplate. Bevel edges at interruptions.

E. On breechings, install insulation on standoffs, with required air space.

3.21 INSTALLATION ON COLD SURFACES

A. Type in accordance with Equipment Insulation Schedule.

B. Cut, score, or miter insulation to fit contours of equipment. Secure with a full coating of adhesive. Provide weld pins or stick clips with washers spaced 18 inches apart. Stagger joints between layers.

C. Fill voids with small pieces of insulation applied with adhesive on all sides to maintain complete vapor barrier. Seal joints, breaks, and punctures in facing.

D. Insulation on chilled water pumps: For each pump, construct an insulated box assembly with removable cover, or access panels.

1. Size: To surround pump housing, drive shaft, and piping, including suction diffuser, and allowing clearance for draining and adjustment of pump shaft seal.
2. Construction: 18-gage galvanized steel; formed with edge returns so that insulation is not exposed; provided with openings for drive shaft and pipes; no part resting on pump.
3. Access: Design box for disassembly or access. Provide fasteners such as clips or cam latches, so that access is possible without the use of tools.
4. Insulation: Secured to inside of box with pins and adhesive.

3.22 INSTALLATION ON HOT SURFACES

A. Type in accordance with Equipment Insulation Schedule.

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B. Cut, score, or miter insulation to fit contour of equipment and secure with 0.5 by 0.015 inch (13 by 0.4 mm) galvanized steel bands on 12-inch (305-mm) centers. Use weld pins or stick clips with washers for flat surfaces, spaced 18 inches (760 mm) apart. Stagger joints where possible and fill voids with insulating cement. Apply wire mesh over entire surface of equipment and corner beads to all outside corners and edges.

3.23 INSTALLING FINISHED SURFACE

A. Apply a coat of insulating cement to smooth out surface. When cement is dry apply a coating of lagging adhesive. Embed a layer of glass cloth, overlapping all seams 2 inches (50 mm), and finish with a second coat of same adhesive.

3.90 EQUIPMENT INSULATION SCHEDULE

EQUIPMENT	INSULATION TYPE	THICKNESS INCHES
Heating water air separator	A	1.5
Heating water expansion tank	A	1.5
Chiller cold surfaces (not factory-insulated)	B	2 layers each 0.75
Chilled water air separator	B	2 layers each 0.75
Chilled water pump box assemblies	B	2 layers each 0.75
Chilled water expansion tank and buffer tank	B	2 layers each 0.75

END OF SECTION

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SECTION 23 07 19 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. HVAC piping insulation for the piping systems listed in the schedule at the end of this section.

B. Work of this section includes:

1. Insulation for new piping installed under this contract.
2. Patching existing insulation where removed to make connections to existing piping.
3. Patching existing insulation damaged during demolition and construction.

1.14 RELATED SECTIONS

A. Section specifying requirements for LEED rating is specified in Division 01.

B. Definitions and general insulation requirements: Section 23 07 00.

C. Painting: Division 09.

D. Pipe hangers and protection shields: Section 23 05 29.

E. Electric heat cable (heat tracing): Section 23 05 33.

1.20 REFERENCES

A. ASTM C 450: Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments.

B. ASTM C 534: Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

C. ASTM C 547: Mineral Fiber Pipe Insulation.

D. ASTM C 553: Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. LEED submittal:

1. Product data for credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.

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C. Schedule of products: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.

D. Product data: Sufficient to show that the product meets the specified requirements for materials, composition, and performance.

1.34 QUALITY CONTROL SUBMITTALS

A. Manufacturer's instructions: Recommended accessory materials and products; installation instructions.

1.40 QUALITY ASSURANCE

A. Meet requirements specified in Section 23 07 00.

B. Comply with requirements for LEED certification specified in Division 01.

C. Installers shall be mechanics skilled in this trade.

1.50 DELIVERY, STORAGE, AND HANDLING

A. Meet requirements specified in Section 23 07 00.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article "Product Options" in Section 23 01 01.

B. Fiberglass insulation:

1. Johns Manville.
2. Knauf Fiber Glass GmbH.
3. Owens-Corning.

C. Flexible elastomeric insulation:

1. Armacell LLC
2. Rubatex

D. Coatings, adhesives, and fabrics:

1. Childers.
2. Foster.
3. Manville Building Materials Group.
4. Rock Wool Manufacturing Company

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2.10 FIBERGLASS PIPE INSULATION

A. Fiberglass insulation: Glass fibers bonded with a thermosetting resin.

1. Preformed pipe insulation, ASTM C 547 Type I, with all-service jacket.
2. Flexible sheet insulation, ASTM C 553 Type IV, without facing.

B. All-service jacket (ASJ): Factory-applied, fire-retardant, vapor-barrier foil/scrim/kraft jacket. All-service jacket with self-sealing lap (ASJ-SSL) is acceptable as Contractor's option.

1. Tape: Matching jacket, pressure-sensitive.

C. Fittings and valves: Prefabricated and field fabricated, meeting ASTM C 450 requirements for dimensions used in forming insulation to cover valves, elbows, tees, and flanges.

2.12 FLEXIBLE ELASTOMERIC PIPE INSULATION

A. Flexible elastomeric tube and sheet: Equal to Armacell "AP Armaflex," or "Armaflex 2000", closed-cell, sponge- or expanded-rubber materials, ASTM C 534, Type I (tubular) and Type II (sheet).

B. Fitting and valve covers: Field fabricated, meeting ASTM C 450 requirements for dimensions used in forming insulation to cover valves, elbows, tees, and flanges.

2.16 ADHESIVES

A. Joints, fittings, and general application:

1. Fiberglass insulation: Foster "Quick-Tack" 85-60.
2. Flexible elastomeric insulation: Foster "Drion" 85-75.

B. Lagging adhesive: Polyvinyl acetate adhesive, equal to Foster "Lagfas" 81-42W. If applied within interior, VOC content not to exceed 250 g/L.

2.17 MASTICS AND COATINGS:

A. Flexible elastomeric insulation: Armacell "WB Armaflex" latex enamel.

B. Bituminous mastic: Fed. Spec. SS-C-153, Type I. If applied within interior, VOC content not to exceed 300 g/L.

C. Insulating and finishing cement: Mineral fiber cement with a hydraulic-setting binder, conforming to ASTM C 449.

D. Vapor barrier coating:

1. On fiberglass insulation: Foster "Vapor-Fas" 30-65.
2. On flexible elastomeric insulation: Two coats of latex enamel coating.

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E. Finish coating for fiberglass insulation or lagging: Washable, abrasion-resistant, coating equal to Foster "Sealfas" 30-36. If applied within interior, VOC content not to exceed 250 g/L.

2.18 LAGGING AND REINFORCING TEXTILES

A. Canvas: Eight ounces/sq. yd. (270 g/sq. m), fire-retardant treated.

B. Glass cloth and tape: MIL-C-20079. Tape: Type II, Class 3, 4.5 ounce/sq. yd. (150 g/sq. m). Cloth: Type I, Class 1, untreated.

2.19 FASTENERS

A. Aluminum bands: 0.75 inches (19 mm) wide and 0.020 inches (0.4 mm) thick.

B. Staples: Outward clinching type, Type 304 or 316 stainless steel.

C. Pins: Serrated shaft, Type 304 or 316 stainless steel.

2.20 PROTECTIVE PIPE JACKETS

A. Canvas: Finished with lagging coating, uniform, smooth, and ready for painting.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

A. Install in accordance with the Minimum Thickness Schedule at the end of this section, as modified by specifications for each location and type.

B. Fiberglass insulation: Apply insulation to a neat and smooth finish. Comply with manufacturers' recommendations and installation instructions. Butt joints tightly and apply a brush coat of vapor barrier coating to each lap and joint strip. Seal or fasten laps in jacketing as specified for location, pulling jacketing tight and smooth. Coat all fittings, valves, and flanges with vapor barrier coating and reinforcing mesh before applying fitting covers.

C. Flexible elastomeric insulation: Apply by slipping seamless sections of tubing over the end of the piping, wherever possible. Use slit tubing only as necessary. Seal joints and slit seams with joint adhesive.

1. Fittings and valves: Field fabricated from insulation same thickness as on the piping. Use manufacturer's miter tubes and boxes and templates.

D. Tape and seal with vapor barrier coating to all terminations of insulation.

E. Staple, tape, or seal plastic pipe fitting covers by methods recommended by manufacturer.

F. Coordination with pipe hangers and supports:

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1. Insulation shall be continuous through hangers for all piping systems. Install pipe covering protection shields with thickness of structural insulation inserts equal, under load, to that of adjoining insulation. Shields and saddle supports are specified in Section 23 05 29, Hangers and Supports for HVAC Piping and Equipment.

3.21 INSTALLING INSULATION AT PENETRATIONS

A. Where the insulated piping systems pass through sleeves or openings in partitions and floors, the insulation shall be continuous through the sleeves and openings. See Firestopping specifications, for coordinating insulation and fire protection sealing.

3.22 INSTALLING CANVAS JACKET

A. Locations:

1. All pipe insulation in mechanical rooms, mechanical closets, and on exposed piping as defined in Section 23 07 00, HVAC Insulation.

3.26 INSTALLING HEATING WATER PIPING INSULATION

A. Insulation: Fiberglass pipe insulation with jacket, in accordance with Minimum Thickness Schedule. Staple or seal ASJ laps at Contractor’s option.

B. Fittings, valves, and covers: Cover with prefabricated fitting covers.

C. Do not cover unions and flanges.

D. Casings and headers of heating water coils: Fiberglass same thickness as on adjacent piping. Finish with a layer of glass cloth embedded in two coats of lagging coating.

E. Insulation on strainers: Removable without damage.

3.27 INSTALLING CHILLED WATER PIPING INSULATION

A. Piping systems: Insulate supply and return with fiberglass insulation in accordance with Minimum Thickness Schedule. Seal ASJ lap to form vapor barrier.

B. At all valves, flanges, and fittings, and at intervals of not more than 21 feet (6400 mm) on continuous runs of pipe, make a joint in insulation. Finish and seal ends with vapor barrier coating on both sides of joint.

C. Fittings, valves, and flanges: Cover with prefabricated fitting covers. Coat all fittings, valves, and flanges with vapor barrier coating and reinforcing mesh before applying fitting covers.

D. Do not cover unions and flanges.

E. Casings and headers of cooling coils: Fiberglass of thickness equal to that of adjoining pipe insulation, finished with vapor-barrier jacket.

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F. Insulation on strainers: Removable without damage.

3.30 INSTALLING REFRIGERANT PIPING INSULATION

A. Piping systems: All refrigerant suction, hot gas and liquid piping, indoors and outdoors. Insulate refrigerant discharge lines where there is a possibility of contact by people other than service personnel.

B. Insulation: Flexible elastomeric, thickness in accordance with Minimum Thickness Schedule.

C. Fittings and valves:

1. Coat with vapor barrier coating.
2. Field-fabricated covers same thickness as on adjacent piping.

3.31 INSTALLING EXTERIOR PIPING INSULATION

A. Locations: Piping systems exterior of building heated space.

1. Chilled water
2. Refrigerant liquid
3. Refrigerant suction

B. Insulation: As specified for the same system interior, minimum thickness 2 inches (50 mm), or 0.5 inches (13 mm) thicker than scheduled for interior insulation on similar system, whichever is greater.

C. Start insulation 30 inches (760 mm) below roof or 30 inches (760 mm) inside exterior wall. Secure insulation with aluminum bands on 12-inch (305-mm) centers.

D. Where insulated piping is exposed to weather, apply one of the following protective jackets:

1. Over flexible elastomeric insulation: Fully adhere a layer of glass cloth to the insulation surface, with adhesive specified for elastomeric system. Apply two coats of latex enamel finish.

3.90 SCHEDULES

A. Minimum Thickness Schedule: Thicknesses scheduled are for aboveground, interior piping. See “Installing Exterior Piping Insulation” for additional thicknesses required.

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MINIMUM THICKNESS SCHEDULE

Piping System Types	Fluid Temp. Range (Degrees F)	PIPE SIZES (NPS) Equipment Connections Up to 1-1/4 (1)	1-1/2 & less	2	3 to 4	5 & 6	8 and larger
Heating water	120-200	1.5	1.5	2.0	2.0	2.0	2.0
Chilled water	40-55	1.5	1.5	1.5	1.5	1.5	1.5
Refrigerant	0-60	--	1.0	1.0	1.0	1.0	1.5
Refrigerant	120-200	--	1.5	2.0	2.0	2.0	2.0

(1) - Piping within 2 feet of equipment may be insulated with 1.0-inch flexible elastomeric.

END OF SECTION

SECTION 23 08 00 – MECHANICAL SYSTEM COMMISSIONING

PART 1 GENERAL

1.01 WORK INCLUDED

A. Systems and equipment testing and startup.

B. Completion of Pre-FPT Installation Checks.

C. Validation of proper and thorough installation of Division 23 systems and equipment.

D. Systems balancing verification.

E. Performance Verification Testing of equipment and systems.

F. Functional Performance Testing of equipment and systems.

G. Documentation of tests, procedures, and installations.

H. Coordination of Training Events.

I. Generic Startup Procedures for mechanical systems and equipment.

1.02 GENERAL DESCRIPTION

A. Commissioning (Cx) is the process of ensuring that all building systems are installed and perform interactively according to the design intent; that systems are efficient and cost effective and meet the Owner's operational needs; that the installation is adequately documented; and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.

B. Commissioning Authority (CA) is retained by the Owner and shall work with the Contractor and the Design Engineer to direct and oversee the Cx process and perform functional performance testing.

C. This Section outlines the Cx procedures specific to the Division 23 Contractors. Commissioning requirements common to all Sections are specified in Section 019100, Section 019110, the individual specifications and the Cx Plan.

1.03 SCOPE

A. The following are included in the Scope of Commissioning on this project:

B. Mechanical/HVAC Systems

1. Dedicated Outdoor Air Systems (DOAS-01 through DOAS-12)
2. Air Handling Units (AHU-01 through AHU-04)
3. Air Cooled Condensing Units – VRF (ACCU-01 through AACU-03)
4. Variable Refrigerant Terminal Units (VRT-01 through VRT-37)
5. Ductless Split Systems (DSS-01 through DSS-05)
6. Fan Coil Units (FCU-01 through FCH-39)
7. Variable Air Volume Terminals (1-1 and 1-2)
8. Hydronic Unit Heaters (CUH-01 through CUH-06 & PUH-01)
9. Exhaust Fans (EF-01 through EF-06)
10. Centrifugal Pumps (P-01 through P-04)

C. Building Automation Systems
   1. Analyze trends
   2. Verify Standalone Capability of Controllers
   3. Verify BMS Interface, Software, Graphics, and Functions
   4. Verify Integration with DOAS Units, Heat Pumps and RTUs
   5. Verification of Miscellaneous Points

1.04 RELATED WORK AND DOCUMENTS

A. **Commissioning Plan**: The Commissioning Plan outlines the commissioning process beyond the construction specification. All Contractor responsibilities are outlined in Specifications. Cx Plan is available to the Contractor to understand the context of their responsibilities but does not define any additional responsibilities of the Contractor

B. **Section 01 30 00 – Submittals**: Addresses documentation and procedures relative to the submittal process, including Operation and Maintenance Manuals.

C. **Section 01 50 00 – Temporary Utilities**: Specifies the requirements for using Owner's existing and/or permanent equipment and controls for temporary conditioning in the facility.

D. **Section 01 77 00 – Project Close Out**: Defines the milestones in completion incorporating the commissioning process.

E. **Section 01 91 00 – General Commissioning Requirements**: Details the Cx requirements common across all Divisions beginning with the Construction Phase. Focus is on Contractors' responsibilities for the Cx process.

F. **Section 01 91 10 – Commissioning Functional Performance Testing**: Provides 'generic' functional performance testing procedures to illustrate the level-of-effort expected during acceptance testing.

G. **Individual Sections in the Various Divisions**: Individual sections stipulate installation, startup, warranty and training requirements for the system or device specified in the section.

H. **Section 23 08 10 – Building Automation System Commissioning**: Details the commissioning procedures specific to the Building Automation System.

I. **Section 26 08 00 – Electrical Systems Commissioning:** Details the commissioning procedures specific to Division 26 work.

1.05 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 01 91 00 and the Cx Plan.

1.06 REFERENCE STANDARDS

A. ASHRAE Guideline 1.1-2007, "HVAC&R Technical Requirements for the Commissioning Process"

B. ASHRAE Guideline 4-2008, "Preparation of Operating and Maintenance Documentation for HVAC&R Systems"

C. NEBB - Procedural Standards for Building Systems Commissioning

1.07 DOCUMENTATION

A. In addition to the documentation required in Section 019100 , Contractor shall provide to the Commissioning Authority the following per the procedures specified herein, in the Cx Plan, and in other sections of the specifications:

1. **Balancing Plan:** The plan shall include the following:
   a) Certifications for all instrumentation to be used throughout the testing. This must document certification within the last 6 months.
   b) Résumés and Certification of individuals who will be balancing systems.
   c) Detailed step by step plans for each procedure to be performed.
   d) Sample forms to be used for each measurement.
   e) Sample balancing report.
2. **Factory Test Reports:** Contractor shall provide any factory testing documentation or certified test reports required by the specifications. These shall be provided prior to Acceptance Phase. Factory Test Reports should be provided in PDF electronic format. These may include but are not limited to:
   a) Chillers
   b) Air Handling Units
   c) Rooftop Units (DOAS)
   d) Variable Frequency Drives
   e) Fan Capacity
   f) Fan Sound Power Levels
   g) Boilers
   h) Pump Capacity
3. **Field Testing Agency Reports (other than TAB)**: Provide all documentation of work of independent testing agencies required by the specification. These shall be provided prior to Acceptance Phase. Field Testing Agency Reports should be provided in PDF electronic format. These may include but are not limited to:
   a) Pipe Pressure Testing
   b) Duct Leakage Testing
   c) Vibration Testing
   d) Generated Noise and Resultant Noise Level
   e) Water Treatment
4. **Completed Test and Balance Reports**: Commissioning Authority will review prior to FPT.

1.08 SEQUENCING AND SCHEDULING

A. Refer Section 01 91 00 and the Cx Plan.

1.09 COORDINATION MANAGEMENT PROTOCOLS

A. Coordination responsibilities and management protocols relative to Cx are initially defined in Section 01 91 00 and the Commissioning Plan, but shall be refined and documented in the Construction Phase Cx Kick-Off meeting. Contractor shall have input

into the protocols and all parties will commit to scheduling obligations. The Commissioning Authority will record and distribute.

1.10 CONTRACTOR RESPONSIBILITIES

A. **Refer to Section 01 91 00**: Detailed Contractor responsibilities common to all Divisions are specified in Section 01 91 00. The following are additional responsibilities or notable responsibilities specific to Division 23.

B. Construction Phase

1. Provide skilled technicians qualified to perform the work required.
2. Provide factory-trained and authorized technicians where required by the Contract Documents.
3. Prepare and submit required draft Startup Procedures and submit along with the manufacturer's application, installation and startup information.
4. TAB: Specifically as it relates to Cx:
    a) Attend Cx kick-off meeting and Cx progress meetings held within 2 months of and during Acceptance Phase.
    b) Submit Balancing Plan as indicated above.
    c) Meet with Cx Team to review TAB procedures and documentation required.
    d) As requested by Commissioning Authority, participate in Commissioning Team demonstrations of balancing procedures for repetitive procedures such as zones.
    e) Provide all documentation electronically.
    f) On airflow tracking zones:
        1) Balance all outlets downstream of VAV terminal. Record final settings
        2) Measure airflow at both minimum and maximum flow conditions and calibrate VAV flow signals at both extremes. Extremes of flow shall be established by putting the zone into full heating and full cooling. Record all parameters and final flow coefficient If only one flow coefficient is available and this does not permit setting the range to within specified tolerances, enter the flow coefficient the average of the two required flow coefficients and report the deficiency in an Action Item.
        3) Measure and record supply air flow at flow extremes with reheat valves both open and closed as required above.

C. Acceptance Phase

1. Assist Commissioning Authority with Performance Verification and Functional Performance Testing. Assistance will generally include the following:
    a) Manipulate systems and equipment to facilitate testing (as dictated in Section 01 91 00 and the Cx Plan;
    b) Provide any specialized instrumentation necessary for functional performance testing;
    c) Manipulate BAS and other control systems to facilitate functional performance testing as dictated in sections 01 91 00, 01 91 10, 23 08 10, and the Cx Plan.

D. Warranty Phase

1. Maintain record documentation of any configurations, set ups, parameters, etc. that change throughout the period.

2. Provide representative for off season testing as required by Commissioning Authority.
3. Respond to Warranty issues as required by Division 1 and the General Conditions.

1.11 EQUIPMENT SUPPLIER RESPONSIBILITIES

A. Refer to Section 01 91 00.

1.12 CONTRACTOR NOTIFICATION AND SCHEDULING

A. Refer to Section 01 91 00.

1.13 STARTUP PROCEDURES AND DOCUMENTATION

A. Refer to Section 01 91 00.

1.14 BAS TRENDING REQUIREMENTS

A. Trending requirements are specified in Section 01 91 00 and Section 23 08 10.

1.15 PERFORMANCE VERIFICATION TESTING

A. Contractor shall participate in Performance Verification Testing as stipulated in Section 01 91 00 and Section 01 91 10.

1.16 FUNCTIONAL PERFORMANCE TESTING

A. Contractor shall participate in Functional Performance Testing as stipulated in Section 01 91 00 and Section 01 91 10.

1.17 FPT ACCEPTANCE CRITERIA

A. Acceptance criteria for tests are indicated in Sections 01 91 00 and 01 91 10, and in the specification sections applicable to the systems being tested. Generally, unless indicated otherwise, the criteria for acceptance will be that specified with the individual system, equipment, component, or device.

1.18 TRAINING

A. Contractors, Subcontractor, Vendors, and other applicable Parties shall prepare and conduct training sessions on the installed systems and equipment they are responsible for per the requirements of Section 01 91 00 and the individual Specifications.

1.19 SYSTEMS MANUAL CONTENT - PREPARATION AND LOGISTICS

A. Refer to Section 01 91 00 the individual Specifications.

PART 2 PRODUCTS

2.01 INSTRUMENTATION

A. **General**: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of +/- 0.1°F.
2. Pressure sensors shall have an accuracy of +/- 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
3. All equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.

B. **Standard Testing Instrumentation**: Standard instrumentation used for testing air and water flows, temperatures, humidity, noise levels, amperage, voltage, and pressure differential in air and water systems shall be provided by the Commissioning Authority.

C. **Special Tools**: Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and turned over to the Owner upon project completion.

2.02 *CXWORX* SOFTWARE

A. **General:** *CxWorx* is a web-based software program that supports the commissioning process through a web browser or Android Application. It allows multiple Parties to collaborate on commissioning information management using the Internet to either enter data or synchronize local copies of the project data held on tablets provided by the CxA with the master project database. *CxWorx* facilitates either completing information directly via the software or by printing forms to fill out in the field. Refer to the Cx Plan for further details on *CxWorx.*

B. **Participation:** Mechanical, Electrical, TAB, and BAS Contractors shall participate in the use of *CxWorx* to document the Cx procedures.

C. **Requirements for Use**: Refer to Section 01 91 00.

D. ***CxWorx* Training**: Refer to Section 01 91 00.

2.03 TEST KITS FOR METERS AND GAGES

A. Test kits for meters and gages shall be provided to the Owner new and in good condition. Previously used kits will be unacceptable. Kits shall be submitted prior to the Acceptance Phase. Kits included shall be as a minimum:

1. Digital indication of temperature and pressure with associated sensors to work with the P/T test ports
2. Companion readout kit (with fittings) for calibrated balancing valve with ranges as required by all devices on this project

PART 3 EXECUTION

3.01 STARTUP PROCEDURES - GENERAL

A. This Section outlines ‘generic’ or minimally acceptable Startup Procedures (delineated as Startup Checks and Startup Tests) and individual systems training requirements for systems and equipment. These procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct per standard quality control practices. These items shall provide a minimum or guideline for required Contractor development of Startup Procedures. Contractor shall synthesize these minimum requirements along with their own internal quality control practices, those of the manufacturer, and any applicable codes and standards to develop specific and itemized Startup Procedures specific to the equipment and systems installed on this project.

3.02 PROCEDURES COMMON TO ALL SYSTEMS

A. The following start up verifications/procedures are common to all systems

B. Checkout shall all sensors and system components.

C. Verify labeling is affixed per specifications and visible.

D. Verify prerequisite procedures are complete.

E. Inspect for damage and ensure none is present.

F. Verify system is applied per the manufacturer’s recommendations.

G. Verify system has been started up per the manufacturer’s recommendations.

H. Verify that access is provided for inspection, operation and repair.

I. Verify that access is provided for replacement of the equipment.

J. Verify the record drawings, submittal data and O&M documentation accurately reflect the installed systems.

K. Verify all gages and test ports are provided as required by contract documents and manufacturer’s recommendations.

L. Verify all recorded nameplate data is accurate.

M. Installation is done to ensure safe operation and maintenance.

N. Verify specified replacement material/attic stock has been provided as required by the Construction Documents.

O. Verify all rotating parts are properly lubricated.

P. Verify all monitoring and ensure all alarms are active and set per Owner’s requirements.

3.03 VALVES

A. **Startup Checks**: Perform the following checks during startup and as specified in manufacturer's instructions:

1. Operate all valves, manual and automatic, through their full stroke. Ensure smooth operation through full stroke and appropriate sealing or shutoff.
2. Verify actuators are properly installed with adequate clearance.
3. Verify all valves are labeled per the construction documents. Confirm that concealed valves are indicated on the finished building surface.

4. For automatic pneumatically-operated valves, verify spring range and adjust pilot positioners where applicable. For electronically operated valves, check the stroke and range. For all automated valves controlled by a program, ensure that the minimum and maximum stroke and ranges on the valves are coordinated with the limits entered in the program.

3.04 METERS AND GAGES

A. **Startup Checks**: Perform the following checks during startup and as specified in manufacturer's instructions:

1. Adjust faces of meters and gages to proper angle for best visibility.
2. Clean windows of meters and gages and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touch-up paint. For meters and gages requiring temporary manual connection of read-out device such as pressure taps on a flow measuring device, ensure threads are clean and that connection can be made easily.
3. Meters and gages requiring manual connection of readout device shall be installed with adequate access to allow connection of device with normal tools.

3.05 MECHANICAL IDENTIFICATION

A. **Startup Checks**: Perform the following checks:

1. Verify all valve tags, piping, duct, and equipment labeling corresponds with drawings and indexes and meets requirements specified. Correct any deficiencies for all piping and duct systems.
2. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.
3. Cleaning: Clean face of identification devices, and glass frames of valve charts.

3.06 MECHANICAL INSULATION

A. **Startup Checks**: Examine all piping, systems and equipment specified to be insulated.

1. Ensure quality of insulation. Patch and repair all insulation damaged after installation.
2. Ensure the integrity of vapor barrier around all cold surfaces.

3.07 PIPING - GENERAL

A. **Startup Checks**: These Procedures apply to all installed piping systems, including underground site utilities.

1. Inspect all piping for proper installation, adequate support (with appropriate vibration isolation where applicable) and adequate isolation valves for required service.
2. Submit welding certifications as required by the applicable specification section or referenced ASME specification.
3. Submit certified welding inspection results per the applicable specification section or referenced ASME specification. ASME B31.1 requires 100% inspection based on pressure class.
4. Provide notification of pipe cleaning and flushing activities.

5. Flush and clean all piping and clean all strainers. Provide documentation of all related procedures.
6. Ensure adequate drainage is provided at low points and venting is provided at high points.
7. Ensure air is thoroughly removed from the system as applicable. Ensure facilities to effectively drain and fill the system are in place.
8. Ensure all piping is adequately supported and anchored to allow expansion. Bump across-the-line pumps and inspect for excessive pipe movement.
9. Provide notification of pressure testing.
10. Pressure and/or leak test all applicable systems in accordance with the requirements in the applicable sections, ASME B 31.1 and 39.1 as applicable.
11. Sterilize applicable piping systems as specified in the individual Sections and as required by regulatory authorities.
12. Submit pressure test reports that document the pressure testing results with Certification of the results.
13. Verify the operation of applicable safety relief valves, operating controls, safety controls, etc. to ensure a safe installation.
14. Set and adjust fill, pressure, or level controls to the required setting.

3.08 AC MOTORS

A. **Startup Checks**: Perform the following checks during startup and as specified in manufacturer's instructions:
   1. Verify proper alignment, installation, and rotation.
   2. Verify properly sized overloads are in place.

B. **Startup Tests**: Perform the following tests, measurements, or procedures during startup and as specified in manufacturer's instructions:
   1. Measure insulation resistance, phase balance, and resistance to ground.
   2. Measure voltage available to all phases. Measure amps and RPM after motor has been placed in operation and is under load.
   3. Record all motor nameplate data.

3.09 BEARINGS

A. This applies to all bearings on fans, pumps, compressors, etc.

B. Use infrared thermometer to measure temperature at peak conditions. Ensure temperature is below manufacturer’s recommendations.

C. Check alignment as applicable.

D. For bearings in drives with motors over 10 HP, use a vibration meter and measure the maximum peak to peak acceleration. Compare it to the “Vibration Severity Chart”. Rectify any condition causing conditions indicated as “Rough” or worse.

E. Lubricate all bearings per the manufacturer’s instructions. When bearing is used for temporary conditioning, lubricate on manufacturer’s recommended frequency and document it.

3.10 VARIABLE SPEED DRIVES

A. **General**: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

B. **Startup Checks**: Perform the following checks before startup and as specified in manufacturer's startup instructions:

1. Check unit for shipping damage.
2. Perform a point-to-point continuity test for all field installed wiring interconnections. Verify terminations of field installed wiring.
3. Check for proper torque on connections.
4. Verify use of shielded cable where specified and check that shields have been terminated properly.
5. Verify grounding.
6. Check motor nameplate against drive input rating.
7. Manually rotate motor shaft to ensure free rotation.
8. Check that motor leads are not grounded.

C. **Startup Tests**: Perform the following tests, measurements, or procedures during startup and as specified in manufacturer's instructions:

1. Ensure device and system which drive is serving is configured to withstand the device operation specified below.
2. Adjust the Minimum Voltage Adjustment to enable starting but not to draw excessive power at start.
3. Adjust the Volts/Hz adjustment to proper setting.
4. Adjust the Acceleration and Deceleration rates to the specified times.
5. Adjust Current Limiting to coordinate with the overcorrect device and protect the motor.
6. Set the Maximum and Minimum speed pots.
7. Manually ramp fan speed from minimum to maximum and check for excessive noise and vibration.
8. Determine any critical speeds to avoid and set these in the drive.
9. Check for acceptable voltage and current distortion on the power system. Record the input and output voltages and currents showing the harmonic content as a percentage of the base frequency.
10. Measure and record overall efficiency at 50%, 75%, and 100%.
11. Record the motor terminal voltage.

D. **Training**: Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventative maintenance.

1. Review data in Operating and Maintenance Manuals.

3.11 HYDRONIC PIPING

A. **Startup Checks**: Perform the following checks:

1. Prepare hydronic and test piping in accordance with applicable Section and ASME B 31.9 and/or B 31.1.

2. Flush system with clean water in accordance with applicable Section.
3. Clean strainers.
4. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
5. Set automatic fill valves for required system pressure.
6. 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).
7. Set and coordinate automatic fill pressure and relief valve settings

B. **Startup Tests**: Perform the following tests, measurements, or procedures during startup:

1. Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.12 PUMPS

A. Refer to AC Motors in this section.

B. Refer to Bearings in this section.

C. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.

D. **Startup Checks**: Perform the following checks before startup:

1. Check suction lines connections for tightness to avoid drawing air into the pump.
2. Clean and lubricate all bearings.
3. Check motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.
4. Check that pump is free to rotate by hand. For pumps handling hot liquids, pump shall be free to rotate with the pump hot and cold. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.
5. Clean associated strainers.
6. Check that the proper overloads have been installed in the starter and are the correct size.
7. Verify that the integrity of the vibration isolation is maintained throughout the support and the connections.
8. Align pump within manufacturers recommended tolerances.
9. Ensure all associated piping has been cleaned, tested, and de-aerated.
10. Verify that all thermometers and gages are installed, are clean and undamaged, and are functional.

E. **Startup Tests**: Perform the following tests, measurements, or procedures during startup:

1. Start the pump per the manufacturer’s instructions.
2. Check the general mechanical operation of the pump and motor.
3. Verify that check valve seal is appropriate.
4. Check noise and vibration levels and ensure they are within the manufacturers recommended tolerances.
5. Check that the NPSH is with that allowable for the operating condition.

6. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.

3.13 FOSSIL FUEL BOILERS

A. Refer to AC Motors in this section

B. Startup Checks: Perform the following checks before startup:

1. All associated piping has been cleaned, tested, filled, and de-aerated.
2. Ensure cast-iron boilers are flushed and cleaned upon completion of installation, in accordance with manufacturer's startup instructions.
3. Ensure hydrostatic tests on assembled boiler and piping were performed and documented in accordance with applicable sections of ASME Boiler and Pressure Vessel Code.
4. Arrange with National Board of Boiler and Pressure Vessel Inspectors for inspection of boiler piping, observation of hydrostatic testing, and for certification of completed boiler units.

C. Startup Tests: Performed by a factory-authorized service representative

1. Inspect the installation and access/clearance for service and maintenance to ensure it meets the project and manufacturer’s requirements.
2. Check for adequate fuel line pressures throughout operational range.
3. Test and adjust operating and safety controls.
4. Adjust burner for maximum burning efficiency throughout the range of fire.
5. Ensure adequate draft in the flue throughout firing range with various combinations of multiple boilers.

3.14 BOILER ACCESSORIES

A. Startup Tests: Perform the following before or during startup:

1. Flush and clean boiler accessories upon completion of installation, and in accordance with manufacturer's installation instructions.
2. Hydrostatically test, if required, assemble boiler accessories and piping in accordance with applicable sections of ASME Boiler and Pressure Vessel Code.
3. Operate all safeties and control interlocks and to ensure proper operation and adjustment.

3.15 VARIABLE REFRIGERANT VOLUME AIR COOLED CONDENSING UNITS

A. Provide the services of a factory authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

B. Refer to AC Motors in this section

C. Startup Checks: Perform the following inspections/checks before startup:

1. Ensure unit is level.
2. Coils are undamaged and fins are combed.
3. Condenser fan rotates freely and check rotation direction.

D. Startup Tests: Perform the following before or during startup:

1. Startup condensing units, in accordance with manufacturer's startup instructions.
2. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
3. Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.

E. Training: Factory-authorized representative shall train Owner's maintenance personnel including:
1. Procedures and schedules related to startup and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals.

3.16 AIR COOLED CHILLERS

A. General: Provide the services of a factory authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below. Representative shall provide a written report documenting the startup.

B. Refer to Bearings in this section.

C. Refer to AC Motors in this section.

D. Startup Checks: Perform the following inspections/checks before startup:
1. Ensure that all associated piping is cleaned, tested, filled, and de-aerated.
2. Inspect the installation and access/clearance for service and maintenance to ensure it meets the project and manufacturer’s requirements.
3. Check control interfaces for proper ranges and approve the interface

E. Startup Test and Service:
1. Provide the services of a factory authorized service representative to provide startup service.
2. Evacuate, dehydrate, vacuum pump and charge with specified refrigerant, and leak test in accordance with manufacturer's instructions. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
3. Perform lubrication service, including filling of reservoirs, and confirming that lubricant is of quantity and type recommended by manufacturer.
4. Optimize chiller charge and operating characteristics.
5. Log machine parameters at various load, at a minimum 25%, 50%, 75%, and 100%.
6. Confirm chiller cycles are within manufacturer’s recommendations and that compressors generally do not start more than 6 times per hour.
7. Submit factory startup report per specifications.

F. Training: Factory-authorized representative shall train Owner's maintenance personnel including:
1. Procedures and schedules related to startup and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals.

3.17 ROOFTOP HEATING AND COOLING UNITS (DOAS UNITS)

A. Provide the services of a factory authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

B. Refer to AC Motors in this section

C. Startup Checks: Perform the following inspections/checks before startup:

1. Ensure unit is level.
2. Coils are undamaged and fins are combed.

D. Startup Tests: Perform the following before or during startup:

1. Startup units in accordance with manufacturer's startup instructions.
2. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
3. Test for leaks. Repair leaks and replace lost refrigerant and oil.
4. Install new filters after start up.

E. Training: Factory-authorized representative shall train Owner's maintenance personnel including:

1. Procedures and schedules related to startup and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals.

3.18 CENTRAL-STATION AIR-HANDLING UNITS

A. Provide the services of a factory authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

B. References: The following additional Sections shall also apply:

1. Refer to AC Motors in this Section.
2. Refer to Fans in this Section.
3. Refer to Section 23 05 93 "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.
4. Refer to Section 23 08 10 “Commissioning Building Automation System” for procedures for starting the controls related to the AHU.

C. Startup Checks: Perform the following inspections/checks before startup:

1. Inspect the field assembly of components and installation of central-station air-handling units including piping, ductwork, and electrical connections.
2. Cleaning: Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
3. Adjust and lubricate dampers and linkages for proper damper operation.
4. For field fabricated units, ensure the sections are properly connected within acceptable tolerances.
5. Seal the all penetrations air tight and ensure access doors seat tightly.
6. Verify unit is secure on mountings and supporting devices and verify connections for piping, ductwork, and electrical are complete.

7. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
8. Ensure vibration isolation integrity is maintained throughout the AHU installation and its connections.
9. Tension all belts per the drive manufacturer's recommendations.
10. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
11. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
12. Comb coil fins for parallel orientation.
13. Install clean filters.
14. Ensure condensate drains properly and that trap is adequate.
15. Stroke all valves and dampers to ensure free and full travel

D. Startup Tests: Perform the following before or during startup:

1. Pressure test units as required in the AHU specification

E. Training: Factory-authorized representative shall train Owner's maintenance personnel including:

1. Procedures and schedules related to startup and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals.

3.19 FAN COIL UNITS

A. Provide the services of a factory authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

B. References: The following additional Sections shall also apply:

1. Refer to AC Motors in this Section.
2. Refer to Fans in this Section.
3. Refer to Section 23 05 93 "Testing, Adjusting, and Balancing" for procedures for fan coil unit testing, adjusting, and balancing.
4. Refer to Section 23 08 10 "Commissioning Building Automation System" for procedures for starting the controls related to the FCU.

C. Startup Checks: Perform the following inspections/checks before startup:

1. Inspect the field assembly of components and installation of fan coil units including piping, ductwork, and electrical connections.
2. Cleaning: Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
3. Seal the all penetrations air tight and ensure access doors seat tightly.
4. Verify unit is secured to hanging/supporting devices and verify connections for piping, ductwork, and electrical are complete.

5. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
6. Ensure vibration isolation integrity is maintained throughout the FCU installation and its connections.
7. Tension all belts per the manufacturer's recommendations.
8. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
9. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
10. Comb coil fins for parallel orientation.
11. Install clean filters.
12. Ensure condensate drains properly and that trap is adequate.
13. Stroke all valves to ensure free and full travel.

D. Training: Factory-authorized representative shall train Owner's maintenance personnel including:

1. Procedures and schedules related to startup and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals.

3.20 VAV TERMINAL UNITS

A. Refer to and coordinate with Section "Testing, Adjusting, and Balancing"

B. Startup Checks: Perform the following inspections/checks before startup:

1. After construction is completed, including painting if applicable, clean unit exposed surfaces.
2. Clean factory-finished surfaces. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
3. Ensure unit is properly supported and that integrity of vibration isolation has been maintained where applicable.
4. Ensure that air velocity sensor is correctly installed and that inlet/outlet restrictions for accurate measurements have been met.
5. Ensure air inlet is free of obstructions.
6. Ensure the coils are undamaged, combed, and vented.
7. Check the heating device and control to ensure functionality and proper installation. Check stroke and range on the valve and ensure it closes and seals tightly.

C. Startup Tests: Perform the following before or during startup:

1. Calibrate and adjust the airflow control parameters. Set applicable min and max set points. Coordinate with the ATC contractor as necessary to obtain flow parameters required.
2. Install new filters where required.
3. Set all temperature and humidity set points to those as directed by Owner.
4. Record supply air temperature at full cooling and at full heating (compare both with current air handler temp).

3.21 VARIABLE REFRIGERANT TERMINAL UNITS

A. Refer to and coordinate with Section "Testing, Adjusting, and Balancing"

B. Startup Checks: Perform the following inspections/checks before startup:

1. After construction is completed, including painting if applicable, clean unit exposed surfaces.
2. Clean factory-finished surfaces. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
3. Ensure unit is properly supported and that integrity of vibration isolation has been maintained where applicable.
4. Ensure air inlet is free of obstructions. Start fans and ensure proper rotation (as applicable). Measure and record motor amperage and voltage.
5. Ensure the coils are undamaged, combed, and vented.
6. Check the heating and cooling devices and control to ensure functionality and proper installation.

C. Startup Tests: Perform the following before or during startup:

1. Install new filters where required.
2. Set all temperature and humidity set points to those as directed by Owner.
3. Record supply air temperature at full cooling and at full heating (compare both with current air handler temp)

3.22 FANS

A. **General:** Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

B. **References**: The following additional Sections shall also apply:

1. Refer to AC Motors in this Section.
2. Refer to Bearings in this Section.
3. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.
4. Refer to Division 15959 Section “BAS Commissioning” for procedures for starting the controls related to the Fan.

C. **Startup Checks**: Perform the following inspections/checks before startup:

1. Inspect the field assembly of components and installation of central-station air-handling units including piping, ductwork, and electrical connections.
2. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
3. Adjust and lubricate dampers and linkages for proper damper operation.
4. Verify unit is secure on mountings and supporting devices and that the connections for ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
5. Ensure vibration isolation integrity is maintained with the fan installation and the connections to it.

6. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
7. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
8. Stroke all dampers to ensure free and full travel.

D. **Training**: Factory-authorized representative shall train Owner's maintenance personnel including:

1. Procedures and schedules related to startup and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals.

3.23 METAL DUCTWORK

A. **Temporary Closure:** At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

B. **Startup Checks**: Perform the following checks before startup and as specified:

1. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.
2. Strip protective paper from stainless ductwork surfaces if applicable, and repair finish wherever it has been damaged.

C. **Startup Tests**: In addition to specifications, perform the following as a minimum:

1. Leakage Tests: After each duct system which is constructed for duct classes over 3" is completed, test for duct leakage in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Repair leaks and repeat tests until total leakage is less than 1% of system design air flow.
2. Balancing: Refer to Division-23 section "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork; not work of this section. Seal any leaks in ductwork that become apparent in balancing process.

3.24 DUCTWORK ACCESSORIES

A. **Startup Checks**: Perform the following checks before startup and as specified:

1. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

B. **Startup Tests**: In addition to specifications, perform the following as a minimum:

1. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leak proof performance.
2. Label access doors in accordance with Division-23 section "Mechanical Identification".

3. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.
4. Final positioning of manual dampers is specified in Division- 23 section "Testing, Adjusting, and Balancing".
5. Fire Damper Testing: For every fire damper, remove the fusible link and verify that the damper operates freely and closes tightly. Reinstall the fusible link.

3.25 BUILDING AUTOMATION AND CONTROL SYSTEMS

A. **Startup Checks**: Perform the following checks before startup and as specified:
1. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

B. **Startup Tests**: Refer to Section 23 08 10 BAS Commissioning. This generally requires manufacturers authorized representative to startup, test, adjust, and calibrate direct digital and other microprocessor-based control systems and demonstrate compliance with requirements. This will include verification of sequences, normal and emergency operations, calibration, interfaces, and interlocks, etc.

3.26 TESTING, ADJUSTING, AND BALANCING

A. **Reference**: Perform testing and balancing procedures on each system identified in accordance with Section 23 09 05 and detailed procedures outlined in individual specification sections and the referenced standards.

B. **Startup Checks**: In addition to specifications, perform the following as a minimum:
1. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.
2. Patch insulation, ductwork, and housings, using materials identical to those removed.
3. Seal ducts and piping, and test for and repair leaks.
4. Seal insulation to re-establish integrity of the vapor barrier.
5. 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.
6. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.
7. Test and adjust mechanical systems for sound and vibration in accordance with the detailed instructions of the referenced standards.

3.27 ROOM/ZONE/PHASE CHECKOUT

A. Contractor shall complete a checklist acknowledging completion of Div. 23 responsibilities for all areas and equipment relevant to testing. Checklist shall include items such as the following as applicable:

B. Typical Room:
1. Diffuser, registers, and grilles installed and cleaned.
2. Zone Control in place and functional.
3. All terminal equipment functional, clean, and punched out.

4. Occupancy schedules entered with applicable control set points.

C. Supplement as applicable for the project.

END OF SECTION

SECTION 23 08 10 – BUILDING AUTOMATION SYSTEM COMMISSIONING

PART 1 GENERAL

1.01 WORK INCLUDED

A. BAS System and equipment testing and start-up.

B. Validation of proper and thorough installation of BAS systems and equipment.

C. Performance Verification Testing of control systems.

D. Functional Performance Testing of control systems.

E. Documentation of tests, procedures, and installations.

F. Coordination of BAS training.

G. Documentation of BAS Operation and Maintenance materials.

1.02 GENERAL DESCRIPTION

A. This section defines responsibilities of the Building Automation System (Division 23) Contractor to Commission the BAS.

B. Commissioning (Cx) is the process of ensuring that all building systems are installed and perform interactively according to the design intent; that systems are efficient and cost effective and meet the Owner's operational needs; that the installation is adequately documented; and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.

C. Commissioning Authority (CA) is retained by the Owner shall work with the Contractor and the Design Engineer to direct and oversee the Cx process and perform functional performance testing.

D. This Section outlines the Cx procedures specific to the Division 23 Contractors. Requirements common to all Sections are specified in Section 01 91 00.

1.03 SCOPE

A. The scope of the Commissioning on this project shall include the entire BAS system.

1.04 RELATED SECTIONS:

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

B. Commissioning Plan: The Commissioning Plan outlines the commissioning process beyond the construction specification. All Contractor responsibilities are outlined in Specifications. Cx Plan is available to the Contractor to understand the context of their responsibilities but does not define any additional responsibilities of the Contractor

C. Section 01 91 00 – General Commissioning Requirements: details the Cx requirements common across all divisions

D. Section 01 91 10 – Functional Testing Procedures: Outlines the generic functional testing procedures required.

E. Section 23 08 00 – HVAC Systems Commissioning: Details the commissioning procedures specific to HVAC (Div 23) work.

1.05 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 01 91 00.

1.06 REFERENCE STANDARDS

A. ASHRAE Guideline 1.1-2007, "HVAC&R Technical Requirements for the Commissioning Process"

B. ASHRAE Guideline 4-2008, “Preparation of Operating and Maintenance Documentation for HVAC&R Systems”

C. NEBB - Procedural Standards for Whole Building Systems Commissioning of New Construction

1.07 CONTRACTOR RESPONSIBILITIES

A. General responsibilities of the Contractor are specified in Section 01 91 00. The following responsibilities indicate specific responsibilities of the BAS contractor in addition to those responsibilities.

B. Assist CA with Performance Verification and Functional Performance testing. Assistance will include the following:

1. Establish trend logs of system operation as specified herein.
2. In-situ calibration of the space temperature sensors. The calibration offset will be determined by the CA, provided to the BAS contractor, and the CA will validate entry of the correct offsets by the BAS contractor.
3. Manipulate systems and equipment to facilitate Performance Verification Testing as outlined in this section, Division 1 and Division 23 Commissioning Specifications, and the Commissioning Plan. Provide Portable Operator Terminals or operator workstations in locations convenient to testing activities as specified below.
4. Provide CA with appropriate passwords, keys, and access to control panels and workstations.
5. Where control systems do not allow a test mode or the overriding of physical input values for testing, program an interim virtual point for all inputs that can be used to represent the point and be overridden for testing.

C. Provide a Control technician to work at the direction of Commissioning Authority for software optimization assistance for a minimum of 16 hours. Refer to Part 3 for a description of the software optimization.

D. Provide a form summarizing all set points and alarm parameters and alarming strategies for the Owner to complete. Organize a meeting to discuss the desired initial set points and alarm parameters. Contractor shall enter the requested set points and alarm parameters at completion of startup and record the applicable settings in the pre-functional documentation.

E. Train Owner's Representatives in system's operation and control equipment use, operation, maintenance and repair. Training shall be conducted as follows:

1. Control system training shall be conducted by the Control Subcontractor. Control system training shall be as specified in Part - 3 of this section.

F. Compensate the Owner for site time necessitated by incompleteness of systems or equipment at time of functional performance testing. All testing failures which require on-site time for retesting will be considered actual damages to the Owner. The contract sum shall be reduced by contract modification at a negotiated rate per man-hour of on-site time necessary to retest failures. All parties under contract with the Owner who are affected by the retesting shall be included in the contract modification. Refer to Section 01 91 00 and 01 91 10 for more details.

1.08 SEQUENCING:

A. Refer Section 01 91 00.

B. The following list outlines the general sequence of events for commissioning of the Building Automation System.

1. Construction Phase:
   a) Collaborate on construction scheduling.
   b) Submit Product Data and Shop Drawings as specified, and receive approval.
   c) Meet with Cx Team to coordinate with all trades.
   d) Begin controls installation.
   e) Submit specific start-up procedures for all equipment provided by the BAS contractor.
   f) Complete BAS portion of Pre-FPT checklists.
   g) Submit Training Plan content; receive approval of Training Plan content.
   h) Provide alarm list and receive approval.
   i) Provide sample graphics and receive approval.
   j) Complete BAS system installation.
   k) Place systems under BAS control.
   l) Enter alarms as approved by Owner.
   m) Complete BAS graphics.
   n) Perform BAS system start up and complete pre-functional documentation.
   o) Submit completed BAS startup checklists
   p) Prepare and initiate Trend Log data storage and format trend graphs.
   q) Train Owner on control system operation and maintenance for basic system offering.
   r) System Turn Over Meeting

s) Submit Commissioning BAS Software/Access and provide password access to Owner and Commissioning Authority.

t) Demonstrate systems to Commissioning Authority and Owner.

u) Submit trend logs in format specified.

v) Receive Demonstration approval and approval to schedule Acceptance Phase.

2. Acceptance Phase

a) Allow a minimum two weeks for Performance Verification Testing at the direction of CA.

b) Receive Performance Verification Testing approval which enables start of Functional Performance Testing.

c) Commissioning Authority Performs Functional Performance Testing and BAS contractor participates in initial samples.

d) Receive Functional Completion approval for the BAS.

e) Substantial Completion as determined by 01 77 00.

3. Warranty Phase

a) Provide administrator access password access to Owner.

b) Train Owner on final Sequences and modes of operation.

c) Update facility manual content with any changes.

d) Revise and Re-Submit Record drawings and O&M manuals.

e) Participate in Opposite Season Functional Performance Testing.

f) Receive Opposite Season FPT approval.

g) Revise and Re-Submit Record drawings and O&M manuals.

h) Update Framed Control Drawings.

i) Complete owner training.

j) End of Warranty Period.

PART 2 PRODUCTS

2.01 INSTRUMENTATION

A. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of + or - 0.1°F.
2. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
3. All equipment shall be calibrated according to the manufacturer’s recommended intervals. Calibration tags shall be affixed or certificates readily available.

B. Standard Testing Instrumentation: Standard instrumentation used for testing air and water flows, temperatures, humidity, noise levels, amperage, voltage, and pressure differential in air and water systems related to functional testing shall be provided by CA.

C. Special Tools: Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and turned over to the Owner upon project completion.

2.02 CXWORX SOFTWARE

A. General: CxWorx is a web-based software program that supports the commissioning process through a web browser or Android Application. It allows multiple Parties to collaborate on commissioning information management using the Internet to either enter data or synchronize local copies of the project data held on tablets provided by the CA with the master project database. CxWorx facilitates either completing information directly via the software or by printing forms to fill out in the field. Refer to the Cx Plan for further details on CxWorx.

B. Participation: Mechanical, Electrical, TAB, and BAS Contractors shall participate in the use of CxWorx to document the Cx procedures.

C. Requirements for Use: Refer to Section 01 91 00.

D. CxWorx Training: Refer to Section 01 91 00.

2.03 TEST KITS FOR METERS AND GAGES

A. Test kits for meters and gages shall be provided to the Owner new and in good condition. Previously used kits will be unacceptable. Kits shall be submitted prior to the Acceptance Phase. Kits included shall be as a minimum:

1. Digital indication of temperature and pressure with associated sensors to work with the P/T test ports
2. Companion readout kit (with fittings) for calibrated balancing valve with ranges as required by all devices on this project

2.04 TAB & COMMISSIONING PORTABLE OPERATORS TERMINAL

A. Provide the CA with all software, connection devices, licenses, passwords, etc. to facilitate connection to the BAS throughout the building. Provide a license to graphic software, and all operating software necessary for testing and configuration of all control elements at all levels. License may be a temporary license that will expire after the completion of the Warranty Period. Options include:

1. Provide access to BAS system for CA throughout the Construction and Acceptance Phases.
2. Browser access to the full graphic software. CA will provide laptop, however, BAS contractor shall set up the laptop as necessary to successfully connect. A minimum of three simultaneous license seats must be provided.

3. Licensed Client Software to be installed on CA Computer. BAS contractor shall install the software and ensure it is functional.
4. Terminal Services session access to a Graphic server with required CALs to allow use of all required software. BAS contractor shall configure the CA computer to connect to the terminal session. A minimum of three simultaneous license seats must be provided.

B. Access to the BAS must be provided throughout the building defined as follows:

1. Full wireless connection to the graphic server throughout the building will be adequate.
2. Network connection for full access to the graphic server within 50' of any point in the building
3. Exception to 1 and 2 above: an acceptable alternative to full building access to the graphic server relating to terminal controls shall be providing to the CA the devices and software required to connect to local terminal controllers through a connection port in the space such as connection to a jack on the temperature. This does not apply to mechanical rooms as full graphic access is required in mechanical rooms.

C. Provide software required by TAB to calibrate all flow sensors. TAB will provide computer to be used as a portable operator's terminal. Any manufacturer specific hardware such as connection cables, converters, hand held devices, etc. shall be provided by the contractor.

D. Connections shall be provided local to the device being calibrated. For instance, for VAV boxes, connection of the operator's terminal shall be either at the sensor as well as at the box. Otherwise a wireless system shall be provided to facilitate this local functionality.

PART 3 EXECUTION

3.01 BAS START-UP TESTING, ADJUSTING, CALIBRATION

A. Work and/or systems installed under Division 23 shall be fully functioning prior to Demonstration and Acceptance Phase. Contractor shall start, test, adjust, and calibrate all work and/or systems under this Contract, as described below:

1. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
2. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
3. Verify integrity/safety of all electrical connections.
4. Coordinate with TAB subcontractor and CA to fine tune control settings that are determined from balancing procedures. Record the following control settings as obtained from TAB contractor, and note any TAB deficiencies in the BAS Start-Up Report:
   a) Optimum duct static pressure set points for VAV air handling units.
   b) Minimum outside air damper settings for air handling units.
   c) Optimum differential pressure set points for variable speed pumping systems.

d) Calibration parameters for flow control devices such as VAV boxes and flow measuring stations.

1) BAS contractor shall provide hand held device as a minimum to the TAB and CA to facilitate calibration. Connection for any given device shall local to it (i.e. at the VAV box or at the thermostat). HHD or portable operator's terminal shall allow querying and editing of parameters required for proper calibration and start up.

5. Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the BAS display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range). Record the measured value and displayed value for each device in the BAS Start-Up Report.
6. Check and set zero and span adjustments for all transducers and transmitters.
7. For dampers and valves:
   a) Check for adequate installation including free travel throughout range and adequate seal.
   b) Where loops are sequenced, check for proper control without overlap
8. For actuators:
   a) Check to insure that device seals tightly when the appropriate signal is applied to the operator.
   b) Check for appropriate fail position, and that the stroke and range is as required and coordinated with the programmed ranges when it is operating under normal conditions.
   c) For pneumatic operators, adjust the operator spring compression as required to achieve close off. If positioner or volume booster is installed on the operator, calibrate per manufacturer’s procedure to achieve spring range indicated. Check split range positioners to verify proper operation. Record settings for each device.
   d) Check the stroke and range under actual loading conditions and validate that they correlate with programmed values
   e) For sequenced electronic actuators, calibrate per manufacturer’s instructions to required ranges.
9. Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the OI display. Record the results for each device.
10. For outputs to reset other manufacturers devices (VFDs) and feedback from them, calibrate ranges to establish proper parameters. Coordinate with representative of the respective manufacturer and obtain their approval of the installation.
11. Verify proper sequences by using the approved checklists to record results. Verify proper sequence and operation of all specified functions.

12. Verify that all safety devices trip at appropriate conditions. Adjust set points accordingly.
13. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the BAS Start-Up Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within three minutes of any set point challenge (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted):
    a) Duct air temperature: ±1°F.
    b) Space Temperature: ±3°F within 3 minutes and control within ±2°F
    c) Chilled Water: ±1°F
    d) Hot water temperature: ±2°F.
    e) Duct pressure: ± 0.25" w.g.
    f) Water pressure: ±1 psid
    g) Duct Humidity: ±3% when adding humidity
    h) Space Humidity: ±5% when adding humidity to control
    i) Terminal Air flow control: ±5% of set point. This includes all VAV terminal control and exhausted BSCs, canopy hoods, ventilated cage racks, necropsy tables, and other scientific equipment with supply or exhaust ventilation
14. For communication interfaces and DDC control panels:
    a) Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the record drawings.
    b) Ensure that terminations are safe, secure and labeled in accordance with the record drawings.
    c) Check power supplies for proper voltage ranges and loading.
    d) Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
    e) Check for adequate signal strength and acceptable bandwidth utilization on communication networks.
    f) Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
    g) Ensure that all outputs and devices fail to their proper positions/states.
    h) Ensure that buffered and/or volatile information is held through power outage
    i) With all system and communications operating normally and all trends functioning, sample and record update/annunciation times for critical alarms fed from the panel to the OI.
    j) Check for adequate grounding of all DDC panels and devices.

k) Run self-diagnostic routines and ensure they are functional

l) Check the memory allocation and loading to ensure adequate and excess capacity is available and that it will not affect control functionality.

15. Coordinate desired initial alarm strategies with Owner's Operators. Set all required alarms and document the initial settings in the startup documentation
16. Coordinate all initial set points with Owner's Operators. Ensure those set points are active
17. For Operator Interfaces (OIs):
    a) Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
    b) Output all specified BAS reports for review and approval.
    c) Verify that the alarm printing and logging is functional and per requirements.
    d) Verify that trend archiving to disk and provide a sample to the CA for review.
    e) Verify alarm enunciation functionality. Time delay from actual occurrence to the time updated or enunciated on the screen. Ensure it is per the specified requirements.
    f) Verify that real time and historical trends are accessible and viewable in graph format.
    g) Verify that paging/dial out alarm annunciation is functional.
    h) Verify the functionality of remote OIs and that a robust connection can be established consistently.
    i) Verify that required third party software applications required with the bid are installed and are functional.
    j) Demonstrate open protocol and custom third party interfaces reliably communicate and check response time.
    k) Verify response times and screen update and refresh times are per the requirements.
    l) Verify that all custom programs are editable from the OI. Check upload, download, backup and restore capabilities of system configuration information as well as custom programs.
    m) Verify schedules are set up and working.
    n) Verify Owner stipulated security and permissions is set up and functional.
    o) In concert with the Building Power Outage test, validate that critical GUI installations are properly powered by UPS and emergency outlets to keep it functional during a power outage. Validate that the space has adequate lighting to manage the building in the event of an outage.
18. Verify proper interface with fire alarm system.
19. Verify proper interface with control panels of equipment with self-contained controls that are being monitored by the BAS.

B. Submit Start-Up/Pre-functional Documentation. This shall be completed, submitted, and approved prior to demonstration and Acceptance Phase.

3.02 SENSOR CHECKOUT AND CALIBRATION

A. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading of each other for pressure. Tolerances for critical applications may be tighter.

B. Calibration: Calibrate all sensors using one of the following procedures:

1. Sensors Without Transmitters--Standard Application. Make a reading with a calibrated test instrument within 6 inches of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat, gage or EMCS) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20% of the expected range.
2. Sensors With Transmitters--Standard Application. Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer’s resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or EMCS) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.

C. Sensor Tolerance: Sensors shall be within the tolerances specified for the device. Refer to Section 23 09 13 and 23 09 23.

D. In-situ calibration of space temperature sensors: The calibration offset will be determined by the CA, provided to the BAS contractor, and the CA will validate entry of the correct offsets by the BAS contractor.

3.03 LOOP TUNING

A. For all control loops, contractor shall tune the loops to ensure the fastest stable response without hunting, offset or overshoot with tolerances defined above. Contractor shall introduce upsets to the load when possible to affect response. Otherwise, set points can be changed to affect the response.

B. Tune loops during periods of high gain.

C. Document all parameters either by capturing text, short interval trends, or screen shots of trend graph documenting the final response.

3.04 COIL VALVE LEAK CHECK

A. Verify proper close off of the valves. Ensure the valve seats properly by simulating the maximum anticipated pressure difference across the circuit. Calibrate air temperature sensors on each side of coil to be within 0.5°F of each other. Via the OI, command the valve to close. Energize fans. After 5 minutes observe air temperature difference across coil. If a temperature difference is indicated, and the piping surface temperature entering the coil is within 3°F of the water supply temp, leakage is probably occurring. If it appears that it is occurring, close the isolation valves to the coil to ensure the conditions change. If they do, this validates the valve is not closing. Remedy the condition by adjusting the stroke and range, increasing the actuator size/torque, replacing the seat, or replacing the valve as applicable.

3.05 VALVE STROKE SETUP AND CHECK

A. For all valve and actuator positions checked, verify the actual position against the OI readout.

B. Set pumps to normal operating mode. Command valve closed, verify that valve is closed, and adjust output zero signal as required. Command valve open, verify position is full open and adjust output signal as required. Command valve to a few intermediate positions. If actual valve position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics)

3.06 ALARM SET POINT COORDINATION

A. The Contractor shall prepare a list of all conceptual point types and recommend the types and recommended alarming strategies and set point for review of the Commissioning Agent and the Owner. Owner shall use this alarm list to provide direction to Contractor for alarm strategies and set points. Alarm list shall be provided at least two months prior to the first functional test. Contractor shall have alarm set points entered prior to functional testing. Omitting an alarm setting, using the wrong strategy, or entering the wrong set points will be considered a failure from the perspective of the functional test.

3.07 GRAPHIC COORDINATION

A. The Contractor shall prepare all graphics (only one example graphic is required for typical systems like terminal units) with points embedded for review of by the Commissioning Agent and the Owner. Owner shall use these graphics to provide direction to Contractor for the required final graphic. All final graphics must be complete and active before functional testing. Any deviation from the approved graphics will be considered a failure from the perspective of the functional test.

3.08 BAS DEMONSTRATION

A. Demonstrate the operation of the BAS hardware, software, and all related components and systems to the satisfaction of the Commissioning Agent and the Owner. Schedule the demonstration with the Owner's representative 1 week in advance. Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report are approved. If the Work fails to be demonstrated to conform to Contract specifications, so as to require scheduling of additional site visits by the Commissioning Authority for

re-demonstration, Contractor shall reimburse Owner for costs of subsequent Commissioning Authority site visits.

B. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems. All training documentation and submittals shall be at the job site.

C. Demonstration shall typically involve small representative samples of systems/equipment randomly selected by the Owner and CA.

D. The system shall be demonstrated following the same procedures used in the Start-Up Test by using the approved Commissioning Checklists. Demonstration shall include, but not necessarily be limited to, the following:

1. Demonstrate that required software is installed on EMCS workstations. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.
2. Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified.
3. Demonstrate that remote dial-up communication abilities are in accordance with these Specifications.
4. Demonstrate correct calibration of input/output devices using the same methods specified for the start-Up tests. A maximum of 10 percent of I/O points shall be selected at random by Commissioning Authority and/or Owner for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by Commissioning Authority for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.
5. Demonstrate that all DDC and other software programs exist at respective field panels. The Direct Digital Control (DDC) programming and point database shall be as submitted and approved.
6. Demonstrate that all DDC programs accomplish the specified sequences of operation.
7. Demonstrate that the panels automatically recover from power failures, as specified.
8. Demonstrate that the stand-alone operation of panels meets the requirements of these Specifications. Demonstrate that the panels' response to LAN communication failures meets the requirements of these Specifications.
9. Identify access to equipment selected by Commissioning Authority. Demonstrate that access is sufficient to perform required maintenance.
10. Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.

E. BAS Demonstration shall be completed and approved prior to functional testing.

F. Any tests successfully completed during the demonstration will be recorded as passed for the functional performance testing and will not have to be retested.

3.09 ACCEPTANCE PHASE TESTING

A. After approval of the BAS Demonstration, the Acceptance Phase shall commence. Acceptance Phase testing includes Performance Verification Testing and Functional Performance Testing. The requirements for BAS assistance with Performance Verification and Functional Performance testing are specified in the Section 01 91 10.

B. Acceptance phase testing shall not be scheduled until all HVAC systems for the areas to be tested are in operation and have been started and the startup documented, all required cleaning and lubrication has been completed (i.e., filters changed, piping flushed, strainers cleaned, etc.), and TAB report has been submitted and approved. Acceptance testing will be performed on a system-by-system basis as mutually agreed upon by Contractor, CA and Owner.

C. Preliminary Operational Verification: At the beginning of the Acceptance Phase, the system shall operate properly for two weeks or a time period agreed on by CA and Owner, without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. At the end of the two weeks, contractor shall forward the trend logs to the CA for review. CA shall determine if the system is ready for Performance Verification Testing and document any problems requiring contractor attention.

1. If the systems are not ready for Performance Verification Testing, Contractor shall correct problems and provide notification to the CA that all problems have been corrected. The Acceptance Period shall be restarted at a mutually scheduled time. This process shall be repeated until Commissioning Authority issues notice that the BAS is ready for Functional Performance Testing.

D. During the Acceptance Period, the contractor shall maintain a hard copy log of all alarms generated by the BAS. For each alarm received, contractor shall diagnose the cause of the alarm, and shall list on the log for each alarm, the diagnosed cause of the alarm, and the corrective action taken. If in the contractor’s opinion, the cause of the alarm is not the responsibility of the contractor, contractor shall immediately notify the Owner’s representative.

E. During the Acceptance Phase, the contractor shall maintain all controller network and workstation hardware and software in a state that will allow remote access by Commissioning Agent to Trend Logs as specified below.

3.10 PERFORMANCE VERIFICATION TESTING

A. Description: Preliminary operational testing designed to help ensure that the building will maintain comfort conditions for students and staff. The HVAC equipment can be tested (in most cases) before building occupancy, whereas Functional Performance Testing may take place after occupancy if contractors are not 100% complete.

1. The PV testing will serve as a 'Dry Run' for the FPT. This allows the CA to modify and improve the test for 'real world' conditions that might otherwise result in failure.
2. 100% Equipment testing using FPT scripts to verify readiness for Functional Performance Testing.
3. PV testing will include a detailed field inspection and ‘point-to-point’ testing to verify the proper installation.

4. Point-to-point testing will be executed by BAS contractor and witnessed by CA. Point-to-point includes stroking valves and dampers to a minimum of 3 commanded positions to confirm the dampers and valves use an analog signal, and they are operating correctly.
5. The point-to-point will be followed by a 'Dry Run' of the Functional Performance Tests (FPT's). This FPT Dry Run will be conducted by the BAS contractor at the direction of the CA.

B. Minimum requirements:

1. HVAC and BAS installation for the area/phase to be tested must be 100% complete.
2. The equipment must be capable of maintaining comfort conditions (heating and cooling).
3. Equipment safeties (low temperature shutdown, high pressure shutdown, smoke shutdown, etc.) must be in place and operating.
4. Trends must be in place.

C. Scheduling and Coordination

1. Testing schedule will be for specific equipment groups (like FPT's)
2. Some BAS items may be incomplete, however, a list of those items must be provided by BAS contractor to CA.
3. A Control technician familiar with the project and able to make programming and minor graphics changes must be on site to perform the testing. (Note: FPTs are executed by the CA, with BAS Contractor on hand to advise CA and make corrections when necessary.)
4. Contractor must have available on site a technician familiar with all mechanical systems in the event of any problems.
5. Equipment Manufacturer's representatives do not need to be on site for testing but must be available by phone.

3.11 FUNCTIONAL PERFORMANCE TESTING (FPT)

A. Refer to sections 01 9 100, 01 91 10, 23 08 00, and individual specification sections.

3.12 TREND LOGS

A. This contractor shall configure and analyze all trends required below and under Sections 23 09 13 and 23 09 23.

B. Trends are historical archives on computer disks that document the operation of the systems and equipment. Trends can be interval recordings of system I/O parameters or Change of Value based trends that record when a system value changes by more than a specified threshold.

C. CA will analyze trend logs of the system operating parameters to evaluate normal system functionality. The requirements for this trending are specified below. Contractor shall establish these trends, ensure they are being stored properly, and forward the data in electronic format to the CA. Owner requirements for trending are contained in HCPSS DDC/BAS Conventions, Required Trend/History Setup, Graphic Requirements, Point Naming & Alarm Setup, most current version.

D. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field. Recorded parameters for a given piece of equipment or component shall be trended at the same intervals and be presented in a maximum of two separate two dimensional formats with time being the vertical axis and field name being the horizontal axis. Data shall be forwarded in one of the following formats.

1. Microsoft EXCEL Spreadsheet (.xls)
2. Comma Separated Value (.csv or .txt)

E. Sample times indicated as COV (±) or change of value mean that the changed parameter only needs to be recorded after the value changes by the amount listed. When output to the trending file, the latest recorded value shall be listed with any given time increment record. If the BAS does not have the capability to record based on COV, the parameter shall be recorded based on the interval common to the unit.

F. Contractor shall provide the CA with required passwords, phone numbers, etc. to allow the CA access to the trend log data and allow downloading to a remote location. Contractor shall also provide step-by-step written instructions for accessing the data.

G. Trending Requirements: At a minimum, trend the following on 10 min. intervals for analog values and change of value for binary values.

1. Outside Air Temperature
2. Outside Air Enthalpy
3. All sensed Hydronic Temperatures
4. All sensed air temperatures on primary equipment
5. All air flows (with the exception of terminal devices)
6. All damper outputs on primary equipment
7. All valve outputs on primary equipment
8. All sensed Fan Volumes on primary equipment
9. All inputs and outputs to VFDs
10. Return (or exhaust) Air Temperature on each air handler
11. All safety indications
12. Status on all primary equipment
13. All air and water pressures on primary equipment or systems
14. Space Temperatures
15. Electricity consumption where monitored.
16. Natural Gas flows
17. Generally, all points on primary equipment and selected sampling of terminal points unless approved otherwise

H. Trending to document functional tests may typically be at a more frequent interval. Consult with the CA to determine the required intervals for functional testing and modify intervals as required.

3.13 TREND GRAPHS

A. Trend graphs shall be used during the Acceptance Phase to facilitate and document testing. Prepare controller and workstation software to display graphical format trends during the Acceptance Period. Trend graphs shall demonstrate compliance with contract documents. Trended values and intervals shall be the same as those specified for the functional performance tests.

B. Lines shall be labeled and shall be distinguishable from each other by using either different line types, or different line colors.

C. Indicate engineering units of the y-axis values; e.g. °F., inches w.g., Btu/lb, percent wide open, etc.

D. The y-axis scale shall be chosen so that all trended values are in a readable range. Do not mix trended values on one graph if their unit ranges are incompatible.

E. Trend outside air temperature, humidity, and enthalpy during each period in which any other points are trended.

F. All points trended for one HVAC subsystem (e.g. air handling unit, chilled water system, etc.) shall be trended during the same trend period.

G. Each graph shall be clearly labeled with HVAC subsystem title, date, and times.

3.14 WARRANTY PHASE BAS OPPOSITE SEASON TRENDING AND TESTING

A. Trending: throughout the Warranty Phase, trend logs shall be maintained as required for the Acceptance Period. Contractor shall forward archived trend logs to the CA for review upon CA's request. CA will review these and notify contractor of any warranty work required.

B. Opposite Season Testing: Within 6 months of completion of the Acceptance Phase, CA shall schedule and conduct Opposite Season functional performance testing. Contractor shall support this testing and remedy any deficiencies identified.

3.15 SOFTWARE OPTIMIZATION ASSISTANCE

A. The contractor shall provide the services of a controls technician as specified above at the project site to be at the disposal of the CA. The purpose of this requirement is to make changes, enhancements and additions to control unit and/or workstation software that have been identified by the CA during the construction and commissioning of the project and that are beyond the specified Contract requirements. The cost for this service shall be included with the bid. Requests for assistance shall be for contiguous or non-contiguous 8 hour days, unless otherwise mutually agreed upon by contractor, Commissioning Authority, and Owner. The Owner's representative shall notify contractor 2 days in advance of each day of requested assistance.

B. The controls technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the controls technician provided cannot perform every software task requested by the Commissioning Authority in a timely fashion, contractor shall provide additional qualified personnel at the project site as requested by the Commissioning Authority, to meet the total specified requirement.

3.16 BAS OPERATOR TRAINING

A. Refer to Division 23 specification sections.

END OF SECTION

SECTION 23 09 01 - AUTOMATIC TEMPERATURE CONTROL SYSTEM

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Complete new automatic temperature control (ATC) system.

B. Sequence of operation for automatically controlled equipment is shown on drawings. ATC subcontractor shall cooperate with the unit suppliers and provide all relays and wiring required to integrate the sequence of operation.

1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Automatic control valves, pressure and flow switches, and insertion wells in piping: For installation under Section 23 21 13.

B. Dampers: For installation under Section 23 31 13.

1.13 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. Duct smoke detectors: Section 28 31 00.

1.14 RELATED SECTIONS

A. Controls: Sections 23 09 01 through 23 09 23.

B. Balancing: Section 23 05 93.

C. Commissioning requirements: Divisions 01 and 23.

1.25 SYSTEM DESCRIPTION

A. Provide a complete system of electronic and electric, direct digital temperature controls with electronic and actuation.

B. The system shall consist of two levels of network communication and wiring, DDC controllers, application-specific controllers, software, operator I/O devices, sensors and other necessary input hardware, dampers, valves, actuators and other necessary output hardware, fire and smoke devices, electrical power surge protection, other necessary equipment and a complete system of wiring to fulfill the intent of the sequences of operation shown on the drawings.

1.26 DESIGN REQUIREMENTS:

A. The products specified, scheduled, and shown on drawings are the basis of the design of this project.

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B. For requirements affecting use of optional manufacturers, or substitutions, see Division 01 and Section 23 01 01, HVAC General Provisions; and Section 23 05 00, Common Work Results for HVAC.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings: Provide a point schedule and composite control diagram of all equipment provided for each control sequence, including factory and field controls. Include a written description of sequences, in which each control device or item of equipment is identified by the designation indicated on the diagram.

C. Product data: See individual controls sections.

D. Certifications:

1. Factory authorization and certification of the installing company.
2. Evidence of training, and certification of each supervisor and mechanic assigned to this project.

E. Project record documents: As specified in Division 01 and Section 23 01 01, provide a drawing at the same scale as the contract drawings, showing the locations of all components installed.

1.40 QUALITY ASSURANCE

A. Acceptable installers:

1. Johnson Controls
2. EASI
3. Honeywell

B. Subcontractor qualifications: One hundred percent company-owned, full-service, local branch or authorized factory-direct contractor for one of the acceptable national temperature control manufacturing companies named below, as follows:

1. Full service: Includes system engineering, shop drawing preparation, software programming, installation, commissioning, and service.
2. Factory-direct contractor: Is contracted directly with manufacturer to buy components and has direct access to manufacturer’s local branch office for engineering, service, and technical support without any third-party involvement.
3. Experience: The branch or factory-direct contractor shall have completed at least three system installations of the same type, size, and design, which have successfully operated their sequence of operations for at least three years.
4. Supervisors and mechanics: Factory-trained and certified in the type of control system (pneumatic, electric, digital, electronic) being installed, and directly employed by the subcontractor.

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a. The programmer responsible for programming digital controllers shall have a minimum of three years' experience programming digital controllers of the manufacturer, for HVAC systems.

C. Perform work in accordance with the plumbing, electrical, building, fire and safety codes of the state, county, or city in which the work is performed.

D. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Electric, electronic, or direct digital system:

1. Johnson Controls, Inc.
2. Honeywell, Inc. (Tridium Niagra Framework)

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

A. Coordinate with equipment suppliers to integrate controls provided by manufacturers into the control sequences shown on drawings.

B. Mount devices and control panels provided by equipment manufacturers, and provide required control wiring.

C. Operate, test, calibrate, and adjust each control system until it operates as intended by the manufacturer and as specified in the control sequence.

3.61 TESTS

A. Thoroughly test and check the completed system to ascertain that all equipment is functioning as intended and that dampers and valves respond properly to their controls. Installer of work of this section shall cooperate with the equipment suppliers, and with balancing and testing work, to make necessary adjustments to ATC devices for proper operation of the completed system.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

B. Refer to Section 23 09 23 for additional instruction time and training.

END OF SECTION

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SECTION 23 09 02 - CONTROL SYSTEMS WIRING

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Wiring for automatic temperature control system.

1.14 RELATED SECTIONS

A. Automatic temperature control system: Sections 23 09 01 through 23 09 23.

B. Control sequences: Shown on drawings.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Wire, cable, conduit and fittings, disconnecting switches, and transformers.

1.40 QUALITY ASSURANCE

A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

B. ATC circuit shall not supply other building components such as lights or receptacles.

PART 2 - PRODUCTS

2.10 MATERIALS, GENERAL

A. Electrical materials and devices shall be UL listed and shall meet the requirements of NEC (NFPA 70) and Division 26, Electrical.

2.21 WIRING

A. Wiring 50 V and below: Fully color coded, copper 600 V type THW or THHN, minimum No. 22 or as specified in Division 26, Electrical.

B. Wiring above 50 V: As specified in Section 26 05 19, Wires and Cables.

2.22 CONDUIT AND FITTINGS

A. Galvanized steel conduit: Minimum size 0.75 inch (21 mm), hot-dip galvanized with threads galvanized after cutting, one of the following:

1. Rigid full weight, heavy-wall steel conduit (RGS) conforming to UL 6 and ANSI C80.01.
2. Intermediate steel conduit (IMC) conforming to UL 1242 and ANSI C80.03.

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B. Steel conduit fittings: Cast malleable iron fittings with smooth finish and full threaded hubs. Include steel or malleable iron locknuts, bushings, and other fittings.

1. Insulating bushings: Equal to Thomas and Betts Series 22.
2. Hub fittings with recessed sealing ring and nylon insulated throat equal to Thomas and Betts Series 370.
3. Fittings for exposed locations: Conduit outlet bodies, zinc- or cadmium-plated.

C. Electrical metallic tubing (EMT): Minimum size 0.5 inch (16 mm), maximum 1.5 inch (41 mm), hot-dip galvanized or sherardized thin-wall steel conduit conforming to UL 797 and ANSI C 80.03.

D. Connectors and couplings for EMT: Concrete- or rain-tight, compression or set screw type, made of cadmium-plated steel with nylon insulating throat, equal to Thomas & Betts Series 5031, 5123 and 5120.

E. Flexible metal conduit: Minimum size 0.5 inch (16 mm), made of sheet metal strip, interlocked construction, conforming to UL 1.

F. Liquidtight flexible metal conduit shall conform to UL 360.

G. Connectors for flexible metal conduit: Equal to angle wedge “Tite-Bite” with nylon insulated throat, Thomas & Betts Series 3110 and 3130.

H. Liquidtight connectors: UL 14814A, with fittings and nylon-insulated throat, equal to Thomas & Betts Series 5331.

I. Surface metal raceway: Equal to Wiremold No. 700 minimum size, complete with fittings, connectors, and accessories.

2.30 EQUIPMENT

A. Control transformer: Designed for power sources for 24-V ac control circuits, and precision built to ensure rated power, proper voltage regulation and maximum efficiency. Units shall be equipped with integral manual reset circuit breaker for over-current protection on the secondary winding. Output regulation shall be 10 percent from no load to full load.

B. Disconnecting switches: Specified in Section 26 28 00.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Electrical equipment is specified in Division 26, Electrical. Include in the work of this section relays, pushbuttons, transformers, coils, power wiring, control wiring, or other equipment, meeting requirements of Division 26, so that the automatic temperature control system will function as specified and indicated on the drawings.

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B. Do not use equipment power supply as source for ATC power. Provide a circuit breaker in an electrical panelboard to make ATC connection.

1. Provide circuit breakers that match and are compatible with the other breakers in the panelboard.
2. Panelboards for emergency power are available. Connect ATC to emergency power panelboards.

C. Install conduit and wiring as specified in Sections 26 05 19 and 26 05 33.

D. Provide data systems, including outlets, cabling, and required infrastructure, to support the manufacturers' requirements. All data system components shall meet the requirements of Section 27 15 00, Voice/Data Systems.

E. Make each run of cable or conductor connecting two points with a single continuous piece of cable or conductor. Do not splice.

F. All input, output, and communications wire is to be shielded except when specifically disallowed by the controller or end device manufacturer.

G. All shields on controller input and output wiring shall be terminated except when specifically disallowed by the controller or end device manufacturer. The shield must be terminated at the controller end only.

H. RS-485 communication shield wiring shall be continuous from one end of the trunk to the other and must only be terminated at the ‘originating’ router.

I. The shields (foil and drain wire) from individual wire segments at a controller must be twisted, and the free end of the shield taped back (using electrical tape) to one of the comm wires. A portion of the shield must be exposed to allow a technician to verify the continuity of the shield.

J. When connecting to electrical wiring of equipment provided with pilot lights, connect to circuit so that pilot light is energized only when equipment is energized.

K. Where necessary to connect conduit to motors or motor-driven equipment, or to attach conduit to fan housings or air-handling units which contain fans, use a 24-inch (610-mm) looped section of flexible metallic conduit.

L. When connecting to electric wiring of exhaust fans with Hand/Off/Automatic (HOA) switches and exhaust dampers, connect to circuit so that damper opens in both Hand and Automatic positions.

M. Securely attach disconnecting switches and starters to the wall with lead anchors.

END OF SECTION

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SECTION 23 09 07 - CONTROL DAMPERS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Dampers for automatic control.

1.12 PRODUCTS SUPPLIED BUT NOT INSTALLED UNDER THIS SECTION

A. Dampers: Install under Section 23 31 13.

1.14 RELATED SECTIONS

A. Smoke detectors: Section 28 31 00.

B. Ductwork: Section 23 31 13.

C. Fire dampers, motorized fire dampers, and smoke dampers: Section 23 33 00.

D. Control system, general: Section 23 09 01.

E. Control sequences: Shown on drawings.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data, including test data and ratings, for each type of damper and operator included in the work.

1.91 EXTRA MATERIALS

A. Provide spare damper actuator for each air-handling unit and dedicated outdoor air system unit.

PART 2 - PRODUCTS

2.21 CONTROL DAMPERS AND OPERATORS

A. Supply and return dampers: Equal to Ruskin Model CD35. Dampers for two-position control may be parallel blade type. Dampers for modulating control shall be balanced, multi-louver, opposed-blade type.

1. Blades: Interlocking, minimum 16 gage galvanized steel. Maximum blade width: 8 inches (205 mm). Maximum blade length: 48 inches (1220 mm) without intermediate bearing and frame stiffener.

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2. Frames: Dampers shall be mounted horizontally in a welded channel angle or flat steel frame filled with solid air-stops which shall prevent air leakage between frame and blades. Provide corner braces on frames that measure more than 24 by 24 inches (610 by 610 mm). Finish: two coats of black enamel.
3. Operation: Provide blades with brass pivots operating in non-stick, corrosion-resistant bearings securely mounted in damper frames. Hardware and operating linkage shall be brass or cadmium plated steel. Linkage shall be adjustable in length; joints shall be pin and clevis or ball and socket, free of excessive play. Dampers shall be capable of being positioned accurately from 100 percent open to 100 percent closed and of maintaining any given position indefinitely. Dampers requiring 100 percent closure shall have neoprene gasketed edges.

B. Outdoor air (OA), pressure relief (PR), and exhaust air (EA) dampers: Equal to Ruskin CD 50 low-leakage damper, AMCA-rated Class 1 in accordance with AMCA 511, leakage no more than 4 cfm per square foot at 1-inch wg when tested in accordance with AMCA 500D.

1. Blades: Interlocking, minimum 0.125- inch (3.2-mm) thick extruded aluminum, airfoil shape, maximum width 6 inches.

   a. Dampers for two-position control: May be parallel-blade type.
   b. Dampers for modulating control: Opposed-blade type.

2. Frames: Minimum 0.125-inch (3.2-mm) thick extruded aluminum, with provisions for mounting.
3. Edge seals: Inflatable, replaceable, double-edge blade seal, mechanically held. Flexible metal frame seal.
4. Operation: Linkage out of airstream, axles 0.5-inch (13-mm) diameter and hexagonal, molded synthetic bearings.

C. Electric damper operators: Damper operators shall be Belimo, Johnson Controls, or Honeywell operators with manual override; no other manufacturer is acceptable. Electric motor type with opening time of at least 30 seconds, of size to have 50 percent more power than the minimum required to operate the damper. Fail safe in the event of loss of power: Fresh air and exhaust air dampers shall close and return air dampers shall open.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Furnish dampers to be set in place under Section 23 31 13, Metal Ducts, under the supervision of the control subcontractor.

B. Install operators on control dampers. Operation of particular dampers in conjunction with operation of air-handling equipment is described in control sequences.

C. Set screws shall be set on a flat space on a round shaft. Provide a double set screw as a lock.

END OF SECTION

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SECTION 23 09 08 - CONTROL VALVES

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Automatic control valves, actuators, and accessories.

1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Control valves: Section 23 2113.

1.14 RELATED SECTIONS

A. Control system, general: Section 23 09 01.

B. Control sequences: Shown on drawings.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Valves, devices, and actuators, each type included in project.

1.91 EXTRA MATERIALS

A. Provide spare damper actuator for each air-handling unit and dedicated outdoor air system unit.

PART 2 - PRODUCTS

2.21 CONTROL VALVES

A. Two-way and three-way valves shall be sized by the control subcontractor and guaranteed to be of sufficient size to meet the heating or cooling requirements.

B. With no electric power on the valve actuator, valve shall be in the normal position determined by the application.

1. Unless indicated otherwise, heating system valves are normally open to allow full flow to coils.
2. Cooling valves are normally closed to stop all flow to coils.

C. Valves NPS 2 (DN 50) and smaller: Single-seated globe or union globe type with an equal percentage flow characteristic valve plug, capable of handling water at a maximum 150 psig (1035 kPa), 281 degrees F (138 degrees C). Valves shall have threaded ends.

1. Bodies: Cast brass, rated at 150 psig (1035 kPa).
2. Trim: Brass.

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3. Stem: Stainless steel, with replaceable composition disk seat. The stem packing shall be synthetic elastomer U-copper type, utilizing the system pressure to prevent packing leaks.

D. Valves NPS 2.5 (DN 65) and larger: Single-seated with equal percentage flow characteristic valve plug.

1. Bodies: Cast iron, rated 150 psig (1035 kPa).
2. Trim, stem, replaceable disk, and stem packing: The same as the smaller valves.

E. Three-way valve: Mixing or diverting for modulating or two-position control of the direct-or reverse-acting type with maximum operating temperature of 250 degrees F (121 degrees C).

1. Bodies: Brass or bronze, rated at 150 psi (1034 kPa), with threaded end connections or cast iron rated at 150 psi (1034 kPa) with flanged end connections.
2. Trim: Bronze or brass.
3. Stem: Stainless steel with replaceable bronze or brass seat. The stem packing shall be silicone U-copper Teflon V ring.

F. High-performance butterfly valves: Two-way or three-way modulating for position control of the mixing or diverting applications. Three-way assemblies shall be assembled with two valves and a flanged cast-iron tee, or dual valve pipe assemblies. Valve body shall be supplied with stainless steel stem, bronze or steel disk and synthetic rubber seat. Valve shall be suitable for electric actuation. Valves shall be rated for 150 psi (1034 kPa) and 225 degrees F (107 degrees C).

G. Maximum pressure drop across water valves shall be 4.0 psi (28 kPa).

H. Three-way control valves shall have the same CV rating on both ports unless otherwise indicated.

2.23 ELECTRIC VALVE OPERATORS

A. Valve operators shall be Belimo, Johnson Controls, or Honeywell operators with manual override; no other manufacturer is acceptable.

B. Low or line voltage electric or electronic motor type with minimum opening and closing time of 15 seconds, sized to provide sufficient power to operate the valve, and for full shutoff against the operating pressure.

C. Solenoid valves (quick-closing) are not acceptable.

PART 3 - EXECUTION

3.21 INSTALLING VALVES

C. Install valves complete with operators, as indicated on drawings and as required by Control Sequences. Ensure that valves are accessible and provide sufficient clearance to permit service and actuator removal. Position valve operator to permit visual observation of the valve position.

END OF SECTION

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SECTION 23 09 13 - INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Control devices and accessories.

1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Wells: Section 23 21 13.

B. Flow switches: Section 23 21 13.

C. Differential pressure switches: Section 23 21 13.

1.13 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. Duct-mounted smoke detectors: Section 28 31 00.

1.14 RELATED SECTIONS

A. Automatic temperature control system: Section 23 09 01 through 23 09 23.

B. Sequence of operations: Shown on drawings.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings:

1. Each control device labeled with setting or adjustable range of control.
2. Wiring diagrams. Differentiate between factory-installed and field-installed wiring.

C. Product data:

1. For each device, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes, and installation instructions.
2. Each type of accessory. Include finishes.

D. Maintenance data: As required in Section 23 01 01, HVAC General Provisions.

1.90 MAINTENANCE

A. Provide two sets of manufacturer’s special tools for operating tamperproof fasteners, marked to identify their use.

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B. Calibration kit for carbon dioxide sensors: Portable, for field calibration, including nitrogen gas, tubing, regulator, and case, with manufacturer's instructions for performing calibration.

C. Deliver maintenance products to Owner's designated storage area and store as directed.

D. Maintenance service: On Substantial Completion and building occupancy, calibrate carbon dioxide sensors and instruct Owner's personnel in the procedure.

PART 2 - PRODUCTS

2.10 CONTROL DEVICES, GENERAL

A. Instruments with predetermined temperature or pressure setpoints shall be provided with a means of adjustment over a reasonable range. Adjustable devices for control of temperatures shall be graduated and calibrated in degrees F. Markings such as WARMER and COOLER shall be acceptable for room temperature sensors.

B. Devices mounted outdoors shall be weathertight construction or mounted in weathertight enclosure or inside weathertight units.

2.13 DIGITAL CONTROLS (ELECTRONIC)

A. Each room temperature sensor shall include a setpoint adjustment dial, and a terminal jack.

1. The setpoint adjustment dial shall allow for modification of the temperature by the occupant. Setpoint adjustment may be locked out, overridden or limited as to time or temperature through software by an authorized operator. Set to allow plus or minus two degree adjustment by occupant.
2. The terminal jack shall be used to connect a portable operator’s terminal to control and monitor all hardware and software points associated with the controller.
3. Provide controller to accommodate sensor type. Provide room temperature sensors closely matched to the requirements of the associated controllers. Signal input and output shall be accurate, responsive, and silent. The sensor may be either RTD or thermistor type providing the following minimum performance requirements are met:

Accuracy:	plus or minus 1 degree F (0.6 degrees C)
Operating range:	35 to 115 degrees F (2 to 46 degrees C)
Set point adjustment range:	55 to 95 degrees F (2 to 30 degrees C)
Set point modes:	Independent Heating, Cooling, Night Setback-Heating, Night Setback-Cooling
Calibration adjustments:	None required
Installation:	Up to 100 feet from controller

B. Humidity sensors: Wall-mounted or insertion type as required by the installation. Range shall be 10 to 90 percent RH with ± 2 percent RH accuracy for duct-mounted sensors and ± 3 percent RH accuracy for wall-mounted sensors.

1. Wall-mounted sensor: Vaisala HMW80 (no substitutions).
2. Duct-mounted sensor: Vaisala HMD60 (no substitutions).

C. Enthalpy sensors: Sensing element shall be combination bimetal/nylon. Span shall be 24 BTU/lb. dry air. Range shall be 16 to 40 BTU/lb. dry air. Units shall be suitable for duct mounting.

D. Carbon dioxide sensors: Wall or duct insertion type, 0-2000 ppm range, typical accuracy of ±30 ppm or ±2 percent of reading between 60 and 90 degrees F, 0-10 VDC output, less than 5 percent drift over 5 year calibration interval. Wall-mounted units shall be furnished without display. Sensors shall be Senva CO2-CAL, no substitutions.

E. Static pressure sensors:

1. Duct static pressure sensors shall be of the solid-state diaphragm type with integral 2-wire, with high and low adjustments. Range shall be 0-5 inches wg. Accuracy shall be 0.025 percent per degree C maximum over a temperature sensitivity range of 25 to 75 degrees C.
2. Space pressure sensor: Solid-state, temperature compensated piezoresistive balanced bridge, minus 0.25 to plus 0.25 inch wg range, ±0.02 percent at 77 degrees F accuracy, ±0.2 percent drift/year stability.

F. Differential pressure sensing in piping: Pressure sensors for control of variable frequency drives on pumping systems shall be of the solid-state type with NEMA 250 Type 1 cast aluminum housing. The static error band shall not exceed ±0.5 percent of full scale. The operating temperature range shall be minus 40 to plus 200 degrees F and shall be temperature compensated. Zero and span adjustments shall be accessible externally.

G. Sensors installed in pipes shall be installed in thermometer wells of bronze or stainless- steel materials. Heat transfer compounds shall be compatible with the sensor. Compression type fittings between sensors and thermometer wells are not acceptable.

H. Temperature sensors for air systems shall be RTD type. Sensors shall have a time constant response of less than 3 seconds to a temperature change of 1 degree. Sensors shall be coupled with industrial grade adjustable span transmitters to achieve the following range with the accuracy specified: 10 to 100 degrees F, plus or minus 1 degree F. Sensors shall be suitable for insertion into air ducts and have a minimum insertion of 6 inches.

1. Averaging type sensors shall be used within all unit casings.

I. Differential pressure sensors: Pressure sensors shall have adjustable high and low limits and be suitable for operation in an ambient temperature range of 30 to 140 degrees F. Accuracy shall be within one percent of full scale. Operating range shall be adjustable. Provide three valve manifolds for isolation.

J. Differential pressure sensors for room pressure control: Equal to Sentra Systems 264 pressure

transducer. Accuracy shall be within 0.25-percent of full scale, with a design input range of 0 to 0.25 inches WG. Provide high (room) side with Dwyer wall plate and low side to outdoors.

K. Differential pressure switches: Pressure sensing elements shall be bellows or diaphragm type, corrosion resistant. Units shall have adjustable range and differential pressure settings. Pressure sensor switches shall be snap action type with contacts rated at 120 V, 15 amps ac. Sensor assembly shall operate automatically and reset automatically when conditions return to normal.

L. Freezestats: Freezestats shall have a sensor element, one-foot far each square foot of coil, adjustable setpoint, and manual reset.

M. Flow switches: Flow switches shall be of the paddle type equipped with SPDT contacts to establish proof of flow.

N. Condensate overflow switches: Sensor/switch to be installed in secondary condensate pans to detect clogged drains, equal to Grainger 3XY17.

2.14 AUXILIARY CONTROLS

A. Emergency fan disconnecting switch:

1. Switch: Flush-mounted emergency switch, red with molded, raised-letter identification.

a. Octagonal pushbutton marked PUSH.
b. Reset: Turn button.
c. False alarm protector: Tamperproof clear polycarbonate shield in a frame that fits over the emergency switch. When the shield is lifted to gain access, a warning horn shall sound. Include 9-V dc battery.

2. Operation: Deenergizes the air-handling units when indexed to the off position.
3. Instructions: Emergency sign, operating instructions, and laminated plastic nameplate, white letters on black background, text shown on drawings.

2.22 AIRFLOW MEASURING STATIONS (AMS)

A. AMS applications:

1. Thermal dispersion type AMS for all applications.
2. Provide AMS in ducts and nested in fan inlets, as indicated on the drawings.

B. Each AMS shall include a fan- or duct-mounted airflow sensor assembly and a remote airflow transmitter.

C. Acceptable manufacturers: Ebtron "Gold Series" units (no substitutions).

D. Total installed system accuracy: Within 3 percent of actual flow, including sensor and transmitter accuracy.

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E. Probes: Sensors at concentric area centers across the duct or fan opening and mounted on a structural grid or manifold.

1. Fan inlet probes: Include dual end support brackets suitable for mounting in the fan inlet bell, and symmetrical averaging signal takeoffs and fittings.
2. Probes shall not induce a measurable pressure drop.
3. Probes shall not cause amplification of system sound.
4. Signals: Steady, non-pulsating without need for flow corrections or factors.

F. Electronic flow transmitters: Industrial process control type, capable of receiving signals from the airflow measuring device, of amplifying, extracting the square root, and scaling to produce at 0-5 VDC output signal linear and scaled to air volume or velocity.

1. Transmitters shall include an integral digital LED display for configuration and calibration, and to display one transmitter output during normal operating mode. Input pushbuttons shall provide means to perform transmitter configuration, parameter setting, zero and span calibration, and display formatting and scaling via the on-board microprocessor. Transmitters shall be equal to Air Monitor Veltron II in NEMA 250 Type I enclosure in compliance with the following criteria.

a. Reference accuracy: Plus or minus 0.1 percent of natural span (including non-linearity, hysteresis, and non-repeatability)
b. Zeroing: Automatic, within 0.1 percent of operating span.
c. Temperature stability: 0.015 percent of full span per deg. F. No zero effect.
d. Power supply: 24 VAC or 24 VDC, selectable.

G. Operation:

1. Unit factory-calibrated.
2. Total installed system accuracy: 3 percent of actual airflow, including sensor and transmitter accuracy and sensor location.
3. Sensing ranges:

a. Temperature: -20 to 160 degrees F (-28.9 to 71.1 degrees C).
b. Humidity (non-condensing): 0 to 99 percent.
c. Pressure drop: Less than 0.005 inch wg at 2000 fpm.

4. Flow measurement drift during the lifetime of the equipment shall not exceed manufacturer’s repeatability statement.
5. AMS shall compensate for temperature and humidity.

H. Airflow straightener: Provide for duct-mounted AMS as recommended by the AMS manufacturer. Framed, 1.5-inch-thick aluminum honeycomb, 3/8-inch cells, less than 0.02-inch wg air pressure drop at 1,000 fpm, effect equal to adding 4 diameters of straight duct.

2.24 COMBUSTIBLE GAS DETECTOR AND ALARM

A. Gas monitor to provide continuous monitoring of combustible and toxic gases, and oxygen deficiency equal to MSA Instruments, Ultimate X Series, Model XA; water- and corrosion-

resistant gas detector with display and microprocessor-based transmitter. NEMA 250 Type 4X rated enclosure for mounting in Boiler Room, with interface for connecting to building control system.

B. Sensor/transmitter types:

1. Catalytic bead type combustible sensor/transmitter:

a. Sensor shall have a resistance to degradation of silicones and reduced sulfur gases.
b. Sensor/transmitter shall be set at 20 percent Lower Explosive Limit (LEL) condition (over-range). Front panel liquid crystal display (LCD) shall indicate this condition.
c. The interconnect wire from the transmitter to the sensor shall be a 5-wire cable.

C. Sensor/transmitter operating requirements:

1. Operating voltage: 8 to 30 VDC.
2. Electronics: Consist of one PCB to offer expandability to allow for optional LED's and relays.
3. Wiring configurations:

a. 3-wire cable for all combustible units configured with or without LED or relay options.

4. Allow for optional reset connector for resetting latched alarms.
5. Setup and startup can be accomplished without having to open the enclosure.
6. Provide factory-calibrated sensor/transmitter. Gas check shall be performed to ensure proper operation.
7. Capable of being remotely mounted from monitor/readout.
8. CE approved with SIL 2 Certification.

D. Sensor/transmitter display:

1. Local LCD: Display is integral to the enclosure that indicates gas type being monitored and the concentration of gas present.
2. Indicate diagnostic check/fault conditions with a scrolling message.

E. Relay options: 3 for alarm levels and one for fault.

1. Ratings: 5 amps at 30 VDC, 5 amps at 220 VAC.
2. Type: Single-pole, double throw.

F. Controller unit: Unit to operate with two independent (dual channel) sensors on a single control module, equal to MSA Model 9020.

1. Power requirements: 115/230 VAC 60 Hz, 24 VDC.
2. Power for sensor transmitters: 0.9 amps at 24 VDC for Ultima X sensors.
3. Provide two (SPDT) relays with change-over controls for verification of warning and alarm conditions common to both channels.
4. Output capability: RS-485 serial interface, ModBus RTU serial bus data transmission for

system configuration, gas concentration, alarm and failure events, alarm inhibit, and reset.
5. Display: Provides information on the gas concentration, alarm status, measurement units, flags indicating status and settings such as calibration interval, time-out function, alarm ON delay, and alarm inhibit.
6. Comply with UL/CSA 61010-1 per MET.

2.70 ACCESSORIES

A. Guards for wall-mounted thermostats, sensors, or other control devices: Size selected to suit device to be protected, designed for vertical or horizontal mounting.

1. For locations accessible to the public, including classroom areas, or provided with line-voltage thermostats: Equal to Shaw-Perkins Protection Series 16, 16-gage perforated steel cover with manufacturer's standard baked enamel finish.
2. Fasteners: Pin In Torx tamperproof. Include 2 sets of special tools as required in Part 1 above.
3. Administrative office areas shall not be considered "public space" as it relates to the requirement for guards.

B. Plastic nameplates: As specified in Section 23 05 00, Common Work Results for HVAC, minimum plate size 0.75 by 2.5 inches, minimum letter size 0.1875 inch, properly identifying equipment and use.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Where averaging type bulbs or tubing and low temperature protection thermostats are installed within ductwork or unit casings, provide a removable galvanized frame with 1-inch square mesh wire for attaching the tubing in desired pattern. Where capillary passes through duct side or unit casing, provide split flange fitting to seal hole and protect the capillary in the duct or casing.

B. Instruments mounted on insulated ducts or equipment shall have mounting brackets arranged to permit full insulation on the duct.

C. Room temperature sensors mounted in unit casing or on sampling chamber shall not be an acceptable substitute for insertion sensor

D. Bulbs for outdoor air temperature sensors shall be shielded from the sun and reflected heat rays. These bulbs may be located behind weather louvers of OA intakes but ahead of any ATC damper.

E. Special-purpose instruments and sensors where two or more are mounted side by side, shall be provided with engraved nameplates which properly identify the items. Nameplates shall be mounted with vandalproof screws on the wall immediately below the item.

F. Room temperature, humidity, and carbon dioxide sensors: Mount on wall/wooden blocking, securely anchored. Mounting height from floor to top of thermostat shall be 48 inches, as required for accessibility to persons using wheelchairs.

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1. All wall-mounted sensors shall be mounted on a 0.75-inch thick finished wooden block. Block edges shall extend past base of sensor mounting plate by approximately 0.25-inches on all sides.
2. Finished wooden block shall include only small holes drilled for two mounting screws and one center sensor cable, with all holes sealed with caulking after installation.
3. Seal base and all edges of wooden block to wall after mounting, to avoid airflow infiltration.

G. Mount room sensors with tamperproof screws. Use wall boxes with insulated backplate securely anchored flush into the wall. Mounting of devices without use of insulated backplate is not acceptable. Use conduit from ceiling to sensor either fished through wall cavity or chased into wall and patched to match existing surface. Use Wiremold to run around ceiling for inaccessible ceilings or conceal above accessible ceiling. All conduit, wire-way, and wall penetrations shall be sealed to prevent infiltration into the sensor area.

H. Provide guards for all wall-mounted thermostats and temperature sensors, where specified.

1. Mount guard base to wall by at least four tamperproof screws, entirely independent of device wall plate and cover.

I. Where thermostats or other devices are removed and not replaced, seal ends of tubing or wiring and push back into wall.

1. On glazed surfaces, provide blank cover plates.
2. On other surfaces, patch in accordance with requirements of Division 01 and Section 23 01 01.

J. Emergency fan disconnect switch: Install in location approved by Fire Marshal and as indicated on the drawings.

K. Mount combustible gas detection and alarm units to monitor Boiler Room, as shown on the drawings.

3.21 INSTALLING DIGITAL CONTROLLER

A. Provide wiring required between digital controller and equipment as scheduled on the Control Point Schedule.

B. Cooperate with Owner to set up the digital controller to operate as shown in sequence of operations on the drawings.

3.70 ADJUSTING

A. Calibrate carbon dioxide sensors: Perform zero and span calibrations, following manufacturer's recommended procedures.

B. Airflow measuring devices shall be field-calibrated in cooperation with the controls contractor prior to executing system air balance.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

B. Instruct Owner's personnel in use of calibration kit to perform annual calibration of carbon dioxide sensors.

END OF SECTION

SECTION 23 09 23 - DIRECT DIGITAL BUILDING SYSTEMS CONTROL

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Direct digital building control (DDC) system.

B. Network communications

C. DDC panels

D. System software

E. Application-specific controllers

F. Operator I/O Devices

1.14 RELATED SECTIONS

A. Coordination, installer qualifications, and acceptable manufacturers: Section 23 09 01.

B. Automatic temperature control system: Sections 23 09 01 through 23 09 23.

C. Control sequences: Shown on drawings.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Installer qualifications: Submit as required in Section 23 09 01, Automatic Temperature Control System. Include, in addition to other requirements, the location of the support facility from which warranty and service will be provided, and a list of the names, titles, and training of the individuals who will be responsible for the work of this project.

C. Documentation: Submit complete documentation for the system hardware and software, including user's manuals and other support sufficient to enable Owner's personnel to understand and correctly operate the system. Include this documentation in Operation and Maintenance submittals in accordance with Division 01 and Section 23 01 01.

D. Certifications:

1. Data sheet or copy of government approval form showing that the system complies with FCC Regulations, Part 15, Section 15.
2. Results of functional and diagnostic field tests and calibrations, specified in Part 3. Submit copies of the installing technician's checklist showing that the system has been completely set up and is ready to operate.
3. Submit Compliance Inspection Checklist, initialed and dated, showing satisfactory completion of the installation tests specified in Part 3.

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1.90 WARRANTY AND SERVICE

A. General requirements: Provide all services, materials and equipment necessary for the successful operation and maintenance of the entire DDC system for the period of the general project correction period required by General Conditions, Division 01, and Section 23 01 01. Provide parts, software, and labor required for the work. Schedule maintenance and adjustments to minimize effects on facility operations.

B. The adjustment and repair of the system includes computer equipment, software updates, transmission equipment, and sensors and control devices. Provide the manufacturer's required adjustments and other work necessary to maintain system operation.

C. Personnel: Provide qualified personnel to accomplish work promptly and satisfactorily. Notify Owner in writing of the name of the designated service representative, and of changes in personnel.

D. Emergency service: Qualified personnel shall be available to provide service to the complete system. Furnish owner with a telephone number where service representative can be reached at all times. Service personnel shall be at the site within 8 hours after receiving a request for service, and shall restore the control system to proper operating condition within 24 hours.

E. Operation: Performance of scheduled adjustments and repair shall verify operation of the system as demonstrated by the initial performance test.

F. Systems modifications: Make recommendations for system modification in writing to Owner. Do not make any system modifications, including operating parameters and control settings, without prior written approval of Owner. Modifications to the system shall be incorporated into the operations and maintenance manuals and other documentation.

G. Software: During the project correction period, provide all software updates and verify operation in the system in a timely manner. Instruct the system operators, and incorporate updates into the operations and maintenance manuals and software documentation. At the end of the correction period, continue to notify Owner of software revisions.

PART 2 - PRODUCTS

2.30 GENERAL PRODUCT DESCRIPTION

A. The DDC system shall integrate multiple building functions including equipment supervision and control, alarm management, energy management, and historical data collection.

B. The building control system shall include the following:

1. Network DDC panels
2. Network application-specific controllers (ASCs)
3. Portable operator's terminals
4. Laptop computer operator workstation(s).

C. The system shall be modular and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC panels, application-specific controllers, and operator devices.

D. Building automation system architecture shall rely on a single primary controller to communicate global commands, provide data exchange and protocol conversions, maintain data buffers, and execute system wide programming.

1. Upon a failure of the primary controller, alarm and trend data will not be reported and schedules on each unit controller will default to the occupied cycle.

E. Each unit controller shall operate on a standalone basis.

1. The systems and equipment will operate in an occupied cycle.
2. Upon a loss of the primary controller or the network communications, alarm and trend data will not be reported, remote monitoring will be lost, and schedules will not be executed.

2.31 NETWORKING COMMUNICATIONS

A. Controller architecture and connections to the HCPSS network:

1. Connections to the HCPSS network via IP connections are to be limited to only the controller designated as the Global Controller or Supervisor (i.e. Honeywell WEBS, Tridium, JACE, or JCI NAE) containing equipment schedules, acts as the alarm router, and is the primary connection point to the building for the HCPSS BADS Server.
2. Additional controllers may be connected to the HCPSS IP network only if they are factory-installed devices on building equipment, and a BACnet MS/TP connected controller is not available or unable to be used (e.g. due to a high point count as from a chiller, fire alarm panel, or lighting control system). These additional IP-connected controllers shall be restricted to communicating directly with the global controller (not peer to peer), and not directly to any other devices on the local network or outside of the building.
3. The only other circumstances that would warrant additional IP connections to the HCPSS network are if the building is large enough to warrant a second global controller, the building points-count is high enough to exceed the capacity of a single building controller, or if another building system or subsystem with a high point count necessitates the IP connection.

B. The DDC system shall network operator workstations.

1. A high performance peer-to-peer network.
2. An application-specific local area network (LAN).

C. Peer-to-peer network level:

1. Operator workstations and DDC panels shall directly reside on a network such that communications shall be executed directly between DDC panels, directly between workstations, and between DDC panels and workstations on a peer-to-peer basis.

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2. Inherent in the system's design shall be the ability to expand or modify the network either via a LAN, or auto-dial telephone line modem connections, or via a combination of the two networking schemes.
3. All operator devices, either network-resident or connected via dial-up modems, shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. Access to data shall be based on 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.
4. Network design shall include the following provisions:

    a. Provide high-speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. An alarm occurring at any DDC panel shall display at one or more workstations or alarm printers within 5 seconds.
    b. Support of any combination of DDC panels and operator workstations directly connected to the peer-to-peer network. The network shall support a minimum of 32 devices.
    c. Message and alarm buffering to prevent information from being lost.
    d. Error detection, correction, and retransmission to guarantee data integrity.
    e. Synchronization of real-time clocks, to include automatic daylight savings time updating among all DDC panels.
    f. Commonly available, multiple source, networking components and protocols shall be used to allow the DDC system to coexist with other networking applications such as office automation. ETHERNET and ARCNET are acceptable technologies.
    g. Use of an industry standard IEEE 802.x protocol. Communications must be of a deterministic nature to assure calculable performance under worst-case network loading.

D. Application-specific local area network (LAN):

1. This level communication shall support a family of application-specific controllers and shall communicate bidirectionally with the peer-to-peer network through DDC panels for transmission of global data.
2. Application-specific controllers shall be arranged on the LANs in a functional relationship with DDC panels. For example, a VAV terminal unit controller shall be on a LAN from the DDC panel that is controlling its corresponding AHU.
3. A maximum of 32 application-specific controllers may be configured on each LAN.

E. Communication capability:

1. Automatic communications shall allow DDC panels to communicate with remote operator stations and remote terminals, as indicated in the sequence of operations.
2. DDC panels shall automatically communicate with workstations to report alarms or other significant events.
3. Operators at the workstation shall be able to perform all control functions, all report functions, and all database generation and modification functions as described for workstations connected via the network. Routines shall automatically answer communications from remote DDC panels. The fact that communications are taking place with remote DDC panels shall be invisible to an operator.

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2.32 DDC PANEL

A. Microprocessor-based panels with a minimum word size of 16 bits: Multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Each DDC panel shall be capable of operating as a stand-alone controller, performing its specified control functions independently of other controllers in the network. Controller size shall be sufficient to fully meet the requirements of this specification and the point list on the drawings.

B. Each DDC controller shall have sufficient memory, a minimum of 1 megabyte, to support its own operating system and databases, including:

1. Control processes
2. Energy management applications
3. Alarm management applications
4. Historical and trend data for points specified
5. Maintenance support applications
6. Custom processes
7. Operator I/O
8. Communications
9. Manual override monitoring

C. Each DDC panel shall support:

1. Monitoring of the following types of inputs, without the addition of equipment outside the DDC panel:

    a. Analog inputs

        (1) 0-10 Vdc
        (2) Thermistors
        (3) 1000-ohm RTDs

    b. Digital inputs

        (1) Dry contact closure
        (2) Pulse accumulator
        (3) Voltage sensing

2. Direct control of electronic actuators and control devices. Each DDC panel shall be capable of providing the following control outputs without the addition of equipment outside the DDC panel:

    a. Digital outputs

        (1) Contact closure (motor starters, sizes 1-4)

    b. Analog outputs

(1) 0-20 psi
(2) 0-10 Vdc

D. Additional space for future point connections, each DDC panel: Minimum 10 percent.

1. Provide sufficient internal memory for the specified control sequences with at least 25 percent of the total memory available for future use.

E. Each DDC panel shall have at least two RS-232C serial data communication ports for operation of operator I/O devices.

F. Each DDC panel shall have point discrete, on-board, limited access Hand/Off/Auto operator override switches for digital control type points and gradual switches for analog control type points. These override switches shall be operable whether the panel processor is operational or not. DDC panels shall monitor the status of all overrides and remotely report each override control operation.

G. DDC panels 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. Status indication shall be visible without opening the panel door.

H. Each DDC panel shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components, and provide both local and remote annunciation of detected component failures, low battery conditions, or repeated failure to establish communication.

I. Provide isolation at each peer-to-peer network termination and each field point termination, to suppress induced voltage transients, meeting requirements of IEEE C62.41.

J. In the event of the loss of normal power, each DDC panel shall shut down in an orderly process which shall prevent the loss of database or operating system software. Provide nonvolatile memory for critical controller configuration data and battery backup sufficient to support the real-time clock and volatile memory for a minimum of 72 hours.

1. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.
2. Should DDC panel memory be lost for any reason, reloading the DDC panel shall be possible via the local RS-232C port, via telephone line dial-in, or from an operator workstation.

K. Provide a DDC panel for each AHU or other HVAC system as indicated on the drawings. It is intended that each unique system be provided with its own point-resident DDC panel.

2.33 SYSTEM SOFTWARE

A. General:

1. Provide all necessary software to form a complete control system as described in this specification.
2. The software programs specified in this section shall be integral in DDC panels and shall not be dependent upon any higher-level computer for execution.

B. Control software:

1. The DDC panels shall have the ability to perform the following pre-tested control algorithms:

    a. Two-position control
    b. Proportional control
    c. Proportional plus integral control
    d. Proportional, integral, plus derivative control
    e. Control loop tuning

2. Include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.
3. Shall protect against excessive demand during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
4. Upon the resumption of normal power, the control software shall analyze the status of controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operations.

C. DDC panels and/or the primary DDC controller shall be able to perform any or all of the following energy management routines:

1. Time-of-day scheduling
2. Calendar-based scheduling
3. Holiday scheduling
4. Temporary schedule overrides
5. Start-stop time optimization
6. Automatic Daylight Savings Time switchover
7. Night setback control
8. Airside economizer
9. Peak demand limiting
10. Temperature-compensated duty cycling
11. Fan speed/CFM control
12. Heating/cooling interlock
13. Hot water reset

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

1. It shall be possible to use any of the following in a custom process:

    a. Any system measured point data or status
    b. Any calculated data
    c. Any results from other processes

d. User-defined constants
e. Arithmetic functions (+, -, *, /,square root, exp, etc.)
f. Boolean logic operators (and/or, exclusive or, etc.)
g. On-delay/off-delay/one-shot timers

2. Custom processes may be triggered based on any combination of the following:

a. Time interval
b. Time of day
c. Date
d. Other processes
e. Time programming
f. Events (e.g., point alarms)

3. The custom control programming feature shall be documented in English.

E. Alarm management shall monitor and direct alarm information to operator devices. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to noncritical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by operation of a PC workstation or local I/O device, or by communications among panels on the network.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
2. The user shall be able to define the specific system response to alarm at each point. Alarms shall be prioritized. Each DDC panel 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.
3. Alarm reports and messages shall be directed to a user-defined list of operator devices.
4. In addition to the point's descriptor and the time and date, the user shall be able to print, display, or store an alarm message to more fully describe the alarm condition or direct operator response.
5. Operator-selected alarms shall initiate a call to a remote operator device.
6. Alarm acknowledgement and "return to normal" functions shall be included in log entries.
7. Disable all online/offline communication alarms on all controllers through the hardware tab.

F. A variety of historical data collection utilities shall manually or automatically sample, store, and display system data for points as specified in the I/O summary.

1. DDC panels shall store and report point history data for selected analog and digital inputs and outputs. Methods of collection shall be either by a predefined time interval or upon a predefined change of value.
2. Refer to "HCPSS DDC/EMS Naming Conventions" for trending, point description, and alarm requirements.

G. DDC panels shall automatically accumulate and store run-time hours for digital input and output points as specified in the point I/O summary.

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H. DDC panels shall automatically sample, calculate, and store consumption totals on a daily, weekly or monthly basis for user-selected analog and digital pulse input type points as specified in the point I/O summary.

I. DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis for points as specified in the point I/O summary.

2.35 APPLICATION-SPECIFIC CONTROLLERS (ASC)

A. Each DDC panel shall be able to extend its performance and capacity through the use of remote application-specific controllers (ASCs).

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

C. Terminal equipment controllers:

1. System shall control each piece of equipment through direct connection to a DDC or ASC. Terminal equipment shall include, but not be limited to, the following:

    a. Unit conditioners (fan-coil units)

2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50 percent of the point outputs (except for unit ventilator controllers) shall be of the universal type, either modulating or two-position. Terminal equipment controllers utilizing proprietary control signals and actuators shall not be acceptable. Provide DDC panels or ASCs with industry standard outputs for control of terminal equipment.
3. Each controller shall perform its primary control function independent of other DDC panel LAN communication, or if LAN communication is interrupted. The controller shall receive its real-time data from the DDC panel time clock and shall ensure LAN continuity. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein.
4. Provide each terminal equipment controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in nonvolatile EEPROM, EPROM and PROM, or minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Operating programs shall be field-selectable for specific applications. Specific applications may be modified to meet the user’s exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of applications are not acceptable.
5. Unit conditioner controllers shall support the following types of terminal units as a minimum:

    Fan-coil units

a. Fan-coil units may be of the following types:

4-pipe heating or cooling

2.42 OPERATOR WORKSTATION (OWS)

A. Provide operator workstation (OWS) for command entry, information management, network alarm management, and database management functions.

1. All equipment shall be licensed and registered to HCPSS.

B. Provide notebook personal computer equal to Dell Latitude 6540, complete with current generation multi-core Intel processor. Include 8 GB RAM and minimum 160 GB/7200 RPM hard disk drive, 16X DVD±RW drive.

1. Minimum 15.6-inch LCD laptop monitor
2. Provide four USB 2.0 ports, Bluetooth wireless capacity (wireless-N and AC), touchpad, mouse, two rechargeable batteries, 110V power supply/charger, and padded backpack type carrying case.

C. Operating system for operator workstation must be preapproved by HCPSS (Currently approved: Microsoft 'Windows XP Professional'). Provide Microsoft Office, latest version, or the preference of HCPSS.

D. Provide software, graphics and programming as specified in this section.

1. Computer shall be provided to HCPSS for imaging, prior to adding any software and graphics.

E. Provide docking station package for OWS, complete with the following components:

1. Port replicator, equal to Dell Latitude E-Series
2. 24-inch LCD monitor, without stand.
3. Soundbar speaker system.
4. Wired keyboard and mouse.

F. Provide printer for OWS, equal to Kyocera P6021CDN and complete with one extra ink cartridge.

G. Provide additional hardware, video drivers, etc., to facilitate all control functions and software requirements specified for the building automation system.

H. Provide all controller configuration and interface software and/or plug-ins for all devices applicable. All shall be loaded and functional. Provide all required interface cables required to connect to all networks, routers, controllers, SDs, etc.

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I. Wherever an OWS connection point is not provided accessible in the same room as the device controlled, provide a wireless system to permit configuration, testing and operating from within the room. Wireless system shall have the range to reliably communicate with the most remote room.

2.43 PORTABLE OPERATOR'S TERMINAL (POT)

A. Portable operator's terminal (POT) shall support system management by connection to the controllers, by connection via the internet, and LAN connection.

1. All equipment shall be licensed and registered to HCPSS.

B. Provide tablet device equal to iPad mini (white and silver), 16 GB storage capacity, with MD531LL/A with AppleCare S4745LL/A.

1. Provide iPad Air case manufactured by Targus
2. Provide 1-meter Lightning to USB cable.

C. Provide software, graphics and programming as specified in this section.

1. Computer shall be provided to HCPSS for imaging, prior to adding any software and graphics.

D. Provide additional hardware, video drivers, etc., to facilitate all control functions and software requirements specified for the building automation system.

E. Provide all controller configuration and interface software and/or plug-ins for all devices applicable. All shall be loaded and functional. Provide all required interface cables required to connect to all networks, routers, controllers, SDs, etc.

F. Wherever a POT connection point is not provided accessible in the same room as the device controlled, Contractor shall provide a wireless system to permit configuration, testing and operating from within the room. Wireless system shall have the range to reliably communicate with the most remote room.

2.44 OPERATOR WORKSTATION SOFTWARE

A. Basic interface description:

1. Operator workstation interface software shall use English-language prompting, English-language point identification, and industry standard PC application software. The software shall provide, as a minimum, the following functions.

a. Graphical viewing and control of environment.
b. Scheduling and override of building operations.
c. Collection and analysis of historical data.
d. Definition and construction of dynamic color graphic displays.
e. Editing, programming, storage, and downloading of controller databases.
f. Alarm management.

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2. Provide a graphical user interface which shall use a mouse or similar pointing device and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays with the pointing device.

    a. Provide that all operations can also be performed using the keyboard as a backup interface device.
    b. Provide at least 10 special function keys to perform often-used operations.

3. The software shall provide multi-tasking that allows the user to run several applications simultaneously. The mouse shall be used to quickly select and switch between multiple applications. This shall be accomplished through the use of Microsoft Windows or similar industry standard software that supports concurrent viewing and controlling of systems operations.
4. Multiple-level password access protection shall be provided to allow the user manager to limit workstation control, display, and data base manipulation capabilities.
5. Software shall allow the operator to perform commands including, but not limited to, the following:

    a. Start up or shut down selected equipment
    b. Adjust setpoints
    c. Add/modify/delete time programming
    d. Enable/disable process execution
    e. Lock/unlock alarm reporting for points
    f. Enable/disable totalization for points
    g. Enable/disable trending for points
    h. Override PID loop setpoints
    i. Enter temporary override schedules
    j. Define holiday schedules
    k. Change time/date
    l. Automatic daylight savings time adjustments
    m. Enter/modify analog alarm limits
    n. Enter/modify analog warning limits
    o. View limits
    p. Enable/disable demand limiting for each meter
    q. Enable/disable duty cycle for each load

6. Reports shall be generated and directed to either 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 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. DDC controller trend overflow warning
    g. List all weekly schedules
    h. List of holiday programming
    i. List of limits and deadbands

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B. Scheduling:

1. Provide a graphical spreadsheet-type format for time-of-day scheduling and overrides of building operations. Provide the following spreadsheet graphic types as a minimum:

    a. Weekly schedules
    b. Zone schedules
    c. Monthly calendars

2. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Each schedule shall include columns for each day of the week as well as holiday and special day columns for alternate scheduling on user-defined days. Equipment scheduling shall be accomplished by simply inserting occupied and unoccupied times into appropriate information blocks on the graphic. In addition, temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.
3. Provide zone schedule for each building zone. Each schedule shall include all commandable points residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Scheduling and rescheduling of points may be accomplished easily via the zone schedule graphic.
4. Monthly calendars for a 24-month period shall allow scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

C. Collection and analysis of historical data:

1. Trending capabilities shall allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point shall be trended automatically at changes of value. Time based tends shall also be created for space temperature only. Trend data may be stored to control system server at HCPSS Building Services for future diagnostics and reporting.
2. Trend data report graphics shall allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of at least 6 points. Provide additional functionality to allow any trended data to be transferred easily to an off-the-shelf spreadsheet package. This shall allow the user to perform custom calculations such as energy use, equipment efficiency, and energy costs and shall allow for generation of these reports on high-quality plots, graphs, and charts.
3. Trending and trending protocols are defined in the "HCPSS DDC/BAS Naming Conventions, Required Trend History Set-up, Graphic Requirements and Alarm Set-up" document located at the end of this section.

D. Dynamic color graphic displays:

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1. Color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air-handling units, chilled water systems and hot water boiler systems, shall be provided as indicated in the point I/O summary to optimize system performance analysis and speed alarm recognition.
2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.
3. 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.
4. The environment of the PC operator workstation shall allow the user to simultaneously view several graphics 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.
5. Graphic generation software shall allow the user to add, modify, or delete system graphic displays.
6. Use of 3D graphics is not acceptable.

E. System configuration and definition:

1. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
2. The system shall be provided complete with all equipment and documentation necessary to allow a BAS System Specialist or Programmer to independently perform the following functions:

    a. Add/delete/modify DDC panel
    b. Add/delete/modify operator workstations
    c. Add/delete/modify application-specific controllers
    d. Add/delete/modify points of any type and all associated point parameters and tuning constants
    e. Add/delete/modify alarm reporting definition for points
    f. Add/delete/modify control loops
    g. Add/delete/modify energy management applications
    h. Add/delete/modify time and calendar-based programming
    i. Add/delete/modify totalization for points
    j. Add/delete/modify historical data trending for points
    k. Add/delete/modify custom control processes
    l. Add/delete/modify any and all graphic displays, symbols and cross-reference to point data
    m. Add/delete/modify dial-up telecommunication definition
    n. Add/delete/modify all operator passwords
    o. Add/delete/modify alarm messages

F. Additional workstation software:

1. Automatic communications shall include the following features as a minimum:

a. Manual communication from the workstation to remote networks shall be accomplishable using only a mouse to select and request the desired remote connection.
b. Alarms shall automatically communicate with the workstation for display at the terminal and for hard-copy printout at the associated event printer.
c. Alarms shall, at the operator's option, communicate with a stand-alone printer to provide for real-time alarm printouts even when the workstation is off-line (such as when it is being used to run operator-selected third party software).
d. Trend data shall be scheduled for automatic updating to the workstation at operator-selected times. The operator shall also have the option of manually collecting trend data at any time.

PART 3 - EXECUTION

3.20 HARDWARE AND SOFTWARE INSTALLATION

A. Install the control system in accordance with manufacturer's instructions, complete and operating as shown and specified.

B. See drawings for the level of controller required for each type system control.

C. Operator interfaces:

1. Set up the workstations and printers as indicated on the drawings or as directed by HCPSS. Install all software and verify that the systems are fully operational. Ensure licensing is provided for all software.
2. No license, software component, key, etc. or any piece of information required to install, configure, operate, diagnose and maintain the system shall be withheld from the County.
3. Install electronic system operation and maintenance manuals, programming guides, network configuration tools, and control shop drawings, etc. on each OWS. Provide interface or shortcuts to guide user to the appropriate information.
4. Set up portable operator terminal and configure it as the remote workstation, Install all software and verify that the system if fully operational.
5. Install systems and materials in accordance with the manufacturer's instructions.
6. Delivery hand-held devices to the Owner prior to specified training.

3.61 TESTS

A. Installer shall test, calibrate, and adjust the system and perform final field test. Commissioning Agent shall witness tests.

B. Refer to Sections 01 91 00, 01 91 10, and 23 08 10 for system testing requirements developed by the Commissioning Agent.

3.81 OPERATING INSTRUCTIONS

A. Coordinate instruction period with requirements of Sections 01 91 00 and 23 05 00. Submit training itinerary to Commissioning Agent at a minimum of two-weeks prior to training.

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B. Training shall be held at the HCPSS services facility in Columbia, Maryland during normal work hours (7:30 a.m. to 4:00 p.m. weekdays). As a minimum, three days of classroom training shall be provided. Provide competent instructors to give full instruction to designated personnel in the adjustment, operation, and maintenance of the system installed, rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are trying to teach. Training details (location of training, number of days, number of courses, number of people, type of training, etc.) shall be coordinated with HCPSS. This training is in addition to and should not be confused with the onsite demonstration, instruction time, and/or functional testing.

C. Provide eight 4-hour days of instruction time for Owner's operating personnel. Coordinate with the Building Services Manager through the Owner or Construction Manager for time and location. Training shall include:

1. Explanation of drawings, operations, and maintenance manuals.
2. Walk-through of the job to locate control components.
3. Operator workstation and peripherals.
4. DDC panel and ASC operation/function.
5. Operator control functions including graphic generation and field panel programming.
6. Operation of portable operator's terminal.
7. Explanation of adjustment, calibration, and replacement procedures.

D. Provide 8 hours of additional instruction time quarterly for a period of one year from final completion of the project.

E. The Owner may require personnel to have more comprehensive understanding of the hardware and software. Additional training shall be available from the installer, after completion of the work of the project. Provide description of available local and factory customer training.

END OF SECTION 23 09 23

HCPSS DDC/BAS naming conventions, required trend/history setup, graphic requirements, and alarm setup (Revision 7.2) follows Section.

HCPSS DDC/BAS Conventions, Required Trend/History Setup, Graphic Requirements, Point Naming & Alarm Setup, Rev 7.2

Below is an example of our desired Trend/History setup & Naming Conventions for our Schools, along with samples of how we would want the required trending to be setup and as to how we want to see the point names themselves, in the place of the old abbreviations that were used in the past, for ease of understanding & use. Latest revision changes in Blue.

NOTE 1 – 3rd Party Integration Requirement: All 3rd Party integration must be coordinated by the BAS/DDC Control Contractor and the 3rd Party HVAC equipment supplier, prior to the beginning of any HVAC work. The BAS/DDC Contractor must obtain & understand the actual definitions for all of the required "in use" BACnet 3rd Party raw data points and the associated names that are being used on the project, along with the point's purpose & enumerations when there are multi-state points. HCPSS should be given Point List to review and choose what Points to keep and those that should be shown on the Graphics. All unused Data Points that are integrated (imported) must be deleted. Any BACnet Integratable devices shall be added to the scope of work through the RFP chain. Example; Munters DX Automated Logic controller.

NOTE 2 – Controls & Cx Kickoff Coordination meeting: A meeting shall be held before the Project begins and should include the 3rd Party vendor, the Owner (Construction & Facilities HVAC Representatives), the Mechanical Engineer of Record & the Commissioning Agency, to help to determine if the 3rd party HVAC Equipment approved/supplied will or will not meet the given "Sequence of Operation" by the Engineer of Record for the given Project. If a discrepancy is found, then it will be up to the Engineer of Record to come up with a comparable or new "Sequence of Operation" or require the approved 3rd Party equipment supplier to alter their own HVAC equipment programming to meet the given "Sequence of Operation". If this is not possible, then the CxA, ATC, Mechanical, & ME will come up with corrections to the Sequence and add any missed requirements by HCPSS.

NOTE 3 - Point Naming Requirements: After the HVAC 3rd Party Point raw data names & the Control Contractor's own created Controller Points are defined into plain & understandable HVAC terminology (as defined below), they shall then match the points found in the given "Point Schedule" & given "Sequence of Operations" to create the actual equipment point list to be used for each piece of equipment. This list may or may not include both Legacy &/or 3rd Party BACnet points. The Control Contractor shall then come up with a complete DDC Point list, which will be made up of AI's, AO's, BI's, BO's, Setpoints, Pseudo Points, Multi-State Points, etc.… This shall be done for each piece of HVAC equipment, whether it is a Cabinet Unit Heater, Variable Air Volume box, Packaged Roof Top Unit, Contractor Controlled Stand-Alone Air handling Unit, etc.… The Control Contractor will create &/or import the points that are required by the Project Specifications & Contract Drawings, whether the equipment is legacy or 3rd Party in nature. Use Contract Document Room #'s in Point Names for permanent record and reference, since Principals have option to change Room #'s when they want.

NOTE 4 - BAS Contractor to take Control of all RTU Controls except DX & inherent Safety Circuits: It is now the desire of HCPSS Construction & Building Services to utilize Control Contractor to completely control all Roof Top Units with exception to the DX Safety circuits, timers & interlocked Condenser Fan operation, if used in place of Chilled Water cooling. We would like the RTU manufacturer to preinstall all DX Components, with Stand-Alone Condenser Control, Safeties, and include a 0-10 VDC input for DX Compressor Staging. Feedback points should be available for DX System Compressor Command, Status & Alarms.

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NOTE 5 - Requirements for all Contractors to meet to maintain Graphics uniformity: All individual Graphics should be created with attention to the actual Unit layout and more importantly, the ability to quickly analyze the Units operation status and the ability to quickly troubleshoot the BAS Systems, by keeping Setpoint w/ variable controlled & Command w/ Status. This statement can be discerned in many different ways so examples of our desired Graphic layouts are shown below & will be reviewed by the CxA & Owner. We do not expect all Contractors to have Graphics that look alike, but the layouts should be typical & uniform. Please consider the position of all points as they relate in location to the Unit and Sequence of Operation. The Graphics will be reviewed and accepted early in the projects by our Facilities HVAC/EMS department, as discussed in previous meetings since they will be the end users. *Do NOT use Feedback points, as this is no longer needed with Proportional control.

1. Show all Setpoints next too or on top/bottom of the Controlled Value.
   a) Examples;
      1. Effective DA Temp Setpoint w/ DA Temp
      2. Mixed Air Low Limit Setpt w/ MA Temp
      3. Preheat Temp Setpt &/or Heat Enable w/ the Heat Coil & Preheat Temp
      4. Zone Temp Setpt & Effective Zone Temperature Setpoint w/ the Zone Temp (shown below Unit).
      5. Duct Static Setpt w/ the Duct Static (show split in ductwork to show that Duct Static Pressure is read from a position 2/3rd's downstream.
      6. Economizer Enable State & Economizer Setpoint with the Min OA cfm Setpoint &/or Damper Position w/ the Min OA Flow &/or Damper Position
2. Show all Commands next too or on top/bottom of the devices Status.
   a) Examples;
      1. Fan Command w/ Fan Status (if VFD used, also show Status Value of Analog Output Speed %)
      2. Pump Command w/ Pump Status (if VFD used, also show Status Value of Analog Output Speed %)
3. Show all Commands that are determined by a Value & Setpoint.
   a) Examples;
      1. Economizer Lockout Setpt w/ the Economizer State (locate near the Outside Damper)
      2. Heat Enable Setpoint w/ the Heating Output Value (locate near the Heat Coil)
      3. Cool Enable Setpoint w/ the Cooling Output Value (locate near the Cool/DX Coil)
      4. Warmup Setpoint w/ the Return/Space Temp that it is referencing.

*On the Graphic in the top area not used, a box should be used for points that do not have an associated Cmd/Status or Setpt/Value. Examples of Points that should be in the upper box; Multi-state points such as, Occupancy Schedule, Unit State, Unit Mode, Alarm Points not specifically related to point on below graphic (General Alarm), Unocc Heat/Cool Setpoint (as these are not usually in play during working hours), Fan control mode, Warm-Up & Cool-Down Modes, etc. …

- **Required Trend/History Setup**

COV Trend/History requirements to be used when Tridium Jace or NAE/NCE's Controllers are installed. Purpose is for immediate evaluation & troubleshooting, to confirm correct operation.

- All trends must be setup when each point is created.

- Every viewable point in Main School Web Integrator item tree must have a trend created & sent to the repository/Server.
- This info is a starting point for "Change of Value" trend setup on all Projects.
- There may be separate trend requirements by the Commissioning Agent, which should be created at the same time as the COV trends and will usually be set up as timed trends. Cx trends MUST be removed when project is complete. Please accommodate requests for Cx trends.
- Separate timed trends are required for all space temperatures at a sample rate of 600 seconds and must be created along with space temperature COV trends.
- Setup trends to send collected data to the NAE Repository/Tridium Server quickly for current trend viewing (Lowest current setting is 1 minute interval).
- Tridium Data from Schools must be set to transmit data collected at 1 minute intervals. 1 minute is for immediate troubleshooting. If issue with Network traffic, value can be changed to a 5 minute interval.
- Direct NAE Trend viewing should be setup per below values in order to give enough data to use in troubleshooting before the server is online for project.
- All trends shall be sent to the repository/server in no more than 5 minute increments or samples above 130.

****NOTE 3:** All Points must have COV trends created at the Local NAE/NCE/WEB's/Jace etc... Controllers, in order for the HVAC Technicians to troubleshoot any physical or pseudo DDC point & at the very least have the ability to go back 3 days by using the trending convention format shown below. The convention below is designed to use the least amount of RAM of the said Local NAE/NCE/WEB's/Jace etc... Controllers & if necessary, the COV increment value can be raised to allow for a broader range in the 3 day desired time frame. This is necessary for times when the Tech's are unable to see the Front End server @ the Facilities Harriet Tubman Building & when any Calibration work is needed at the Local Controller. All COV trends should be sent to the Server Repository, for records that are needed that go farther back to any time frame after the trends were created to compare & troubleshoot operation.

*Below are examples of sample rates to use, in order for Technician to see the longest timeframe possible through the controller, if server is down or if connected locally. If any issue occur with Bus transfer speeds or RAM loss due to an overabundance of Trend Samples, then it is recommended to change the COV increment 1st, & if that doesn't work properly, then a delete/rebuild of the trend will be necessary with a smaller Buffer size.

Analog Outputs (0~10Vdc) that change values = 144 buffer size, with 0 seconds for interval and a Client COV increment setting of 0.2~0.5Vdc or 2.0~5.0%.
Most Analog inputs = 144 buffer size, with 0 seconds for interval and a Client COV increment setting of 0.2~5.0 F.
Room Temp inputs = (*2 Trends each) 1st - 144 buffer size, with 0 seconds for interval and a Client COV increment setting of 0.4~1.0 F.
2nd - 144 buffer size (24 Hrs.), with 600 seconds for interval and a Client COV increment setting of 0.0 F.
Supply Air Temps = 288 buffer size, with 0 seconds for interval and a Client COV increment setting of 1.0 F.
Static Pressure = 288 buffer size, with 0 seconds for interval and a Client COV increment setting of 0.05"WC.
Building Static Pressure = 288 buffer size, with 0 seconds for interval and a Client COV increment setting of 0.005"WC.

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All Binary Inputs = 44 buffer size, with 0 seconds for interval and a Client COV increment setting of 1.0 or blank.
All Binary Outputs = 44 buffer size, with 0 seconds for interval and a Client COV increment setting of 1.0 or blank.
Supply & Return Fan Command & Status = 44 buffer size, with 0 seconds for interval and a Client COV increment setting of 1.0 or blank. Send to repository

All multi-State Enumeration points = 144 buffer size, with 0 seconds for interval and 0 seconds for interval and a Client COV increment setting of 1.0. Send to repository.

***All Trends MUST be set to "Send to Repository/Server", with transfer setpoint lower then buffer size.**

➢ **Examples of Engineering Units for Lon/BACnet Points. ** Value only is not acceptable.**
NOTE: Use of 1 decimal is preferred on all points with Duct Static pressure using 2 decimals & Bldg Static using 3.

	Eng Units	
Temperature	Deg F or F	****Use 1/10ths (70.0 deg F as example) on all Temperatures.**
Water Flow	Gpm	Gallons per minute
Air Flow	CFM	CFM Cubic Feet per Minute - Show Setpoint & Actual Airflow together on Graphic.
Water Pressure	Psi	Pressure per Square Inch - Show Setpoint & Actual Psi together on Graphic.
Static Pressure	inchWC	Inches of Water Column (1.50"W.C.) - decimal 100ths/Duct Press & 1,000ths/Bldg
Enthalpy	Btu/lb	British Thermal Units per pound - Show Stpt & Actual Enthalpy together on Graphic
Humidity	%RH or %	Show Setpoint and Actual Humidity on Graphic
CO2	PPM	Show Setpoint and Actual CO2 on Graphic
Valve	% Open (to coil)	**Use whole numbers, **1/10ths are not acceptable**
Damper	% Open or %Closed	**Use whole numbers, **1/10ths are not acceptable**
Inlet Vanes	% Open	**Use whole numbers, **1/10ths are not acceptable**
Position	% Open or %Closed	**Use whole numbers, **1/10ths are not acceptable**
VFD	%	**Use whole numbers, **1/10ths are not acceptable**
Frequency	Hz	**Use 1/10ths on this type of Point.
Voltage	Volts	Electrical Pressure **Use 1/10ths on this type of Point.
Amperage	Amps	Electrical Current (Flow) **Use 1/10ths on this type of Point.
Elect Power	KW	Kilowatts **Use 1/10ths on this type of Point.
Energy - CHW	Tons	1 Ton = 12,000 Btu's **Use whole numbers, **1/10ths are not acceptable**

Alarm Setup

Alarm Priority Settings for Critical System Alarm Points to Page Emergency personnel
Prepared by Wayne Miles, of the Facilities HVAC Department on 10/16/2014.

Priority Ranges that route alarms to critical personnel

Rob Geelhaar	>=80 & <=99	(Any Day of the Week)
Sam Knight	>=80 & <=99	(Any Day of the Week)
Pat Cusack Weekdays	=81	(Mon-Fri)
Galen Monti Weekdays	=83	(Mon-Fri)
Austin Robinson Weekdays	=84	(Mon-Fri)
On Call West Side Weekdays	=91	(Mon-Fri after hours ONLY)
On Call East Side Weekdays	=92	(Mon-Fri after hours ONLY)
Pat Cusack Weekend	=81	(Sat & Sun)
Galen Monti Weekend	=83	(Sat & Sun)
Austin Robinson Weekend	=84	(Sat & Sun)
On Call West Side Weekend	=91	(Sat & Sun)
On Call East Side Weekend	=92	(Sat & Sun)

Alarm configuration in Server for All Projects

Starting 10/16/2014 in coordination with Wayne Miles.

*All Alarm assignments must be configured to incorporate the 3rd # in the School NAE/JACE IP address. Example; 171.21.**183**.71 for Thomas Viaduct Middle School would incorporate 183.so that whoever the HVAC Mechanic that is assigned TVMS, would then receive ALL of the Alarms for that School, after Formal Training has taken place & project is turned over to Facilities,.

Analog Alarm Points with Setpoint;

Unoccupied Heat Temp	50.0 deg F
Unoccupied Cool Temp	90.0 deg F
Chilled Water Temp	95.0 deg F
Condenser Water Temp	105.0 deg F
Hot Water Temp (Boiler)	200.0 deg F
Hot Water Temp (Geo HP)	145.0 deg F
Carbon Dioxide ppm	1500 ppm

*Do not use deviation from Setpoint Alarms, as they cause too many nuisance Alarms.

Types of Binary Alarms & their associated Engineering Text;

Air Filter	Clean/Dirty
Lead Chilled Water Pump	CHP1/CHP2
Lead Condenser Pump	CP1/CP2
Lead Boiler	Blr1/Blr2 (or Blr1/Blr2/Blr3)
Lead Hot Water Pump	HWP1/HWP2
Chill Pump-1 Failure	Normal/Alarm
Hot Water Pump-1 Fail	Normal/Alarm
Flame Safeguard switch	Normal/Alarm
Building Low Temperature	Normal/Alarm

- **Naming Convention example**

This example is the expected format for Naming Conventions. (This is how we want like to see all Nodes and their child points labeled)

NOTE: Please prioritize this convention to any other Specification shown in a Spec Section used on Projects that differ from this structure below. If there is a problem on a Project site, simply create an RFI & have it refer to the HCPSS Construction Department HVAC Specialist, who will make the final decision. The convention below is required & easy to recognize.

*Use naming without Spaces or wild card characters, except for the underscore, to allow for seamless export to other formats.

Tree View: Example of the Tree View down into the Controller for Northfield ES & Bollman Bridge ES.

HCPSS (Server at Harriet Tubman Building & NOT part of Name String)
NorthfieldES_NAE1 (School Name and the NAE #. *Always start with correct abbreviation of School name, then the Device/controller.
FieldBus1 (BACnet Bus 1 & NOT part of Name String))

Name Example 1 → NFES_VHP27_RmC103_SpecialEd1_EffHeatSetpt
(Preferred), as this node point name string includes; the School abbr., Vert Heat Pump#, Room# & Room use, & the actual point name. *No Spaces. *Use . 'or' _ between sections.

Name Example 2 → NFES._CHP18_RmC100_Speech_ZoneTemp
(Preferred); as this node point name string includes; the School abbr., Vert Heat Pump#, Room# & Room use, & the actual point name. Spaces are note preferred, as base point names cannot include Spaces.

Name Example 3 → BBES_VAV7_2_RmA102_ZoneTempSetpt
(Preferred); Point Name includes the Node name with associated RTU-7, Room # and abbreviated point name) *Please do not spell out complete point name, when easily understood as abbreviation.

Naming Conventions

- **Revised Naming Conventions for Control System, BAS & Graphics;**

*Old N2 abbreviations are NOT to be used in Point names, unless they are logical & easily understood by any HVAC Mechanic while performing their monitoring & troubleshooting duties using the new DDC/Lon/BACnet Points and Graphics. Understandable abbreviation acceptable. This should be done at the direct Point name view in the Control System BAS Point tree by Johnson Controls &/or by EASI, Inc.

Here are some acceptable examples;
Setpoint = Setpt
Temperature = Temp
Outside Air = OA
Command = Cmd
Status = Sts
Condenser = Cond

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Building = Bldg
Hot Water = HW
Chilled Water = CHW
Condenser Water = CW
Face & Bypass = F&B
Valve = Vlv
Damper = Dmpr
Effective Discharge Air Setpoint = EffDaSetpt
Effective = Eff
Enable = En
Discharge Air = DA
Supply Air = SA
Return Air = RtA
Relief Air = RlA
Economizer = Econ
Low Limit = Lo Lmt
High Limit = Hi Lmt
Duct Static Pressure = DuctStPress
Exhaust Fan = EF
Humidity = RH
Pressure = Press
Cool Lockout Setpt = ClgLkoutStpt
Heat Lockout Setpt = HtgLkoutStpt
Variable Frequency Drive = VFD

Acceptable Point Name use Abbreviations	**Description Acceptable description name**
SP	Static Pressure
Setpt	Setpoint
DSP	Duct Static Pressure
DSPStpt	Duct Static Pressure Setpoint
DS	Door Switch
FZ	Freeze Stat (or Low Limit Safety)
LLT	Low Limit Temperature
MALL	Mixed Air Low Limit
HPL	High Pressure Limit
SD	Smoke Detector
SF	Supply Fan
RF	Return Fan
OA	Outside Air
RA	Return Air
MA	Mixed Air
HCD	Heating Coil Discharge
CCD	Cooling Coil Discharge
SA	Supply Air
SAT	Supply Air Temp

SAStpt	Supply Air Temp Setpoint
HTG	Heating
CLG	Cooling
BLR	Boiler
HWP	Hot Water Pump
HWS	Hot Water Supply
HWR	Hot Water Return
CH	Chiller
CHP	Chilled Water Pump
CWP	Condenser Water Pump
CHS	Chilled Water Supply
CHR	Chilled Water Return
CWS	Condenser Water Supply
CWR	Condenser Water Return
SF-C	Supply Fan Command
SF-S	Supply Fan Status
SA-T	Supply Air Temp
CLG-VLV	Cooling Valve Control
HTG-VLV	Heating Valve Control
MA-T	Mixed Air Temp
MA-LT	Mixed Air Low Temp
OA-DPR	Outside Air Damper or OA Damper
OAHtgLkOut	Outside Air Heating Lockout
OAClgLkOut	Outside Air Cooling Lockout
RA-T	Return Air Temp
RA-H	Return Air Humidity
SA-SP	Supply Air Static Press
SF-VFD	Supply Fan VFD
CH1-C	Chiller 1 Command
CH1-S	Chiller 1 Status
CHP1-C	Chilled Water Pump 1 Command
CHP1-S	Chilled Water Pump 1 Status
CWP3-C	Condenser Water Pump 3 Command
CWP3-S	Condenser Water Pump 3 Status
CHS-T	Chilled Water Supply Temp
CWS-T	Cond Water Supply Temp
SAT	Supply Air Temperature
RHV	Reheat Valve
SF1	Supply Fan 1
RF1	Return Fan 1
CH1-CHST	Chiller 1 Chilled Water Supply Temp
CH1-CWST	Chiller 1 Condenser Water Supply Temp
HX1-HWST	Heat Exchanger-1 Hot Water Supply Temp
HX1-VLV	Heat Exchanger -1 Steam Valve
TON-STRT	Tons to Start Lag CH
STRT-DLY	Delay before Lag Start (or Start Delay)
STRT-TMR	Lag Start Timer (or Start Timer)
VFD	Variable Frequency Drive

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SECTION 23 11 23 - NATURAL-GAS PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Piping, specialties, and accessories for natural-gas systems within building.

1.14 RELATED SECTIONS

A. Pipe assembly: Section 23 05 00.

B. Valve charts and tags: Section 23 05 23.

C. Pipe supports on roof: Section 23 05 06.

D. Grounding: Section 26 05 26.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Pipe, valves, fittings and accessories.

C. Certifications:

1. Test and approval of gas piping installation by the authorities having jurisdiction.

1.40 QUALITY ASSURANCE

A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

B. Flexible stainless-steel gas piping shall be stored in an area that will not expose it to damage or outdoor elements.

C. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label, directly on the pipe, indicating compliance.

1.42 REGULATORY REQUIREMENTS

A. Installation of gas piping shall meet requirements of the authority having jurisdiction, the gas supplier for gas service, and NFPA 54.

B. Upon completion of the work, the piping shall be tested as required by inspection authorities having jurisdiction.

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PART 2 - PRODUCTS

2.20 PIPE AND FITTINGS

A. Aboveground pipe: Black steel, ASTM A 53, Grade B, Type E (electric resistance welded).

B. Underground pipe: Black steel, ASTM A 53, Grade B, Type E (electric resistance welded), with coating.

1. Factory-applied pipe coating: Either high density polyethylene, or polypropylene copolymer, equal to products of General Steel Industries, Inc., nominal thickness 25 to 60 mils, adhered to pipe with modified rubber adhesive.

a. For coating joints and fittings, provide one of the following:

(1) Heat-shrinkable pipe sleeves, semi-rigid polyethylene, which shrink onto the joint when heated with a torch, equal to "Thermofit" manufactured by Raychem Corporation.
(2) Field-applied primer and tape, equal to "Polyken No. 900-12" utility tape and "Polyken No. 1027" primer manufactured by Polyken Division of The Kendall Company.

C. Steel pipe fittings: Underground and rooftop piping shall be welded; threaded fittings not permitted for those applications in any pipe size.

1. Threaded: Pipe systems 1.5 inches and smaller (when welding fittings are not permitted), malleable iron or black steel, ASME B16.3 Class 150, with pipe joint compound approved for gas service or PTFE tape.
2. Welding: Steel, ASME B16.9 Class 150 buttwelding, or ASME B16.5 flanges and flanged welding fittings.

2.21 GAS VALVES

A. NPS 2 (DN 50) and smaller: Ball valve equal to Conbraco Industries "Apollo 80" Series, Watts 6000 Series or equal by ASCO; UL approved and listed for natural and LP gas service.

1. Material: Bronze.
2. Rating: 400 psi WOG nonshock.
3. Connections: Threaded.

B. NPS 2.5 (DN 65) through 4 (100): Eccentric plug valve equal to Key Port Valve Fig. 425, UL approved and listed for natural and LP gas service, with resilient plug seal recommended by manufacturer for gas service.

1. Material: Cast iron.
2. Rating: 170 psi WOG nonshock.
3. Connections: Flanged.

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C. NPS 6 (DN 150) and larger: Eccentric plug valve equal to DeZurik PEC style valve with resilient plug facing recommended by manufacturer for gas service, with handwheel operator.

1. Material: Cast iron.
2. Rating: 175 psi CWP nonshock.
3. Connections: Flanged.

D. Gas regulators (and relief valves): Fisher Controls spring-adjustable diaphragm type, 10 psi inlet, of size and capacity as shown on the drawings or equal by Sensus, Maxitrol, or American Meter Division of the Singer Company. Maxitrol Model 325-7AL is not acceptable.

E. Safety shutoff valve: Equal to Siemens VGD Series gas valve, FM approved, UL listed, two-way, automatic reset type, with cast-aluminum body, size NPS 1 through 6 (DN 25 through 150); 120 Volts,60 Hz.

1. NPS 1 through 3 (DN 25 through 80): Class 250, threaded end.
2. NPS 4 and 6 (DN 100 and 150): Class 125 flanged.

2.23 ACCESSORIES

A. Gas flexible connections: Coated stainless-steel gas flexible connector, equal to Dormont "Flared Series," one-piece construction of annealed austenitic stainless steel with chemical corrosion resistant coating; RoHS compliant fittings of plated steel or brass. Maximum working pressure of 15 psig.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Install piping as indicated on the drawings, in accordance with the regulations of the local authority and local gas company, and in accordance with installation and testing requirements of Section 23 05 00.

B. Take branches from horizontal runs from side or top of such runs. A tee shall be placed at the bottoms of risers in gas piping. Bottom of tee shall be provided with a six-inch-long nipple and cap the same size as riser. When riser is concealed, the cap shall project through wall to be accessible and shall be properly marked with engraved plastic nameplate, "DANGER, GAS, CLEANOUT". Red background with white letters.

C. Purge gas lines to equipment when the gas is turned on from the gas supply.

D. Provide cast-iron sleeve where line enters the building.

E. Heat shrink pipe sleeves over joints of factory-coated underground gas piping, or prime and coat with field-applied tape in compliance with manufacturer's instructions.

F. Piping installed in masonry partitions and walls shall be galvanized and covered with flexible elastomeric insulation.

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G. Install valves at the house side of each meter and specialties readily accessible for operation and maintenance, with ample clearance for turning wheel handles or operators.

H. Valves are not permitted in accessible ceiling space whether or not used as air plenums.

I. Install valves at each connection to equipment, accessible and adjacent to the equipment. Install valves in branch lines as indicated on drawings.

J. Vents:

1. Provide vent lines to the outside in accordance with the regulations of the local authority and local gas company. Vents are required on main gas regulators, pilot regulators, high- and low-pressure switches, diaphragm gas valves, and dump valves.
2. Run vents separately to the outside unless otherwise permitted by the local authority or gas company. Vents shall terminate in a screened, turned-down elbow.
3. Vents shall not terminate below any window, door, air intake, or opening to the building. Dump-valve vent shall terminate at the highest possible point outside to prevent nuisance gas leak complaints.

K. Gas piping under floor slab on earth: In conduit, as specified in Section 23 05 00, Common Work Results for HVAC.

L. Underground piping:

1. Install gas distribution piping according the requirements of the manufacturer.

M. Install a jumper wire across the stainless-steel flex connector. Refer to Section 26 05 26, Grounding and Bonding, for installation details.

N. All above ground gas piping 1.5-inch and smaller shall be assembled with threaded fittings, piping 2 inches and larger shall be welded.

O. All above ground gas piping shall be painted OSHA yellow.

END OF SECTION

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SECTION 23 21 13 - HYDRONIC PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Heating water supply and return.

B. Chilled water supply and return.

1.13 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. Control valves: Section 23 09 08.

B. Wells: Sections 23 05 19 and 23 09 13.

C. Pressure switches: Section 23 09 13.

D. Flow switches: Section 23 09 13.

1.14 RELATED SECTIONS

A. Piping materials, installation, and testing: Section 23 05 00.

B. Pipe cleaning and water treatment: Section 23 25 00.

1.20 REFERENCES

A. American Society of Testing and Materials

1. ASTM A 53: Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded
2. ASTM B 88: Standard Specification for Seamless Copper Water Tube
3. ASTM A 536: Standard Specification for Ductile Iron Casting
4. ASTM F1476 – Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications

B. American Society of Mechanical Engineers

1. ASME B 16.1: Cast Iron Pipe Flanges and Flanged Fittings
2. ASME B 16.4: Gray-Iron Threaded Fittings
3. ASME B 15.5: Pipe Flanges and Flanged Fittings, NPS 1/2 to NPS 24
4. ASME B 16.9: Factory-Made Wrought Steel Butt Welding Fittings
5. ASME B 16.18: Cast Copper Alloy Solder Joint Pressure Fittings
6. ASME B 16.22: Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 0101.

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B. Product data: Each specified material and product.

1.40 QUALITY ASSURANCE

A. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label, directly on the pipe, indicating compliance.

B. All grooved couplings and fittings shall be the products of a single manufacturer. Grooving tools shall be approved by grooved component manufacturer.

C. Date stamp all castings used for coupling housings for quality assurance and traceability.

D. Installers of pressure-seal joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe fittings.

PART 2 - PRODUCTS

2.10 PIPE

A. Black steel, threaded or plain end: ASTM A 53, Grade B, Type E (electric resistance welded), Schedule 40.

B. Black steel, grooved: Schedule 40, ASTM A 53, Grade B, Type E (electric resistance welded); NPS 3 (DN 80) and smaller, rolled grooved; NPS 4 (DN 100) and larger, cut or rolled grooved.

C. Copper tubing ASTM B 88, Type L hard or soft drawn, plain end or roll grooved.

2.20 FITTINGS

A. For steel piping: Cast iron, Class 125, ASME B16.1 (flanged) and 16.4 (threaded).

1. NPS 2 (DN 50) and smaller, threaded.
2. NPS 2.5 (DN 65) and larger, flanged.

B. Mechanical couplings and fittings for grooved steel pipe, NPS 2 (DN 50) through NPS 12 (DN 300): Equal to Victaulic Style 107 QuickVic “installation ready” rigid coupling with Grade EPH gasket, and Victaulic Style 07 standard rigid couplings with Grade E gasket and angle-pattern bolt pads. Fittings shall be ductile iron or steel with grooved ends designed to accept standard couplings. Couplings, gasket and fittings shall be able to withstand a constant temperature of 230 degrees F (110 degrees C) and 175 psi (1200 kPa) working pressure. Elbows NPS 4 (100 mm) and larger shall be long radius type.

C. Mechanical flange adapters for grooved steel pipe.

1. NPS 2.5 (DN 65) through NPS 12 (DN 300): Ductile iron castings, flat face, Class 125 and 150 bolt-hole pattern, equal to Victaulic Style 741; Class 300 bolt-hole pattern, equal to Victaulic Style 743.

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D. Fittings for plain end copper pipe: Solder joint, cast brass, ASME B16.18; or wrought copper, ASME B16.22.

E. Fittings for grooved copper pipe:

1. Couplings, gasket, and fittings capable of withstanding 300 psi (2070 kPa) working pressure at 230 deg F (110 deg C).
2. Grooved-end fittings: ASME B16.22 wrought copper and ASTM B75 / B75M, copper tube or ASTM B16.18 and ASTM B584 bronze casting. Manufacture fittings in copper tube sizes. Construct to accept grooved-end couplings of same manufacturer.

    a. Reducing couplings not permitted; use reducing fittings at changes in pipe size.

3. Gaskets: EPDM
4. Rigid type couplings: Equal to Victaulic Style 607, manufactured in copper tube sizes, two-piece cast housing with EDPM gasket of central cavity pressure-responsive design and of grade to suite intended service, with nuts, and bolts to secure grooved pipe and fittings.
5. Flange adapters: Equal to Victaulic Style 641, copper tube dimensions, flat faced for direct connection to flanges with ANSI Class 125 and 150 bolt-hole patterns.
6. Fittings: ASME B16.22 wrought copper with copper tubing sized grooved ends designed to accept Style 606 couplings.
7. Mechanical-T: Cast bronze (C83600 85-5-5-5) upper housing with female NPT threaded outlet and locating collar, ductile iron (ASTM A536) lower housing coated with copper-colored enamel and synthetic rubber gasket equal to Victaulic Style 622.

F. Welding fittings: Steel, 150 psi (1030 kPa), ASME B16.9, products of Bonney Forge, Hackney Ladish, Inc., Penn Machine, The Phoenix Forge Group, Taylor Forge, or Weldbend Corporation.

G. Companion flanges: ANSI B16.5, Class 150, welding neck or slip-on type.

H. Dielectric pipe nipples shall comply with Section 23 0508.

I. Threaded joints for heating and cooling water systems: Compound recommended by manufacturer for use at the temperature and pressure of the system, or “Teflon” pipe thread tape, specified in Section 23 0500, Common Work Results for HVAC.

J. Elbows in piping NPS 4 (DN 100) and larger shall be long radius type.

K. Copper or bronze pressure-seal fittings:

1. Acceptable manufacturers:

    a. Apollo Express
    b. Nibco Press System
    c. Viega Pro Press System

2. Fittings shall fit copper piping that conforms to ASTM B88.
3. Fittings: NPS 0.5 (DN 15) through NPS 4 (DN 100): Conforms to ASME B16.18, ASME B16.22, or ASME B16.51 with an internal EDPM seal.

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4. Tools: Manufacturer's special compression tools.
5. Minimum 200 psi (1379 kPa) working pressure at 250 deg F (121 deg C).

PART 3 - EXECUTION

3.20 INSTALLATION

A. Install piping as indicated on the drawings and in accordance with provisions of Section 23 05 00 and the piping installation schedule at the end of the Section.

B. Install automatic control valves, pressure and flow switches, and insertion wells furnished under Automatic Temperature Controls sections, as indicated on the drawings, and in accordance with manufacturer’s instructions.

C. Provide dielectric nipples between steel and copper pipe.

D. Pressure-seal fittings shall be installed in accordance with the manufacturer's installation instructions by a qualified installer certified by the manufacturer. Use manufacturer-recommended tool and procedure.

3.60 FIELD QUALITY CONTROL

A. Install grooved joints in accordance with the manufacturer’s latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks. Gaskets shall be molded and produced by the coupling manufacturer, and shall be verified as suitable for the intended service.

B. A factory-trained field representative (direct employee) of the mechanical joint manufacture shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. The factory-trained representative shall periodically review the product installation and ensure best practices are being followed. Contractor shall remove and replace any improperly installed products. A distributor’s representative is not considered qualified to conduct the training.

3.75 CLEANING AND TREATMENT

A. Clean piping and provide water treatment as specified in Section 23 25 00, HVAC Water Treatment.

3.90 SCHEDULES

(See Schedule, next page)

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HEATING AND COOLING PIPE INSTALLATION SCHEDULE

Contractor has option where more than one x appears on a line

	A	B	C	D	E	F	G	H
Heating water	X	X	X	X	X	X	X	X
Chilled water	X	X	X	X	X	X	X	X

A. Schedule 40 black steel, welded; NPS 2.5 (DN 65) and larger pipe sizes with welded or flanged fittings.
B. Schedule 40 black steel, threaded; NPS 2 (DN 50) and smaller with threaded fittings, except water over 125 psi (860 kPa).
C. Schedule 40 black steel, rolled groove; NPS 2 and 3 (DN 50 and 80) pipe sizes with mechanical coupling and fittings.
D. Schedule 40 black steel, cut or rolled groove; NPS 4 (DN 100) and larger pipe sizes with mechanical couplings and fittings.
E. Copper tubing; NPS 2 (DN 50) and smaller pipe sizes with cast or wrought fittings.
F. Copper tubing; NPS 2.5 (DN 65) and larger pipe sizes with cast or wrought fittings.
G. Copper tubing, rolled groove; NPS 2.5 through 8 (DN 65 through 200) with mechanical couplings and fittings.
H. Copper or bronze pressure-seal fittings; NPS 2 (DN 50 and smaller).

END OF SECTION

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SECTION 23 21 15 - PREFABRICATED INSULATED PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Insulated piping for underground installation, factory-designed and completely prefabricated.

B. Systems:

1. Chilled water supply and return

1.14 RELATED SECTIONS

A. General information and piping materials and methods: Section 23 05 00.

B. Underground warning tape: Section 23 05 01.

C. Piping: Section 23 21 13.

D. Trenching: Section 23 05 01.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings: Provide shop drawings at a scale no smaller than 0.25 inch equals 1 foot (1:50), showing layout of piping system and identifying pipe segments and fittings.

C. Product data:

1. Each type of piping system, with fittings and accessories; include manufacturer's written installation instructions.
2. Insulation.
3. Jacket.

D. Certificates:

1. Qualifications of manufacturer's factory-trained technician.
2. Supervising technician's certificate that system has been installed in accordance with manufacturer's recommendations.

1.40 QUALITY ASSURANCE

A. System shall be installed under the supervision of the manufacturer's qualified factory-trained technician.

B. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label, directly on the pipe, indicating compliance.

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1.50 DELIVERY, STORAGE, AND HANDLING

A. Store fitting insulation materials at temperatures between 50 and 70 degrees F (28 and 39 degrees C) until the time of installation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide system manufactured by Perma-Pipe, or comparable system by one of the following:

1. Insul-Tek
2. Perma-Pipe
3. Rovanco Corp.
4. Thermacor
5. Thermal Pipe Systems
6. Tricon Piping Systems, Inc.

2.10 MATERIALS

A. General: Steel pipe and fitting materials shall comply with requirements of Sections 23 05 00 and 23 21 13.

B. Steel pipe and fittings: ASTM A 53, Grade B, Type E (electric resistance welded), Schedule 40, black steel; with welding fittings.

C. Insulation: Rigid polyurethane, no less than 90 percent closed cell.

1. Density: 1.9 to 2.1 lbs per cubic foot.
2. k Factor: 0.14.
3. Thickness: Nominal 1.5 to 1 inch, manufacturer's standard to meet published tables of heat transfer data.

D. Jacket: ASTM D 1784, PVC, Type I, Grade 1, 0.06 inches thick.

2.20 PREFABRICATED SYSTEM WITH STEEL CARRIER PIPE

A. Factory-designed and completely prefabricated system, including insulated, jacketed pipe and fittings, and accessories.

B. Insulation ends shall be protected with factory-applied moisture barrier.

C. Factory-provided fittings and accessories shall be provided factory-insulated and -jacketed, and sealed for shipment and handling.

D. Manufacturer's standard compatible sealing materials.

PART 3 - EXECUTION

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3.05 PREPARATION

A. Piping adjoining the preinsulated piping shall be anchored at or near the point of connection.

3.20 INSTALLATION

A. Install preinsulated piping under the supervision of the manufacturer's qualified representative, in accordance with manufacturer's recommendations.

B. Where insulated lengths are cut, seal.

C. Install in trench as indicated on the drawings, on a bed of sand, giving uniform support along entire length.

D. Connect piping by butt welding as specified in Section 23 05 00, Common Work Results for HVAC.

E. Immediately after piping is installed in the trench, partially backfill in the middle of each unit, leaving joints exposed for testing.

F. Hydrostatically test piping as required in Section 23 05 00, Common Work Results for HVAC.

G. After tests are successfully completed with no leaks, insulate connections and fittings as required, and hand place and hand tamp backfill in 4-inch layers to at least 12 inches above the top of the insulation. Complete backfilling as specified in Section 23 05 01. Do not use tracked or wheeled vehicles for compacting.

H. Submit certificate of manufacturer's representative as required in the article "Submittals" above.

END OF SECTION

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SECTION 23 21 23 - HVAC PUMPS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Base-mounted pumps.

1.14 RELATED SECTIONS

A. Motor: Section 23 05 13.

B. Vibration-control supports: Section 23 05 48.

C. Variable frequency drives: Section 26 29 23.

D. Commissioning requirements: Divisions 01 and 23.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Base-mounted pumps and in-line circulators.

1. Include description of all options and accessories.

C. Include data verifying compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

D. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, and sections, showing any changes in the wiring, arrangement, or access necessary to accommodate the unit furnished.

E. Shop drawings shall show complete dimensions of complete assembled unit with accessories.

F. Include wiring diagram showing factory and field wiring for each unit.

1.40 QUALITY ASSURANCE

A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

B. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

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1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled product, or comparable product by one of the following:

B. Base-mounted end-suction pumps

1. Armstrong Pump Co.
2. Aurora Pumps
3. ITT Bell and Gossett
4. Paco Pumps; Grundfos Group
5. Patterson Pump Co.
6. Taco Inc.
7. Thrush Company, Inc.
8. Weinman Pump Co.

2.30 BASE-MOUNTED PUMPS, GENERAL

A. Pump shall have capacities and current characteristics as shown on the drawings.

B. Pumps shall be factory-assembled and -tested. Casings shall allow removal and replacement of impellers without disconnecting piping.

C. Motors: Comply with requirements of Section 23 05 13.

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1. Motors with 120-V, single-phase current shall have built-in overload protection, and shall be permanent split-capacitor type.

D. Seals: Internally flushed (self-flushing) type:

1. On closed circuits such as heating water, use mechanical seals.
2. Mechanical seals shall consist of carbon steel rotating ring, stainless steel spring, ceramic seat, and flexible bellows and gasket rated for 250 degrees F (120 degrees C).

E. Couplings: Flexible, capable of absorbing torsional vibration and shaft misalignment, complete with metal coupling guard. For pumps operating with variable-frequency drives, provide couplings suitable for variable-speed duty.

F. Mounting frame: Factory-welded frame and cross members, fabricated of steel channels and angles conforming to ASTM B 36. Fabricate for mounting pump casing, coupler guard, and motor. Grind welds smooth prior to application of factory finish. Mounting holes for field-installed motors shall be field-drilled.

G. Motor: Secure to mounting frame with adjustable alignment.

2.31 BASE-MOUNTED END-SUCTION PUMPS

A. Taco FI Series, or Bell and Gossett 1510. Comply with general requirements for base-mounted pumps above.

B. General description: Pumps shall be base-mounted, centrifugal, separately-coupled, end-suction, single-stage, bronze-fitted, vertical (radially) split-case design, and rated for 175 psig (1200 kPa) working pressure and 250 degrees F (120 degrees C) continuous water temperature.

C. Casing: Cast iron, with flanged piping connections, and threaded gage tappings at inlet and outlet flange connections.

D. Impeller: Statically and dynamically balanced, closed, single-suction, fabricated from cast bronze conforming to ASTM B 584, keyed to shaft and secured by a locking cap screw. Trim impeller for pumps not controlled by variable frequency drives to match specified performance. Impeller for pumps controlled by variable frequency drives shall be full size.

E. Shaft and sleeve: Steel shaft, with bronze sleeve.

F. Bearings: Ball.

G. Provide suction diffuser with adjustable support foot, inlet connection to suit pipe size, outlet to suit pump suction size, angle-type body with inlet vanes, and stainless steel combination diffuser/strainer with 3/16-inch (4.8-mm) diameter openings. The flow direction shall be from inside to outside. Include disposable fine mesh bronze strainer.

2.35 DRIVE PROTECTION

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A. Pumps shall be provided with guard over flexible couplings as required by OSHA and MOSHA.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Base-mounted pumps:

1. On slab on grade, anchor to concrete equipment foundation.
2. Set preliminary pump alignment and grout pump base.
3. When grout is set and hardened, make final pump alignment.
4. Provide pump alignment certification from a qualified millwright for each pump.

B. Provide balancing valves with a memory stop in discharge piping for measuring flow and head.

C. Provide check valves in discharge lines with non-slam spring-loaded type.

D. Provide valves for isolating pump on both suction and discharge sides of each pump.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

B. Provide at least 2 hours of additional instruction time for the equipment specified in this section.

END OF SECTION

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SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Refrigerant piping and accessories for equipment in related sections.

1.14 RELATED SECTIONS

A. Piping materials and methods: Section 23 05 00.

B. Condensing units: Section 23 63 13.

C. Chillers: Section 23 64 19.

D. Dedicated outdoor air system units: Section 23 72 00

E. Air-handling units: Section 23 73 22.

F. Split-system air conditioning units: Section 23 81 27.

G. Variable-refrigerant-flow systems: Section 23 81 28.

1.26 DESIGN REQUIREMENTS

A. Refrigerant piping shall be sized by the manufacturer of the refrigeration compressor, as specified in sections describing refrigeration equipment.

B. Design pressures: Calculated in accordance with "System Design Pressure" in ASHRAE 15.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data:

1. Piping, fittings, solder, flux, and pipe joint compound.
2. Each type of valve, including materials, classifications, arrangement, dimensions and required clearances, and installation instructions.
3. Each type of device and accessory.

C. Shop drawings:

1. Precharged tubing, including sizes and approximate lengths of lines.
2. Built-up system piping diagram, including sizes, details, and accessories.

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3. Submit system design pressures for use in testing system. In accordance with the International Mechanical Code, "Field Test" for refrigeration systems, include the pressures listed on the condensing unit, compressor, or compressor unit nameplate, and the settings of pressure relief devices.

D. Certifications: Provide certificate of field tests in a form acceptable to the authority having jurisdiction, as part of the permit and inspection records. Certificate shall include no less than:

1. Name of refrigerant.
2. Field test pressure applied to high and low sides of the system.
3. Signature and printed name of the installer.

1.40 QUALITY ASSURANCE

A. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label, directly on the pipe, indicating compliance.

PART 2 - PRODUCTS

2.10 MATERIAL

A. Refrigerant: HFC 410a.

2.11 PIPING (PRECHARGED TUBING SYSTEM)

A. Refrigerant pipe: Precharged Type L soft drawn, preinsulated seamless copper tubing, ASTM B 280.

2.12 PIPE AND FITTINGS (BUILT-UP SYSTEMS)

A. Refrigerant pipe: ASTM B 280 Type ACR hard-drawn seamless copper tubing.

B. Fittings: Wrought copper, solder-joint type, ANSI B16.22. Flare fittings shall conform to SAE J513d.

2.13 ACCESSORIES (BUILT-UP SYSTEMS)

A. System: Provide the listed accessories as a minimum on each built-up system, in accordance with approved shop drawings. Items provided by the equipment manufacturer with the equipment are acceptable.

B. Brazing solder: Minimum 15 percent silver content.

C. Flux: Non-corrosive.

D. Stop valve: Refrigerant type globe valve, either packless or with sealed cap, UL listed. Connections: threaded, flared, or soldered. Valves meeting this specification are manufactured by the Henry Valve Company.

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E. Charging valves: Packless globe-valve type, balanced action, solder outlet with male flare inlet, equal to Henry Type 623.

F. Expansion valves: Refrigerant type equal to products of Alco, Mueller, or Sporlan.

G. Solenoid valves: Rising-stem type.

H. Flexible connectors: Equal to Anaconda Series FY with a working pressure rating of 450 psi (3,103 kPa), high tensile braid covering, and female ends compatible with copper tubing.

I. Sight glass: Equal to Sporlan "See-All" moisture indicating Type SA-ODF solder.

J. Filter-drier: Equal to Sporlan "Catch-All," with replaceable core of highly efficient desiccant that will not powder or pack.

K. Make threaded joints with pipe joint compound approved for the service, or "PTFE" tape.

PART 3 - EXECUTION

3.20 INSTALLATION (PRECHARGED TUBING)

A. Install piping as shown on drawings and in accordance with manufacturer's instructions and approved shop drawings.

B. Install piping supports in accordance with the manufacturer's recommendations. Refer to Section 23 05 29 for pipe support requirements.

3.21 INSTALLATION (BUILT-UP SYSTEM)

A. Drawings indicate routing of refrigerant piping. Install in accordance with approved shop drawings.

B. Install piping with all joints flared or brazed.

C. Install flexible connectors at condensing unit and at air-handling unit, unless flexibility is otherwise properly built into piping system.

D. Purge oil-pumped dry nitrogen through refrigerant piping while brazing to prevent scale forming inside the tubing. (To permit flow and to avoid pressure build-up, always make sure the other end of the line is open.)

E. Vent relief valves to the atmosphere in accordance with ASHRAE 15 and 34.

F. Provide system with charging valve, expansion device, moisture-indicating sight glass, filter-drier with three-valve bypass, and solenoid valve.

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3.61 LEAK TEST

A. After the refrigeration systems have been installed, perform a leak test before evacuating the systems.

1. The cylinder of oil-pumped nitrogen shall be equipped with a shutoff valve, pressure reducing valve, cylinder pressure gage, line pressure gage, and bleed valve.

B. Remove controls or relief valves which could be damaged by test pressures.

C. Separate the high side from the low side and bleed in enough refrigerant to raise the system pressure to 12 to 15 psig (83 to 103 kPa). Then, using oil-pumped dry nitrogen, raise the pressures to the test pressures established as required in "Submittals" in Part 1 above.

D. With the test pressures in the system, tap each connection sharply with a rubber or rawhide mallet.

E. Test the entire system for leaks.

F. Bleed off the pressure into cylinders, in accordance with ASHRAE Guideline 3, and repair leaks. Do not attempt to repair a leak while the system is under pressure. Do not repair bad joints by remelting and adding more brazing material. Take joint apart, thoroughly clean, and remake as a new joint.

G. Retest the system if a leak is found.

H. When tests and repairs are complete, replace valves or controls removed for protection.

I. Submit test certificate required in "Submittals" in Part 1 above.

3.64 EVACUATION

A. To evacuate the system, use a vacuum pump capable of producing at least 1 mm (0.039 inches) mercury absolute vacuum. Proceed as follows:

1. Connect an accurate high vacuum gage (Micron), such as a Stoke's or Zimmerli gage, to the system. Do not use compound gages.
2. Connect the vacuum pump to both the high and low sides of the system. Leave the compressor suction and discharge valves closed. Evacuate the system to 2.5 mm (0.098 inches) mercury absolute. Keep ambient air temperatures above 60 degrees F (15.6 degrees C) during the evacuation process.
3. Break the system vacuum with oil-pumped dry nitrogen. Open the compressor suction and discharge service valves and re-evacuate the system to 2.5 mm (0.098 inches) mercury absolute.
4. After the system has been double evacuated to 2.5 mm (0.098 inches) mercury absolute, close the vacuum-pump suction valve and stop the pump. Allow the system to stand under a vacuum a minimum of 12 hours and recheck the vacuum. Notify the Architect in time for him to verify the test pressure at beginning and end of time limit, before proceeding to charge the system.

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3.65 CHARGING

A. Charge the system with refrigerant through the liquid-line charging valve. Use a clean strainer-drier in the charging line, along with a pressure gage and shut-off valve to control pressures. Before starting the compressor, ascertain that the oil sight glass, if provided, is 75 percent full, and suction and discharge valves back-seated.

3.66 FINAL START-UP PROCEDURE

A. Check out operating and safety controls in accordance with the compressor manufacturer's recommendations.

B. Recheck the oil level in the sight glass at frequent intervals. It should not drop below 50 percent level.

C. Adjust compressor suction unloaders, if provided, for proper evaporator-compressor balance to maintain the scheduled minimum discharge temperature.

D. Reinspect the system after it has been in normal operation for at least 72 hours. At this time, instruct the Owner in the operation and maintenance of the equipment, as required in the equipment section.

3.71 LUBRICATION

A. If it becomes necessary to add oil to the system, use only the oil recommended by the compressor manufacturer.

END OF SECTION

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SECTION 23 25 00 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Clean heating and cooling piping systems:

1. Heating water.
2. Chilled water.

B. Closed heating and cooling systems: Test water and provide chemical treatment at the end of each phase of the project.

C. Provide supplies and maintenance for 2 years after the date of Substantial Completion.

1.14 RELATED SECTIONS

A. Chemical feeder for closed systems: Section 23 05 08.

B. Cleaning and disinfecting domestic water system: Section 22 11 16.

C. Heating and cooling piping: Sections 23 21 13.

1.27 PERFORMANCE REQUIREMENTS

A. There shall be no chromates, polyphosphates, or heavy metals in the chemical formulation.

B. Water treatment shall not in any way affect the life of any part of the water cooling or heating equipment, pipe, valves, fittings, and other appurtenances.

C. Water treatment system shall introduce chemicals into each system only when the system is operating.

D. Heating water systems shall maintain these conditions:

pH……8 to 10.5
Corrosion inhibitor……00 to 150 ppm as molybdate or 1000 to 1500 ppm sodium nitrite

E. Chilled water systems shall maintain these conditions:

pH…….8 to 10.5
Corrosion inhibitor……50 to 100 ppm as molybdate or 500 to 1000 ppm sodium nitrite

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings:

1. Chemicals proposed for each treated system, with calculations showing that treatment will produce the levels required in "Performance Requirements" above.

C. Product data:

1. Chemicals and concentrations proposed for system cleaning.

D. Certifications:

1. Names and qualifications of staff proposed to be assigned to the project.
2. List of at least five projects meeting the requirements described in the article "Quality Assurance" below, each with name, address, and telephone number of contact person who can confirm satisfactory installation and operation of the system.

E. Water analysis.

F. Test reports required below for service visits. Submit one copy of each report directly to the Owner, and one to the Architect.

1.40 QUALITY ASSURANCE

A. Water treatment subcontractor shall supervise the cleaning of the piping systems and submit a certificate of compliance with the specification.

1.41 QUALIFICATIONS OF WATER TREATMENT SUBCONTRACTOR

A. Contractor shall engage and the Architect shall approve an independent water treatment subcontractor, who shall provide the water treatments specified in this section.

B. Is located in the Baltimore/Washington, DC, metropolitan area.

C. Is regularly engaged in providing and servicing systems of similar type and capacity to that installed on this project.

D. Has a record of at least five projects similar to this project in type and size, which have been in place and operating satisfactorily for at least 5 years.

E. Offers 24-hour emergency service.

F. Maintains locally an adequate stock of parts and supplies to service this system and equipment.

G. Has service contracts available.

1.60 PROJECT CONDITIONS

A. Obtain water analysis from the local agency supplying water to the site, or by a test.

B. The chilled water system will not be operational when the weather is cool.

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1.91 MAINTENANCE SERVICE

A. At the end of each phase and for 2 years after Substantial Completion, test and maintain systems with monthly service calls. Provide chemicals and labor necessary to maintain each system's conditions as specified in "Performance Requirements."

B. Perform an analysis at the time of each visit, or within 72 hours at the firm's laboratory, and submit report as required in "Submittals."

C. Closed systems: During the final 30 days of the project 2-year service period, water treatment supplier's representative shall test each closed system.

1. Make minor adjustments if required to correct chemical balance.
2. If system conditions indicate significant leaks, notify Contractor. After piping corrections or repairs, adjust system chemical balance.

PART 2 - PRODUCTS

2.01 ACCEPTABLE SUPPLIERS AND MANUFACTURERS

A. Water treatment system subcontractors:

1. ARC Water Treatment Company, Inc.
2. Ecolab (Water Management)
3. Water Chemical Service, Inc.
4. Olin Water Services

2.10 MATERIALS

A. For cleaning heating- and cooling-piping systems: Detergent, dispersant, and other required chemicals, in accordance with approved product data.

B. For each system's chemical treatment: Chemicals in accordance with approved product data, to maintain the conditions specified in "Performance Requirements" above.

PART 3 - EXECUTION

3.05 CLEANING PIPING SYSTEMS

A. Before flushing and cleaning the system, isolate coils by closing valves to heating and cooling equipment, and open bypass valves.

B. Flushing portions of the system:

1. After a piping loop has been completed and prior to the installation of strainer baskets, flush that portion of the system. Connections shall be same size as piping being flushed or one size smaller.

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2. When a major section of the building has been completed, repeat the same procedure, except that pipe connections shall be limited to NPS 1.5 (DN 40).
3. Flushing shall remove sediment, scale, rust and other foreign substances.
4. After flushing, install strainers and pressure-test system and repair leaks.

C. Flushing building system: After various portions of the piping system have been tested and flushed and system is substantially completed, fill the system completely with water, venting all trapped air, and operating the pump.

1. Open a drain at the system low point while replacing the water at the same rate.
2. Continue flushing until clean water shows at the drain, but for not less than two hours.
3. After flushing, remove strainers and clean and replace them.

D. Chemical cleaning: Fill system with sufficient detergent and dispersant to remove dirt, oil, and grease.

1. Circulate for at least 48 hours.
2. Open a drain valve at the lowest point and bleed while the system continues to circulate. Assure that the automatic makeup valve is operating.
3. Continue until water runs clear and all chemicals are removed. Sample and test the water until pH is the same as pH of makeup water.
4. After chemical cleaning, remove strainers and clean and reinstall them.

E. After flushing and cleaning the system, open valves to coils of heating and cooling equipment and close bypass valves.

F. Submit certificate and test results.

3.22 INSTALLING CHEMICAL TREATMENT FOR CLOSED SYSTEM

A. Perform water analysis and submit recommended chemicals for treatment.

B. Using the chemical feeder specified in Section 23 05 08, HVAC Piping Specialties, install chemicals.

C. At the end of the project correction period, test the closed system and correct concentration of chemicals if required. Submit test and adjustment report.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

B. Treatment representative shall start up equipment and instruct Owner's representative on its operation.

END OF SECTION

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SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. HVAC supply, return, and exhaust metal ductwork and plenums in pressure classes from minus 2 to plus 10 inches wg (minus 500 to plus 2490 Pa).

B. Single-wall round duct.

C. Double-wall round duct.

D. Insulated flexible ducts in HVAC systems.

E. Special ductwork for:

1. Kitchen hood.
2. Art Classrooms.

F. Sealants.

G. Acoustical lining.

H. Duct leakage testing.

1.14 RELATED WORK SPECIFIED ELSEWHERE

A. Firestopping: Section 23 05 07.

B. Flashing ducts through roof: Section 23 05 06.

C. Insulation: Section 23 07 13.

D. Louvers and vents: Division 08.

E. Balancing: Section 23 05 93.

1.20 REFERENCES

A. SMACNA HVAC DCS: SMACNA HVAC Duct Construction Standards, Metal and Flexible.

B. SMACNA RIDCS: SMACNA Round Industrial Duct Construction Standards.

C. SMACNA: HVAC Air Duct Leakage Test Manual.

D. ASHRAE Handbook: Fundamentals.

E. ASTM C 423: Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.

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F. ASTM C 1071: Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material).

G. ASTM D 1330: Rubber Sheet Gaskets.

H. ASTM G 21: Determining Resistance of Synthetic Polymeric Materials to Fungi.

I. ASTM G 22: Determining Resistance of Synthetic Polymeric Materials to Bacteria.

J. ACGIH-01: American Conference of Governmental Industrial Hygienists, Industrial Ventilation: A Manual of Recommended Practice.

K. UL 181: Factory-Made Air Ducts and Air Connectors.

1.21 DEFINITIONS

A. Seam: Joining of two longitudinal (parallel to the direction of airflow) edges of duct surface material. All other duct surface connections are joints.

B. Joints: Transverse joints (perpendicular to the direction of airflow); branch and subbranch intersections; duct collar tap-ins; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

1.27 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. Do not change the layout or configuration of the duct system except as specifically approved in writing. Accompany requests for modifications with calculations showing that the proposed design will provide the original design results without increasing the system total pressure.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings:

1. Schedule of duct systems with applicable pressure classes and leakage classes.
2. Fabrication, assembly, and installation for each duct system: Indicate duct dimensions, sheet metal thickness, reinforcement spacing, and seam and joint construction; and components and attachments to other work.
3. Calculations when required as specified in the article “System Performance Requirements” above.
4. Include layout drawings for the entire ductwork system, drawn at the same scale as the contract drawings, except no smaller than 0.125 inch equals one foot.
5. Schedule of sealing methods for each type of seam and joint.

C. Product data:

1. Acoustical duct lining, adhesive, and sealants.

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2. Hangers and supports.
3. Manufactured ducts and fittings.
4. Joint and sealing materials.
5. Manufacturer's installation instructions.

D. Test reports: Air Duct Leakage Test Summary: Submit data on forms as indicated in the SMACNA HVAC Duct Leakage Test Manual. (See sample form at end of section.)

1.40 QUALITY ASSURANCE

A. Specified and scheduled duct construction exceeds SMACNA requirements. Comply with specifications and schedules, and for materials or methods not specified or scheduled, comply with SMACNA HVAC DCS and RIDCS.

B. Comply with NFPA 90A and 90B.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design products: Subject to compliance with requirements, provide specified or noted products, or comparable product by one of the following:

1. Manufactured ducts and fittings:

a. Eastern Sheet Metal
b. Hamlin Sheet Metal
c. LaPine Metal Products
d. Lindab, Inc.
e. McGill Airflow Corp.
f. Semco Mfg. Inc.
g. SPIRAmir

2. Manufactured joint connectors:

a. Ductmate Industries
b. C.L. Ward & Family Inc.

B. Special use ducts and fittings: Scheduled manufacturers and named products are intended to set a standard for materials, quality of construction, and performance.

2.10 MATERIALS

A. Galvanized steel sheets: Lock-forming quality, ASTM A 653/A 653M, coating designation G90 (Z275).

B. Carbon steel sheets: Cold-rolled, ASTM A 366/A 366M, commercial quality, with oiled matte finish.

C. Aluminum sheets: ASTM B 209, alloy 3003, temper H14.

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1. Ducts exposed to view: Standard one-side bright finish.
2. Concealed ducts: Mill finish.

D. Stainless steel sheets: ASTM A 480/A 480M, Type 304.

1. Ducts exposed to view: No. 4 finish on exposed surface.
2. Concealed ducts: No. 2B finish.

E. Reinforcement shapes and plates: Galvanized steel where installed on galvanized sheet steel ducts; carbon steel on carbon steel ducts and compatible materials on aluminum and stainless steel ducts.

F. Tie rods: Galvanized steel, minimum diameter 0.25 inch (6 mm) for ducts up to 36 inches (900 mm); 0.375 inch over 36 inches (900 mm).

G. Vapor barrier: Polyethylene sheet, 6 mils (0.15 mm) thick, conforming to Federal Specification UU-P-147 for permeability.

2.11 JOINT AND SEALING MATERIALS

A. Flexible joint material for connections to vibrating equipment: Specified in Section 23 33 00, Duct Accessories.

B. Duct joint and seam sealants: UL classified, fire-resistive, conforming to NFPA 90A and 90B, high pressure type (up to 10 inches (2490 Pa) SMACNA pressure class) equal to the following products:

1. Indoor application: Hardcast “Iron Grip” (IG-601) brush-on water-based vinyl acrylic sealing mastic.
2. Outdoor application:

a. Hardcast “Versa-Grip” (VG-102) brush-on indoor/outdoor water-based polyester/synthetic resin sealant with UV inhibitors.
b. Hardcast “Aluma-Grip” (AFT-701) pressure sensitive sealant on a roll. Two-mil (0.05-mm) aluminum foil backing, peel-off release liner, 33-mil (0.8-mm) modified elastomeric butyl sealant (100 percent solids). To be used outdoors only.

3. Silicone sealant (clear): Dow Corning 795, ASTM C920, Type S, Grade NS, Class 25, single component, indoor/outdoor application, UV resistive.
4. Flange gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.12 CLOSED-CELL ACOUSTICAL LINING FOR RECTANGULAR DUCTWORK

A. Fiber-free, closed cell, flexible foam acoustical insulation, ASTM C 1534; meeting requirements of NFPA 90A and 90B at specified thickness. Equal to K-Flex Duct Liner Gray or equal product by Armacell.

B. Density: Nominal 2 lbs per cu ft (32 kg per cu m).

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C. Vapor transmission without jacketing: Less than 0.06 per inch.

D. Thermal performance: 0.25 k-value at 75 degrees F.

E. Resistance to microbial growth: Tested and shown to support no growth of the following:

1. Fungi in accordance with ASTM G 21.
2. Bacteria in accordance with ASTM G 22.

F. Thickness:

1. Typical: One inch (25 mm) thick, ASTM C 423 (Type A mounting) noise reduction coefficient (NRC) at least 0.50.
2. Where indicated: Two inches (51 mm) thick, ASTM C 423 (Type A mounting) NRC at least 0.85.

G. Adhesive for acoustical lining: LEED compliant, non-flammable elastomer contact adhesive designed for attaching closed cell insulation to sheet metal.

2.20 ROUND DUCTS AND FITTINGS

A. Single-wall, spiral round duct and fittings: Equal to McGill Airflow "Uni-Seal" spiral duct with "Uni-form" fabricated fittings.

1. Material(s): Galvanized steel, aluminum, or stainless steel where indicated.
2. Fittings for branch connections shall be conical type. Centerline radius of elbows shall be 1.5 times the diameter. Duct access door shall be equal to type AR-W.
3. Metal thickness:

Round Ducts	Steel Gage	Aluminum Thickness (Inches)
Up to 14 inches diameter	26	0.032
15 through 26 inch diameter	24	0.040
27 through 36 inch diameter	22	0.050
37 through 50 inch diameter	20	0.064
51 through 60 inch diameter	18	0.071
61 inches and over	16 welded joints	0.090
Fittings up to 36 inch diameter	20	0.064
Fittings 37 to 50 inch diameter	18	0.071
Fittings 51 inches and over	16	0.090

B. Single-wall, longitudinal-seam round duct and fittings: Fabricate of galvanized steel according to SMACNA HVAC DCS.

1. Seam: Flat lock; snap-lock seam not permitted.

C. Double-wall, insulated, spiral round duct and fittings: Equal to McGill Airflow Corporation "Acousti-K27." Dimensions indicated are the clear air passage of the duct.

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1. Walls: Galvanized steel, inner duct perforated.
2. Construction: Spiral lock seam.
3. Insulation: Fiberglass, coated to prevent particles from penetrating the fiberglass, resistance to microbial growth of fungi in accordance with ASTM G 21 and bacteria in accordance with ASTM G 22, maximum 1.5 pounds per cubic foot density, 1 inch thick.

2.21 RECTANGULAR DOUBLE-WALL DUCTS

A. Equal to McGill Airflow “Rectangular-k27” with an outer shell, an inner liner, and insulation between.

B. Thermal conductivity: 0.26 at 75 degrees F (0.037 at 24 degrees C) mean temperature.

C. Outer shell: Galvanized steel, 22 gage, Pittsburgh lock construction, with “TDC” end connectors.

D. Insulation: Fiberglass, coated to prevent particles from penetrating the fiberglass, resistance to microbial growth of fungi in accordance with ASTM G 21 and bacteria in accordance with ASTM G 22, maximum 1.5 pounds per cubic foot density, 1 inch thick.

E. Inner liner: Perforated galvanized steel sheet, 22 gage, Pittsburgh lock construction.

F. End connections: Manufactured joint connectors.

2.22 MANUFACTURED SPECIAL FLEXIBLE DUCTS AND FITTINGS

A. Insulated flexible duct for HVAC systems: Factory pre-insulated, complying with NFPA 90A, listed as Class 1 air duct in conformance with UL 181, and UL rated for a positive pressure of 10 inches of water (2490 Pa) (through 18-inch (457-mm) size).

1. Core: Non-metallic airtight polyester with galvanized wire helix.
2. Insulation: Fiberglass blanket, 1.5 inches (38 mm) thick, 0.75 lb density, and k factor 0.28 at 75 degrees F (23.9 degrees C).

    a. Vapor barrier: Aluminized and reinforced.

3. Connections: Accessories required by manufacturer’s published instructions.

B. Flexible metal duct for dust collecting systems: Universal Metal Hose Company “Nicroflex” U-1OOS302, 302 stainless steel standard weight, unpacked.

C. Flexible duct for venting fumes, smoke, welding, and laundry dryers: Equal to Universal Metal Hose Company, strip-wound interlocked hose constructed of hot-dipped galvanized carbon steel and leak tight.

2.24 HANGERS AND SUPPORTS

A. Hangers: Galvanized sheet steel, or round, galvanized steel, threaded rod.

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1. Hangers installed in corrosive atmospheres: Electro-galvanized, all-thread rod; or hot-dipped-galvanized rods with threads painted with zinc-rich paint after installation.
2. Straps and rod sizes: Conform to SMACNA HVAC DCS for sheet steel width and gage and steel rod diameters.

B. Duct attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

2.80 FABRICATION

A. Dimensions indicated on drawings are outer dimensions of ducts. Dimensions indicated for double-wall ducts are outer dimensions of outer wall.

B. Verify field measurements and resolve conflicts, before beginning to fabricate ductwork, as specified in Part 3 below.

2.81 DUCT CONSTRUCTION:

A. Construct ductwork using the Duct Construction Schedule on the drawings. Schedule includes duct system pressure class requirements, minimum sheet metal gages, leakage allowances, and maximum reinforcement spacing. These requirements exceed the requirements of SMACNA HVAC DCS.

B. Construct ductwork of galvanized steel, except where another material is noted on drawings or specified.

C. Construct gravity duct systems (nonfan-powered), such as pressure relief and transfer, in accordance with SMACNA HVAC DCS minimum one inch pressure class unless otherwise scheduled.

D. Crossbreak or bead ducts of dimensions of 12 inches (305 mm) and over in pressure classes under 2 inches (500 Pa).

E. Plenums, casings, and access doors: Construct in accordance with SMACNA HVAC DCS.

1. Casings and plenums for negative pressures greater than 3 inches wg (747 Pa): Construct in accordance with SMACNA RIDCS.
2. Where casings and plenums are on the suction side of fans, and negative pressure which exceeds their construction class may occur, provide safety relief panels or dampers as indicated on drawings.

F. Joint connections shall be constructed in accordance with SMACNA HVAC DCS, or with a manufactured duct connection system equal to Ductmate Industries “Ductmate,” selected to assure compliance with leakage factors indicated on the drawings. Snap-lock or flat-lock seams are not acceptable.

G. Engineered duct systems using metal gages or reinforcing less than required in the schedules on the drawings are not acceptable.

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H. Where not otherwise specified, scheduled, or detailed, construct ductwork in accordance with SMACNA HVAC DCS.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

A. Before fabricating ductwork, make field measurements and coordinate layout of ductwork shown on the drawings with building components and work of other trades. Resolve conflicts and obtain written approval for deviations before fabrication.

B. Provide duct systems complete with built-in accessories as specified herein, in other sections of the specifications, as indicated on the drawings, and, where not otherwise indicated, in accordance with SMACNA HVAC DCS.

C. Thoroughly clean duct and duct fittings before they are installed, and keep them clean until the acceptance of the completed work. Use a duct cap cover on all unfinished ends to prevent moisture, dirt particles, dust, and debris from entering the installed ductwork during construction.

3.21 INSTALLING METAL DUCTWORK

A. Provide ductwork shown on drawings and specified herein.

B. Ductwork shall not penetrate rated partitions where fire or smoke dampers are indicated on the drawings. Connect ductwork only after the damper installation is complete and accepted, as specified in Section 23 33 00, Duct Accessories.

C. Connecting duct to louver: Provide angles or damper collars as required. Slope duct down toward louver. Blank off any part of louver not required to be open, with double pan panels constructed of the same material as the connecting duct, 1.5 inches (38 mm) thick and insulated with 1.5 inches (38 mm) of fiberglass insulation. Seal connection.

D. Install metal ductwork neat in appearance. Interior surfaces shall be smooth and free of obstructions. Duct lines shall be true and smooth. Where ducts pass through openings in partitions, ceilings and floors, fit them with trim angles to close joint between duct and construction.

E. Acoustical lining: Where indicated on drawings, or required by specifications, install acoustic lining on interior surfaces of ducts. Sizes shown on the drawings for rectangular ducts are sheet metal dimensions and include allowance for liner thickness. Install in accordance with SMACNA HVAC DCS, except as the following requirements are more stringent.

1. Adhesive: Adhere liner to interior surfaces of duct with 100 percent coverage. Before assembling lined sections, coat exposed abutting edges of liner with adhesive.
2. Mechanical fasteners: On 16-inch (406-mm) maximum centers on top and sides; on 4-inch (100-mm) centers within 2 inches (50 mm) of leading edge of transverse joints on top, bottom, and sides.

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F. Support ductwork on metal straps or rods in accordance with SMACNA HVAC DCS and as specified. Comply with manufacturers' load ratings and application data for each type of support and fastener.

1. Connections to substrate:

a. Bar joists: Suspend from top chord or panel points.
b. Concrete: Inserts or fasteners specified in Section, Hangers, Supports, and Anchors. Install inserts before placing concrete.
c. Precast concrete planks: Toggle bolts.
d. Structural steel: Beam clamps.
e. Do not support ductwork from gypsum roof deck supports or metal deck.

2. Ducts 54 inches (1372 mm) wide and under: Strap hangers shall extend down sides of ducts and attach to underside with at least two sheet metal screws per strap. Straps shall be made of the same metal as the ducts they are attached to.
3. Ducts over 54 inches (1372 mm) wide: Support on trapeze hangers formed of structural angle irons and hanger rods in accordance with SMACNA HVAC DCS.
4. Round ducts: Support on rods or galvanized straps, and bands, as shown in SMACNA HVAC DCS and in accordance with manufacturer's recommendations.
5. Support horizontal ducts within 2 feet (610 mm) of each elbow and within 4 feet (1220 mm) of each intersection, in addition to spacing required by SMACNA.
6. Support vertical ducts at a maximum interval of 16 feet (4.9 m) and at each floor.

G. Except in systems with minimum velocity standards, contractor has the option to eliminate reducing transitions and extend ductwork full size, providing space is available and conflict with work of other trades does not occur.

H. Make bends and turns in ductwork using offsets and curved or square elbows as indicated on the drawings. Provide full radius elbows (centerline radius equals 1.5 times duct width). Provide turning vanes in square elbows, as specified in Section 23 33 00, Duct Accessories. Make 90-degree branch duct connections using 45-degree entry fittings where indicated.

I. Provide for and install in ductwork all automatic control systems dampers, thermometers, coils, sound attenuators, duct accessories and similar equipment furnished under this or other sections of the specifications. Where ATC dampers with frames and other accessories are mounted in ductwork, the ducts shall connect to the accessory frame in manner to provide 100 percent free area for air passage. Seal duct connections to frames with gaskets or duct sealant. Secure connections with pop rivets or sheet metal screws spaced no more than 3 inches (75 mm) on centers around both sides of entire frame. Provide angle iron or channel frames as required for mounting ATC dampers and manual dampers over weatherproof louvers for air intakes and exhaust.

J. Generally, it is intended that all horizontal ductwork be a minimum of 10 inches (255 mm) above suspended ceiling (where applicable) to allow for removal of ceiling panels and ceiling-mounted light fixtures and devices.

K. Large ductwork such as outdoor air, return air, and exhaust air duct connections to fans, air handling units, plenums, and appurtenances, shall be sufficiently braced with angle irons to prevent vibration and duct damage, and to reduce noise level.

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L. Assemble round ducts and fittings using duct sealant and sheet metal screws as recommended by the manufacturer.

M. Flashing of ducts through outside walls shall be as detailed on the drawings.

N. Where noted on the drawings provide sheet metal drain troughs under piping.

3.22 INSTALLING ROUND DUCT

A. Single-wall: Single-wall, spiral duct and fittings.

1. Exception: Single-wall, longitudinal-seam duct is permitted where concealed, in systems of 2 inches wg pressure class or less, for connections to individual air outlets.

B. Double-wall: Where double-wall duct is indicated, provide double-wall, insulated spiral duct and fittings.

3.23 SEALING DUCTWORK

A. Ducts shall be sealed so that they meet leakage factors scheduled on the drawings.

B. Prior to sealing, ductwork shall be clean and dry, free of oil or grease.

C. Apply sealant in accordance with the manufacturer's recommendations.

D. Product application:

1. Galvanized steel: Brush-on or pressure sensitive sealant, as applicable.
2. Aluminum: Silicone sealant.
3. Stainless steel: Not applicable.

E. Allow time for sealant to dry or cure, in accordance with manufacturer's recommendations, before leak testing.

3.24 INSTALLING INSULATED FLEXIBLE DUCT (HVAC SYSTEMS)

A. Provide insulated flexible duct where shown on drawings. Install fully extended and route as directly as possible to supply outlets. Lengths shall not exceed 10 feet.

B. Lay out bends and turns with the longest practicable radius, as a minimum exceeding SMACNA standards for radius of rigid duct radius elbows. Ends shall extend straight for at least 6 inches before beginning of bend.

C. Connections: Coat at least 3 inches inside the end of the flexible duct core with duct sealant, install over the rigid duct, and secure with a duct clamp. After replacing the insulation and vapor barrier, secure with another duct clamp.

D. Support flexible duct in accordance with the manufacturer's recommendations or SMACNA DCS, whichever is more stringent.

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3.25 INSTALLING KITCHEN HOOD EXHAUST DUCTWORK

A. Kitchen hood exhaust ducts shall be fabricated of minimum 16 gage stainless steel, all welded construction, in accordance with NFPA 96.

B. Provide flanged, gasketed, bolted access panels where indicated on the drawings. Opening sizes shall be at least 18 inches (457 mm) wide by 12 inches (305 mm) high or full height of duct to allow access for cleaning of the entire duct interior.

C. Kitchen exhaust duct shall extend to top of roof curb.

3.28 INSTALLING ART AREAS EXHAUST DUCTWORK

A. In art areas where ducts are exposed, fabricate them from stainless steel with continuously welded joints and seams ground smooth.

B. Minimum gage: 24, except where heavier gage is scheduled on drawings.

3.59 IDENTIFICATION

A. Mark ductwork in accordance with requirements for identification specified in Section 23 0500, Common Work Results for HVAC.

3.61 AIR DUCT LEAKAGE TESTS

A. Leakage test procedures shall be in accordance with SMACNA Leakage Test Manual.

B. After installation and prior to insulating, test the ductwork for air leakage. Ducts to be tested, test pressures, and leakage factors (maximum volume of leakage per 100 sq ft (9.3 sq m) of duct surface area) shall be as scheduled on the drawings.

C. Conduct tests before any equipment is connected that would be subject to damage from the test pressure. Provide temporary blank-offs or caps.

D. Notify parties whose presence is necessary for the test; and in all cases, the Architect Engineer and testing and balancing subcontractor at least two normal work days prior to the actual test.

E. While system is under test pressure, survey joints for audible leaks. Mark leakage points, shut down blower, and make repairs. Retest after duct sealant has dried or cured.

F. If test duct sections exceed the allotted leakage levels, locate sources of leakage, make repairs and repeat test procedures until acceptable leakage levels are demonstrated.

G. During the installation, continuously examine ductwork to ascertain that it is sealed properly.

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3.75 CLEANING DUCT SURFACES

A. Where ducts will be exposed and therefore are required to be painted, remove labels used for construction and clean surfaces ready for painting.

END OF SECTION

Leakage test form follows Section

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PROJECT NAME _____ PROJECT NO. _____ PAGE _____ OF _____

AIR DUCT LEAKAGE TEST SUMMARY

AIR SYSTEM _____ LEAKAGE CLASS (G_L) _____

FAN CFM (Q) _____ SPECIFIED TEST PRESSURE (P_t) _____

DUCT CONSTRUCTION PRESSURE CLASS (P_c) _____

DESIGN DATA				FIELD TEST DATA RECORD							
		ALLOWABLE LEAKAGE		DIAMETER		PRESSURE "W.G.					
SUBJECT DUCT	SURFACE AREA IN FT^2		CFM (TEST SECTION)					DATE	PERFORMED BY	WITNESSED BY	ACTUAL CFM
TOTAL SYSTEM				****	***	**	*****	****	****	****	
TEST SECTION(S)											

SECTION 23 33 00 - DUCT ACCESSORIES

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Products and devices installed in ducts.

B. Flexible joint fabric.

C. Bird screen.

D. Volume extractors.

E. Air turning vanes.

F. Spin-in or dovetail fittings.

G. Duct access doors.

H. Sound attenuators.

I. Dampers.

J. Duct clamps.

K. Fire and smoke dampers.

1.14 RELATED SECTIONS

A. Access doors: Section 23 05 03.

B. Louvers and Vents: Division 08.

C. Duct-mounted smoke detectors: Section 28 33 00.

D. Diffusers, registers, and grilles: Section 23 37 13.

E. Damper actuators: Automatic temperature control sections.

1.20 REFERENCES

A. AMCA 210: Laboratory Methods of Testing Fans for Rating.

B. ASTM E 477: Test for Measurement of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.

C. ASTM E 2016: Standard Specification for Industrial Woven Wire Cloth.

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D. NFPA 90A: Installation of Air Conditioning and Ventilating System.

E. NFPA 90B: Installation of Warm Air Heating and Air-Conditioning Systems.

F. SMACNA HVAC DCS: HVAC Duct Construction Standards, Metal and Flexible.

G. SMACNA-05: Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.

H. UL 555: Fire Dampers.

I. UL 555C: Ceiling Dampers.

J. UL 555S: Smoke Dampers.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Each type of duct accessory included in the project.

C. Shop drawings: Detail equipment assemblies and indicate dimensions, loadings, required clearances, method of field assembly, components, locations, and size of each field connection. Detail these accessories:

1. Special fittings and manual and automatic volume damper installations.
2. Fire and smoke damper installations, including sleeves and duct access doors and panels.

D. Certifications: Certified test data for dynamic insertion loss; sound power levels; airflow performance data, and static-pressure loss.

1.40 QUALITY ASSURANCE

A. Work of this section shall comply with NFPA 90A and 90B, and SMACNA HVAC DCS.

1.92 EXTRA MATERIALS

A. Provide one spare link for every four fire dampers installed in the project, with a minimum of two of each type.

B. Deliver and store spare links in the cabinet for spare automatic sprinklers, or as directed by the Owner.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturers' names and specific products are described in the articles below to set a standard for materials, quality of construction, options and details, and performance. Provide named products, or equal products by other named manufacturers.

2.10 MATERIALS

A. Sheet metal: As specified in Section 23 31 13.

B. Flexible joint fabric: Woven glass fabric with coating, complying with NFPA 701 for fire retardance and NFPA 90A for use in duct systems.

1. For use indoors: Equal to Ventfabrics "Ventglas," coated with polychloroprene (DuPont "Neoprene"), 30 ounces per square yard (850 g per 0.8 square meter).
2. For use outdoors: Equal to Ventfabrics "Ventlon," coated with DuPont weather-, sunlight- and ozone-resistant "Hypalon," 26 ounces per square yard (732 g per 0.8 square meter).

C. Bird screen: ASTM E 2016, general industrial-use wire cloth, Grade C, medium light or heavier, nominal 0.5-inch (13-mm) mesh and 0.063-inch (1.6-mm) wire diameter, aluminum or stainless steel.

1. Frame: Removable, rewirable, of same material and finish as the duct or accessory to which it is installed.

2.20 MANUFACTURED UNITS

A. Volume extractors: Equal to Hart & Cooley "Vectrol" Type AVLR, with the equal to Young Regulator Co. No. 429 FD end bearing and No. 443-B 3/8-inch operator; or Type VLK, with worm-driven mechanism accessible through face of diffuser or grille with an 18-inch-long removable key operator.

B. Air turning vanes: Double vane type, constructed in accordance with SMACNA HVAC DCS, from the same material as the duct.

C. Spin-in or dovetail fittings in accordance with SMACNA HVAC DCS are acceptable for a round take-off connection from a rectangular duct, provided they meet the duct pressure classification.

2.21 DUCT ACCESS DOORS

A. SMACNA standard construction, Air Balance, Inc., Model FSA-100-H or equal by Ruskin, Inc., Airstream Products Company, Inc., or Commercial Acoustics. Access doors to fire protection devices shall comply with NFPA 90A.

B. Construction: Door and frame fabricated of 24 gage galvanized steel, minimum size 16 inches (406 mm) by 16 inches (406 mm), or 16 inches (406 mm) by maximum duct size.

C. Door: Hinged with continuous piano hinge; number of cam latches to suit door size. Insulated doors shall be double pan construction, one inch (25 mm) thick with one inch (25 mm) thick minimum 3.5 pound (56 kg per cubic meter) density fiberglass insulation cut full to require forcing into the pan.

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D. Gaskets: Continuous around perimeter, sealing frame to duct and door to frame, neoprene or foam rubber.

E. As an option, provide round access doors equal to Ventfabrics "Ventlok Twist-In" doors, complete with safety holding cable, 12 inches (305 mm) diameter.

2.22 SOUND ATTENUATORS

A. Manufactured by Dynasonic Systems, Inc., Semco, Ruskin Sound Control, Vibro-Acoustics, Commercial Acoustics Division of Metal Form Manufacturing, Aerosonics, or Price; sizes and types shown and scheduled on the drawings. Field fabrication will not be permitted.

B. Materials: The entire attenuator shall be incombustible, moisture-resistant, and odorless.

1. Outer casings: 22 gage galvanized steel, seams lock-formed.
2. Interior baffles: 24 gage perforated galvanized steel.
3. Acoustical filler material: Fiberglass, packed under compression to 4.5 pound density.

C. Units for duct mounting: Outer casing seams mastic-filled; casings leakproof to a pressure differential of 8 inches wg (2000 Pa). Measure static pressure loss in accordance with ANSI/AMCA 210.

D. Acoustical performance for duct-mounted units: Only tests made at an independent testing laboratory will be considered, and the test data must include acoustical performance and generated noise levels at various airflow velocities. Acoustical and pressure drop performance shall be as scheduled on the drawings.

1. Insertion loss: Measured by the "Duct to Reverberation Room" method with airflow.
2. Generated noise: Measured in accordance with ASHRAE 36B Test Method.

E. Acoustical performance for transfer air units between spaces: Test by the procedure described in ASTM E 477, latest edition. Only tests made at an independent testing laboratory will be considered. Acoustical and pressure drop performance shall be as scheduled on the drawings.

F. The same test sample shall have been used for both acoustic and aerodynamic measurement.

2.25 DAMPERS

A. Where aluminum duct is required by the specifications, dampers shall be all aluminum construction.

B. Manual volume dampers:

1. 13 inches (330 mm) and larger in height: Balanced multi-louver, opposed-blade type with maximum blade width of 6 inches (155 mm), equal to Ruskin Model MD 35 with corrosion resistant, molded synthetic sleeve type bearing and 0.375-inch (9.5-mm) square control shaft; and with Young Regulator Co. Model No. 443B-3/8 damper regulators designed with 2-inch high base for mounting on externally insulated duct.

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2. 12 inches (305 mm) or less in height: Fabricated from 16 gage metal with hemmed edges, 0.375-inch (9.5-mm) square rod, Young Regulator Co. Model No. 443B-3/8 regulator designed with 2-inch high base for mounting on externally insulated duct and Model No. 429 FD end bearing.

2.27 FIRE DAMPERS

A. Fire dampers shall comply with NFPA 90A and applicable building and fire code requirements. Fire dampers shall be equal to the models specified below, and UL 555 labeled for use in static systems.

B. Dampers connected to ducts: Size and configuration suitable to the connected duct.

C. Material, blades and frame: Galvanized sheet steel, no less than 0.064 inch (1.62 mm) thick.

D. Blades: Folding, with 100-percent interlocking joints to form a continuous steel curtain when closed.

1. Joints: 180 degrees of free movement.
2. Operator: Constant-force, stainless-steel spring for horizontal applications.

E. Fusible links: Replaceable, 165 degrees F (74 degrees C) rated.

F. Sleeves: Galvanized sheet steel no less than 0.052 inch (1.3 mm) thick; length to suit wall or floor application; sleeves, angles, and methods of fastening meeting requirements of manufacturer's UL-approved installation instructions.

G. Ratings and frame types: Equal to Air Balance Inc. 119 Series for use in 1-1/2-hour rated assemblies and 319 Series for use in 3-hour rated assemblies.

1. Dampers in rated partitions between nonducted transfer grilles, or dampers terminating at a ducted wall grille or register: Type A frame, installed within or behind grille or register, access by removal of grille or register.
2. Dampers connected to supply air ductwork: 100 percent free opening, Type C frame with welded-seam housing.
3. Dampers connected to return air or exhaust air ducts: 90 percent free opening, Type B frame with welded-seam housing.

2.28 FIRE/SMOKE AND SMOKE DAMPERS

A. Equal to Ruskin Model FSD-60, low-leakage type.

B. Ratings:

1. Combination Fire and Smoke Dampers:

a. Fire resistance in accordance with UL 555 no less than 1.5 hours.
b. Leakage in accordance with UL Standard 555S no higher than Leakage Class I (4 cfm per square foot at one inch wg).

c. Rated for use in static systems.

2. Smoke Dampers: Same as combination dampers, except need not be rated for fire resistance.

C. Double-skin airfoil-shaped blades, with a pressure loss of not more than 0.1 inch wg in full-open position at damper-face velocity of 2000 fpm (based on 36-inch by 36-inch damper).

D. Sleeve: Furnish each damper complete with factory sleeve of length and gage required for satisfactory installation.

E. Operator: Elevated temperature category B (250 degrees F (121 degrees C)) damper operator, electric or pneumatic as required by control system, factory-installed on exterior of sleeve and properly linked to damper operating shaft.

1. Type: Spring-return fail-closed that will close damper upon power or pressure interruption.
2. Ratings: Listed and labeled in accordance with UL 555 or 555S as fire or smoke damper operators as required by rating of damper.
3. Coordinate damper operator sizing and voltage requirements with manufacturer.

2.70 ACCESSORIES

A. Duct clamps for flexible duct and flexible fabric connections: Positive locking drawbands able to conform to any shape. Fabricate from a single piece of galvanized steel, with zinc-plated steel screw and buckle. Equal to "59 Series" manufactured by Ideal Division, Parker Hannifin Corporation.

B. Nonmetallic duct clamps for flexible duct and flexible fabric connections: Heavy-duty adjustable type equal to products of Tyton Corporation, for 12-inch (305-mm) diameter and smaller flexible ductwork, complying with UL 181.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

A. Duct accessories shall be mounted or installed properly in accordance with the manufacturer's instructions and as indicated on the drawings.

3.21 INSTALLING CONNECTIONS AND SCREENS

A. Flexible connections: Install where duct connects to motor-driven equipment, and in other locations shown on drawings. Securely clamp flexible connection to duct and collar with duct clamps, providing 1 inch (25 mm) slack. Stitch seams with fiberglass thread.

1. Flexible connections are not required where duct connects to air-handling equipment with internally isolated fans.

B. Install bird screen in outdoor air connections.

3.22 INSTALLING MANUFACTURED UNITS

A. Provide necessary devices to balance the air flow to produce air quantities at outlets as indicated on the drawings.

B. Provide turning vanes in 90-degree square elbows.

C. Provide spin-in or dovetail fittings as indicated on the drawings. Where connecting to lined ductwork, provide fittings with sleeve designed for installing with liner.

D. Installing duct access doors:

1. Install duct access doors in ductwork for access to fire dampers, smoke dampers, ATC dampers, controls, vortex dampers, duct coils, control devices, and any other devices, equipment, or components requiring maintenance, service, or adjustment and located inside ducts or adjacent equipment.
2. Provide OSHA-approved labels on doors enclosing fire protection devices. Labels shall have lettering at least 1/2 inch (13 mm) high describing the protection device enclosed.

E. Installing sound attenuator:

1. Where multiple units are used, seal joints after making connections. Provide steel bands around multiple units. Install duct-mounted units with transitions where required, and pressure test with ductwork.

F. Installing air control devices:

1. Install manual volume dampers, volume extractors, and other devices at locations indicated on drawings and where required to properly balance the systems and to deliver the air quantities indicated. Each damper and device shall have substantial operators of proper size with locking facilities. Volume dampers shall be equipped with locking type regulators.
2. Install automatic control dampers.

3.23 INSTALLING FIRE AND SMOKE DAMPERS

A. Fire and smoke dampers are an integral part of the rated partition or floor being penetrated. Install sleeves and dampers before beginning installation of the duct system being connected. Do not begin installing ducts until rated assembly, including installed dampers, has been completed.

B. Install fire and smoke dampers where indicated and in accordance with the applicable requirements of the following:

1. Details on drawings.
2. NFPA requirements.
3. Local building code.
4. Manufacturer's UL-approved installation instructions.
5. SMACNA-05.

C. Install fire and smoke dampers in sleeves. Coordinate with other trades to properly frame openings so that damper and sleeve assembly can be secured in partition or floor.

1. Do not use dampers and sleeves as a lintel for supporting the wall above the damper. Provide separate steel angles on both sides of wall or floor slab to hold damper and sleeve firmly in place.
2. Sleeve thickness and retaining angle size are contingent on type of duct connection, duct size and damper manufacturer's requirements. See SMACNA recommendations and NFPA requirements.

D. Coordinate voltages with manufacturer of motorized dampers.

E. Provide dampers of proper size for ceiling diffusers indicated to have fire-rated dampers. Provide protective thermal blanket of proper size for ceiling diffuser.

F. After damper installation is complete and required ductwork connected, test operation of damper by releasing holding mechanism to see that damper operates freely and properly and closes tight. Make adjustments if required and reset holding mechanism.

END OF SECTION

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SECTION 23 34 00 - HVAC FANS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Exhaust, circulating, and supply fans.

B. Accessories.

1.14 RELATED SECTIONS

A. Curbs: Section 23 05 06.

B. Vibration control supports: Section 23 05 48.

C. Motors: Section 23 05 13.

D. Controls: Sections 23 09 01 through 23 09 23.

E. Commissioning requirements: Divisions 01 and 23.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

1. Reports of specified factory tests.

C. Product data: Include rated capacities of each unit, weights (shipping, installed, and operating), furnished specialties, accessories, and the following:

1. Certified fan performance curves with system operating conditions indicated. Include static pressure, brake horsepower, and static efficiency plotted against air volume.
2. Certified fan sound power ratings.
3. Motor ratings and electrical characteristics, and motor and electrical accessories.
4. Material gages and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.

D. Wiring diagrams detailing power and control wiring and differentiating clearly between manufacturer-installed and field-installed wiring.

E. Maintenance data as required in Division 01 and Section 23 01 01.

F. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

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G. For roof fan to be installed on existing curb, submit shop drawing showing method for weathertight installation.

1.40 QUALITY ASSURANCE

A. Fans shall be tested and rated in accordance with the applicable AMCA Standard Test Code and Certified Rating Program and bear AMCA Certified Air Rating Seal.

B. Fan selections shall be made to the right of the peak static pressure point, but not on any "flat" portion of the fan curve. Generally, fan selection shall be in the 50 percent to 80 percent range of wide open volume.

C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

D. UL label and local testing (if required): Section 23 05 00, Common Work Results for HVAC.

1.71 COORDINATION

A. Coordinate the installation of roof curbs, supports, and roof penetrations. Fan installation shall not reduce weathertightness of roof nor violate roof warranty.

B. Coordinate colors selected for roof-mounted fans with colors of other roof-mounted equipment.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

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1.91 EXTRA MATERIALS

A. Provide adjustments in drives and sheaves and belts as required at time of system balancing to obtain the airflow and static pressure indicated on drawings.

PART 2 - PRODUCTS

2.30 FANS, GENERAL

A. Fan size, capacity, class, arrangement, accessories and discharge shall be as scheduled on the drawings.

B. Motors shall meet the requirements of Section 23 05 13, Common Motor Requirements for HVAC Equipment, including power factor and efficiency.

C. Belt drives and exposed rotating shafts shall be provided with guards meeting OSHA and MOSHA requirements.

D. Fans shall have self-aligning, ball-type bearings designed for thrust load, and grease fittings shall be accessible for relubrication. Fans shall be statically and dynamically balanced.

E. Motors for belt-driven units shall have adjustable variably pitched cast iron sheaves to allow a 10 percent increase or reduction in speed. Belts shall be sized for minimum 150 percent brake horsepower (bhp).

1. Include one change in drive sheave for each unit if necessary to obtain correct air quantities at time of testing, adjusting, and balancing.

2.34 EXHAUST, CIRCULATING, AND SUPPLY FANS

A. Basis-of-design product: Subject to compliance with requirements, provide the specified product, or comparable product by one of the following:

1. Aerovent, a Twin City Fan Company
2. Acme Engineering and Manufacturing
3. Greenheck Fans.
4. Jenco Fan.
5. Loren Cook, Inc.
6. Penn Barry.
7. Twin City Fans and Blowers.

B. Roof centrifugal ventilator: Fan wheels shall be of the centrifugal backward curved non-overloading airfoil design, direct or V-belt drive as scheduled. Fan wheel and fan housing shall be of all-aluminum construction, with motor and drive assembly located out of exhaust airstream in separate compartment that is forced-air-cooled with outdoor air. Exposed fasteners shall be stainless steel. Fan shaft and hub shall be zinc-phosphate coated.

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C. Roof upblast kitchen exhaust fan: Fan wheels shall be of the centrifugal, backward-inclined non-overloading airfoil design, direct or belt drive as scheduled. Fan wheel and fan housing shall be of all-aluminum construction, with motor and drive assembly located out of exhaust airstream in separate compartment that is forced-air-cooled with outdoor air. Exposed fasteners shall be stainless steel. Fan shaft and hub shall be zinc-phosphate coated. Kitchen exhaust fans shall be U.L. listed for restaurant exhaust, conforming to NFPA 96, and shall be provided with grease trough and heat shield.

D. In-line ceiling or wall fan: Blower of steel construction with sound-absorbing lined housing, easily disassembled for service and maintenance, anodized aluminum or baked-enamel-finished steel intake grille, quiet operation, twin squirrel-cage blower wheels and built-in backdraft damper.

2.70 ACCESSORIES

A. Bird screens: Specified in Section 23 33 00, Duct Accessories.

B. A disconnecting switch without overload protection shall be included under the weather hood of roof-mounted units, completely factory-wired to motor. Motors for directly driven units shall be provided with solid-state variable speed control, unless otherwise indicated on the drawings.

C. Provide each unit with self-operating aluminum backdraft damper and frame unless indicated otherwise on the drawings. Damper blades shall operate in unison and shall be counterbalanced or otherwise provided with facilities to positively open under fan suction and to close tight when subject to backdraft.

D. Identification: Each fan shall be identified with a fan number no less than 0.5 inch high, as shown in the fan schedule, on an aluminum strip riveted to hood of roof fans and on the motor side of frame for wall fans.

E. Where indicated, provide roof fans with adapters to fit existing curbs.

PART 3 - EXECUTION

3.20 INSTALLATION, EXHAUST, CIRCULATING, AND SUPPLY FANS

A. Fans shall be installed in compliance with the manufacturer’s recommendations. Ventilating and ceiling exhaust fans shall be supported from the building structure, not attached to the ceiling suspension members or discharge grille system.

B. Roof fans shall be attached to side of roof curbs using 3/16-inch (4.8-mm) cadmium-plated bolts and nuts or screws, as required, on a maximum of 8-inch (205-mm) centers and a minimum of 8 bolts or screws per fan unit. Use 1-inch minimum diameter aluminum washers with stainless-steel lockwashers under bolt or screw heads.

C. Coordinate with air balancing and provide adjustments, sheaves, and belts as required in Part 1 above to obtain the airflow and static pressure indicated on the drawings.

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3.23 ACCESSORIES

A. Fans without supply duct on fan inlet shall be provided with bird screens.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

B. Provide at least 4 hours of additional instruction time for the equipment specified in this section.

END OF SECTION

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SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Single-duct variable-air-volume (VAV) terminal units.

1.13 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. The terminal unit manufacturer shall install controllers and damper actuators furnished as specified in Section 23 09 01, Automatic Temperature Control System.

B. Provide the automatic temperature control subcontractor with a description of the terminal units and requirements for coordinating with control system.

C. Provide wiring, tubing, and hardware components necessary to produce complete operational units, including transformer, fan relay, inlet airflow pickup, and access to controls.

1.14 RELATED SECTIONS

A. Controls: Sections 23 09 01 through 23 09 23.

B. Balancing: Section 23 05 93.

C. Commissioning requirements: Divisions 01 and 23.

1.20 REFERENCES

A. UL 181: Factory-made Air Ducts and Air Connectors.

B. NFPA 90A: Installation of Air Conditioning and Ventilating Systems.

C. NFPA 90B: Warm Air Heating and Air Conditioning Systems.

D. ARI 880: Air Terminals.

1.27 PERFORMANCE REQUIREMENTS

A. Coordinate controls with the control manufacturer to affect specified unit performances and unit operation as required by the control sequences.

B. Coordinate with and assist balancing agency to perform tests specified in section, Testing and Balancing.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

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B. Product data: Each type of terminal unit and each component.

C. Shop drawings:

1. Show complete dimensions of complete assembled unit with accessories.
2. Include schedule of units, showing performance data for each unit.
3. Include unattenuated (raw) sound power levels for each size unit, at specified rating conditions, for both radiated and discharge sound. Submit sound data with no corrections or noise reduction factors applied, at the airflow rates indicated on schedules at end of section.

D. Certifications: Factory certification that sound data required in "Shop Drawings" above have no corrections or noise reduction factors applied; or, if data do include such factors, guaranteeing that the equipment will meet the scheduled sound level requirements.

1.40 QUALITY ASSURANCE

A. Terminal units shall be certified and listed in the current ARI Directory of Certified Applied Air-Conditioning Products. Listed sound power levels shall show that units meet requirements scheduled at the end of this section.

B. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

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PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Scheduled units are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article “Product Options” in Section 23 01 01, and submit product data and shop drawings as specified in article 1.30 above.

B. Single-duct units:

1. Environmental Technologies, A Corporation.
2. Krueger.
3. Metalaire.
4. Nailor Industries, Inc.
5. Price Company.
6. Titus-Environmental Elements Corporation.
7. Trane Company.

C. Drawings show duct and pipe connections, and size and arrangement of unit, based on configuration of design basis unit. Do not propose another manufacturer’s unit, which cannot be made to fit in the space shown. Revise duct and pipe connections and other conditions as necessary to make another manufacturer’s unit meet the project requirements, without addition to the Contract Sum.

2.10 MATERIALS

A. Sheet metal: Galvanized steel.

B. Insulation: Fiberglass, meeting requirements of UL 181 and NFPA 90A and 90B, rated for 4000 fpm air velocity.

1. Thickness: Manufacturer’s standard thickness, to achieve thermal resistance no less than R value of 4.
2. Facing: Manufacturer's standard acrylic matte coating.

2.30 AIR TERMINAL UNITS, GENERAL

A. Terminal units shall be pressure-independent, each a complete factory-assembled unit, including automatic controls and the features specified or scheduled on the drawings.

B. Provide units of the types, sizes, and capacities scheduled on the drawings.

C. Sound power levels: ARI 880, certified and listed in ARI Applied Products Directory, and not exceeding the levels scheduled at the end of this section.

D. Casing: Not less than 22 gage steel; airtight, leakage no more than two percent at 3.0 inches wg (747 Pa).

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1. Lining: Insulation, cut edges exposed to airstream finished and sealed with facing material.
2. Internal access: Removable bottom panel for access to components requiring service, adjustment, or maintenance; with airtight seal.

E. Duct connections: Round or oval duct collar for primary air connection and a single rectangular flanged connection for discharge.

F. Wiring: Completely factory-wired, UL tested and listed as a complete assembly, with a single-point power connection and single-point control connection. Include control transformers and a power disconnect switch.

G. Temperature sensor: Direct digital type, provided as specified in Section 23 09 23, Direct Digital Building Systems Control.

H. Air control valve (damper): Constructed of minimum 22-gage steel, bolted or welded to a continuous shaft which rotates in self-lubricating Delrin or bronze oilite bearings, closing against a closed-cell gasket. Units with multiple blades shall be in the opposed-blade configuration. Blade(s) shall not deflect at inlet pressures up to 6 inches wg. Maximum leakage shall not exceed 2 percent of maximum inlet rated airflow at 3 inches wg inlet pressure.

I. Averaging velocity sensor: Mount in the inlet of the fan terminal. Sensor shall provide a minimum of one air pickup point for each 2.5 inches of inlet diameter (single-point differential sensors are not acceptable). Provide taps for field measuring and balancing.

J. Air control valve (damper) actuator: Type required by the automatic temperature control system, capable of operating air control valve under system air pressures.

K. Heating water coil: Aluminum fins bonded to copper tube by mechanical expansion, tested at no less than 300 psig (2068 kPa), performance scheduled on the drawings, removable for maintenance.

2.33 SINGLE-DUCT VAV TERMINAL UNITS

A. Terminal units as specified above, with heating water coil.

B. Controls: Include a fail-in-place primary air-control valve (damper) with actuator, controller, temperature sensor and devices necessary to accomplish the control sequence.

C. Control sequence:

1. Terminal unit controls shall be placed in the occupied, unoccupied, and morning warm-up cycles by input signals from a source outside this system. Provide compatibility with related sequences of operation shown on the drawings.

2.90 SOURCE QUALITY CONTROL

A. Factory test units to assure that they operate in accordance with the sequence specified.

B. Factory calibrate and adjust controls. Pre-set minimum and maximum airflow setpoints to the values scheduled on the drawings.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Install terminals as recommended by the manufacturer and as detailed on the drawings, suspended from overhead structure. Support terminals independently of ductwork.

B. Install units so that access doors or panels can be opened or removed conveniently.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

B. Provide at least 2 hours of additional instruction time for the equipment specified in this section.

3.90 SCHEDULES

A. Terminals shall not exceed the scheduled sound power levels at the scheduled air flow rates when tested in accordance with ARI 880.

Single-Duct Air Terminals

Nominal Inlet Size	Rated Air Flow CFM	Radiated Sound Power Level, dB Octave Band Center Frequency, Hz						Discharge Sound Power Level, dB Octave Band Center Frequency, Hz					
		125	250	500	1000	2000	4000	125	250	500	1000	2000	4000
4”	150	65	54	49	43	41	39	70	65	59	55	53	52
5”	250	63	53	48	44	38	38	70	66	60	58	53	49
6”	400	66	63	50	44	42	38	73	69	61	59	52	53
8”	700	67	57	52	46	45	44	70	70	64	61	57	55
10”	1100	72	57	53	48	45	43	78	70	65	61	57	54
12”	1600	71	62	58	51	46	43	75	71	67	62	60	59
14”	2100	77	61	55	50	50	48	76	71	68	64	60	59

END OF SECTION

SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Ceiling- and wall-mounted diffusers, registers, and grilles.

1.14 RELATED SECTIONS

A. Louvers: Division 08.

B. Fire and smoke dampers: Section 23 33 00.

C. Automatic control dampers: Section 23 09 07.

D. Balancing: Section 23 05 93.

E. Particulate air filtration: Section 23 41 00.

1.20 REFERENCES

A. NFPA 90A: Standard for the Installation of Air-Conditioning and Ventilating Systems.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Each type of diffuser, register and damper, and grille, including frames and accessories, and performance data.

C. Shop drawings:

1. Schedule, including size, location, function, and finish of each diffuser, register, and grille.
2. For each air control device, provide information required to balance the system. Include the factor for each size and type of device for converting velocity to volume.

    a. Include this information in Operating and Maintenance Manuals.

D. Samples: Manufacturer’s complete line of color chips for anodized aluminum linear grilles and diffusers.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Grilles, registers and diffusers:

1. Hart and Cooley Inc.

2. Krueger.
3. Metalaire.
4. Nailor Industries, Inc.
5. Price Company.
6. Titus Products.

2.21 DIFFUSERS, REGISTERS, AND GRILLES

A. Devices of one of the named manufacturers, with performance data, characteristics, features, and accessories of the model or type specified or indicated on the drawings. Model numbers specified below are Krueger except as noted otherwise.

B. See architectural drawings for type of walls and ceilings where diffusers, grilles, and registers are required. Coordinate margin and frame of each device with the substrate in which it will be installed. Where devices are installed in suspended ceilings, assure that they will fit correctly in the type of suspension supports shown or specified.

C. Materials and finish:

1. Construction:

a. Steel where mounted in ceilings.
b. Either aluminum or steel where mounted in walls near ceiling.
c. Heavy-duty steel where mounted in walls near floor.
d. Welded or mechanically fastened cores in diffusers located in gymnasium.
e. Mechanical fastening shall include metal straps secured at 4 locations per air device.

2. Aluminum devices shall be all aluminum construction, including dampers, where specifications call for aluminum or stainless steel ductwork.
3. Finish: Manufacturer’s standard white enamel, suitable for final finish or for field painting, unless indicated otherwise.

2.22 SUPPLY DIFFUSERS

A. Throw length is based on performance data of the scheduled or specified manufacturer and model. Select units of other manufacturers whose performance data meet the required conditions. Throw direction of square and rectangular ceiling diffusers shall be four-way unless otherwise indicated on the drawings.

B. Square and rectangular ceiling diffusers: Series SH with square, rectangular, or round neck and removable core. Each unit shall have a straightening grid. The grids shall be set at right angles to one another.

1. Frame Style 23 (panel diffuser): Diffusers mounted in nominal 24 by 24-inch (600 by 600-mm) or 24 by 48-inch (600 by 1200-mm) flat steel panels as indicated on the drawings, to lay into suspended ceiling grid of acoustical ceilings.
2. Frame Style 22 (surface mount): Diffuser with flat frame to mount at underside of plaster or gypsum wallboard ceilings.

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C. Round, adjustable diffuser with round neck: RA2 series, surface-mounted frame, 360 degree discharge with infinitely field-adjustable vane settings for discharge pattern from vertical to horizontal, combination air extractor/damper and grid with concealed adjustment, duct-mounted straightening grid (shipped loose for field installation).

D. Linear slot diffusers: Series 1900 with size of slot and number of slots as indicated on drawings. Adjustable blades, for volume and air direction control, shall be furnished behind active supply sections in each slot opening. Blades and internal surfaces exposed to view shall be painted black. Provide surface mounting with positive holding concealed fasteners. Provide alignment tabs in frame where multiple units are joined, and mitered corners at 90 degree turns.

2.23 SUPPLY GRILLES AND REGISTERS

A. For registers, provide opposed-blade dampers with linkage and adjustment through grille face with a screwdriver or allen wrench. For plaster wall or ceiling construction, provide with plaster frames.

B. Wall-mounted near ceiling: Grilles 880H (steel) 5880H (aluminum); registers 880H-OBD (steel) 5880H (aluminum); double deflection with horizontal face bars, minimum 1.25-inch (32-mm) overlap margin.

C. Ceiling-mounted: Register 5180-OBD (aluminum) 180-OBD (steel), individually adjustable curved air deflection blades, 1-, 2-, 3-, or 4-way air pattern as indicated on the drawings, minimum 1.25-inch (32-mm) overlap margin.

2.24 TRANSFER, RETURN, AND EXHAUST GRILLES AND REGISTERS

A. For registers, provide opposed-blade dampers with linkage and adjustment through grille face with a screwdriver or allen wrench. For plaster wall or ceiling construction, provide with plaster frames.

B. Ceiling-mounted and wall-mounted near ceiling: Grille S-80H (steel) or S-580H (aluminum), Register S-80H-OBD (steel) or S-580H (aluminum). Fixed horizontal face bars set at 35 to 45 degrees deflection, minimum 1.25-inch (32-mm) margin.

C. Wall-mounted near floor: Grille S-480-H, register S-480-H-OBD, heavy-duty steel construction, 14 gage fixed horizontal face bars set at 30 to 40 degrees deflection, spaced on 0.5 to 0.7-inch (13 to 18-mm) centers, and 14 gage vertical support bars on maximum 8-inch centers, minimum 1.25-inch (32-mm) margin.

D. Filter grilles, wall-mounted near floor: Model S-480-H, heavy-duty steel construction, 14 gage fixed horizontal face bars set at 30 to 40 degrees deflection, spaced on 0.5 to 0.7-inch (13 to 18-mm) centers, and 14 gage vertical support bars on maximum 8-inch centers, minimum 1.25-inch (32-mm) margin. Provide with filter frame to accept a 1 inch MERV 8 filter.

PART 3 - EXECUTION

3.21 INSTALLING GRILLES, REGISTERS AND DIFFUSERS

A. Securely attach grilles, registers, and diffusers in place. Do not install the grilles and registers until duct interiors have been painted as specified in Section 23 05 00, Common Work Results for HVAC.

B. Install all air control devices complete with the accessories specified, securely attached in position. Make operating devices accessible.

C. Adjust diffuser straightening grids to provide uniform air distribution above diffuser face.

D. Adjust supply register deflectors to provide uniform air distribution to the areas served.

E. Install throw-away filters in filter return grilles prior to energizing the fan-coil grilles.

F. Prior to energizing unit and air balancing, install new filter for filter return grilles as specified in Section 23 41 00.

END OF SECTION

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SECTION 23 37 23 - ROOF-MOUNTED GRAVITY VENTILATORS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Roof-mounted gravity ventilators, connected to HVAC system, for intake or relief.

1.14 RELATED SECTIONS

A. Curb: Section 23 05 06.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: For each type of ventilator included in the work. Include construction details, materials, dimensions and profiles, and finishes.

C. Shop drawings: Show complete dimensions of complete assembled unit with accessories, including dimensions and configuration as required to coordinate with framing and bracing roof structure and deck.

D. Samples: For color selection, submit chips showing manufacturer's complete line of colors. Color will be selected to match other roof-mounted equipment.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Scheduled units are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 23 01 01, and submit shop drawings as specified in article 1.30 above.

1. Acme Engineering and Manufacturing Co.
2. Greenheck Fan
3. Jennco Fan
4. Loren Cook Co.
5. Penn Barry.

2.30 VENTILATORS, GENERAL

A. Material: All aluminum, with aluminum bird screen installed vertically over the opening.

B. Construction: All welded, or riveted and welded.

C. Free area: Such that air pressure drop will not exceed 0.05 inches at 500 fpm.

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D. Dampers: Provide each unit with provisions for receiving air temperature control dampers.

E. Finish: Manufacturer's standard baked enamel or fluoropolymer, factory-applied, color to match color of other roof-mounted equipment.

2.31 VENTILATOR TYPES

A. Rectangular, low-silhouette, relief ventilators: Equal to Loren Cook GR, Acme EV, or Penn Barry "Airette."

B. Rectangular low-silhouette, intake ventilators: Equal to Loren Cook GI, Acme IV, or Penn Barry "Airette."

PART 3 - EXECUTION

3.20 INSTALLATION

A. General: Comply with manufacturer's written instructions. Coordinate installation of roof accessories with installation of roof deck, roof insulation, flashing, roofing membranes, penetrations, equipment, and other construction involving roof accessories to ensure that each element of the work performs properly and that combined elements are waterproof and weathertight. Anchor roof accessories securely to supporting structural substrates so they are capable of withstanding lateral and thermal stresses, and inward and outward loading pressures.

B. Install roof accessory items according to construction details of NRCA's "Roofing and Waterproofing Manual," unless otherwise indicated.

C. Separation: Separate metal from incompatible metal or corrosive substrates, including wood, by coating concealed surfaces, at locations of contact, with bituminous coating or providing other permanent separation.

D. Securely install to the sides of roof curb using 0.1875 inch cadmium-plated bolts and nuts or screws, no more than 12 inches (305 mm) on centers, with a minimum of 8 bolts or screws per unit. Use aluminum washers with stainless-steel lockwashers under bolt or screw heads.

E. Cap flashing: Where required as component of accessory, install cap flashing to provide waterproof overlap with roofing or roof flashing (as counterflashing). Seal overlap with thick bead of mastic sealant.

F. Operational units: Test-operate units with operable components. Clean and lubricate joints and hardware. Adjust for proper operation.

3.75 CLEANING AND PROTECTION

A. Clean exposed surfaces according to manufacturer's written instructions. Touch up damaged metal coatings.

END OF SECTION

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SECTION 23 41 00 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.10 SUMMARY

A. Filters for temporary service during construction are required in the equipment sections, including changes required to meet the requirements of Indoor Air Quality Management in Division 01.
B. Provide two sets of filters for every item of equipment requiring filters, as follows:

1. Filters for regular service, installed before air balancing.
2. Filters for regular service, provided as extra materials for future use.

1.14 RELATED SECTIONS

A. Ductless split-systems units: Section 23 81 27.

B. Diffusers, registers, and grilles: Section 23 37 13.

C. Air-handling units: Section 23 73 22.

D. Variable-refrigerant-flow systems units: Section 23 81 28.

E. Unit heaters: Section 23 82 39.

F. Dedicated outdoor air system units: Section 23 72 00.

G. Packaged rooftop units: Section 23 74 13.

1.20 REFERENCES

A. ASHRAE 52.1: Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices used in General Ventilation for Removing Particulate Matter.

B. ASHRAE 52.2: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
C. ARI 850: Commercial and Industrial Air Filter Equipment.

1.21 DEFINITIONS

A. MERV: Minimum Efficiency Reporting Value as determined by ASHRAE 52.2.

B. Temporary service: Operation of equipment during the construction period, before air balancing.

C. Regular Service: Operation of equipment during air balancing and in normal use during occupancy.

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1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data:

1. For filters, include filter ratings, rated flow capacity, and fire classification.
2. For holding frame, include manufacturer's installation instructions.

C. Shop drawings: Illustrate assemblies and attachments.

D. Closeout submittals: As required for Operating and Maintenance Manuals in Division 01 and Section 23 01 01, provide a schedule of locations of filters, identifying equipment and filter types and sizes, including prefilters and final filters.

1.40 QUALITY ASSURANCE

A. Provide all filters for regular service from a single manufacturer.

B. Test filters by methods described in ASHRAE 52.1 and ASHRAE 52.2.

C. Comply with ARI 850.

1.92 EXTRA MATERIALS

A. Disposable and throwaway filters: For each filter included for regular service, provide one extra filter. Identify each filter with its name and intended location and use.

B. Provide filters and media in protective packaging, with identifying labels or markings.

C. Except as otherwise required in Division 01, deliver to location designated by Owner, and shelve or stack as directed.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design products: Subject to compliance with requirements, provide specified or scheduled products or comparable product by one of the following:

1. Filters and filter-holding systems:

a. AAF International.
b. Airguard; Clarcor Air Filtration Products
c. Camfil Farr
d. Flanders Filters, Inc.

2. Filter Gages:

a. Dwyer Instruments, Inc.
b. H.O. Trerice Co.
c. Miljoco Corporation
d. Weksler Instruments

2.20 FILTERS, GENERAL

A. Coordinate with approved manufacturers of the various approved air handling units and equipment for filter size and thickness required.

B. Thickness: Generally, large air handling units shall have filters 2 inches and more thick. Smaller units such as fan-coil units may be limited to filters 2 inches thick.

C. Filter face areas: As scheduled, or equivalent to one square foot for each 300 cfm.

2.21 THROWAWAY FILTERS

A. FS F-F-310, Type I throwaway frame and media, Grade B high dust holding capacity, of size and thickness to fit units.

2.22 DISPOSABLE FILTERS, MERV 8

A. Camfil Farr “Aeropleat IV”, Class 2, thickness 1 and 2 inches, and size required for each location, disposable.

B. Rating in accordance with ASHRAE 52.1:

1. Average efficiency: 25 to 30 percent.
2. Average arrestance: 90 to 92 percent.

C. Rating in accordance with ASHRAE 52.2: MERV 8.

D. UL 900: Class 2.

E. Medium: Non-woven, reinforced cotton and synthetic fabric, pleated.

F. Medium support grid: Welded wire with an effective open area not less than 96 percent, bonded to medium.

1. Performance: Medium shall not oscillate nor pull away from support grid.
2. Design: Tapered radial pleats, supporting medium both vertically and horizontally.

G. Enclosing frame: High-wet-strength beverage board, with diagonal supports bonded to media pleats. Filter pack continuously bonded to inside of frame so that no air leaks around edges.

2.25 DISPOSABLE FILTERS, MERV 13

A. Camfil (Farr) Opti-Pac high-efficiency, mini-pleated, disposable type. Each filter assembly shall consist of a high-efficiency filter, medium retainer and holding frame.

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B. Medium: Microfine glass media in a close-pleat design bonded into a beverage board holding frame.

C. Rating in accordance with ASHRAE 52.1: Average efficiency 80-85 percent, and average arrestance not less than 98 percent.

D. Rating in accordance with ASHRAE 52.2: MERV 13.

E. The initial resistance to airflow shall not exceed 0.5 inch wg at 500 fpm.

F. UL 900: Class 2.

2.31 FILTER HOLDING FRAME

A. Equal to Camfil Farr Type 8, 16-gage galvanized steel, equipped with gaskets and four spring-type positively sealing fasteners.

B. Fasteners: Capable of being attached or removed without the use of tools.

2.33 FILTER GAGE

A. Gage: Equal to Dwyer “Magnehelic”, Series 2000, range zero to 3 inches wg, with divisions of 0.10 inch.

B. Accessory package: To adapt the magnehelic gage for use as a filter gage. Package includes aluminum surface-mounting bracket with screws, two 5-foot lengths of 0.25-inch aluminum tubing, two static pressure tips, and two molded plastic vent valves, with integral compression fittings on both tips and valves.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

A. Before startup of each item of equipment requiring a filter, install filters for temporary service.

1. Generally, provide throwaway filters for temporary service.
2. On equipment with prefilter and final filter, provide only the specified prefilter for temporary service.

B. Immediately prior to air balancing, remove temporary filters and install filters required for regular service.

3.21 INSTALLING FRAMES

A. Where applicable, install in conformance with SMACNA HVAC Duct Construction Standards.

B. Attach securely, following manufacturer’s installation instructions.

3.22 INSTALLING FILTER GAGE

A. Mount across filter section in accordance with manufacturer's instructions.

END OF SECTION

SECTION 23 52 16 - CONDENSING BOILERS

PART 1 - GENERAL

1.10 SUMMARY

A. This section includes packaged, factory-fabricated and -assembled, gas-fired, fire-tube condensing boilers, trim, and accessories for generating hot water.

1.14 RELATED SECTIONS

A. Commissioning requirements: Divisions 01 and 23.

1.30 SUBMITTALS

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

B. Shop drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.

1. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration isolation base details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
4. Wiring diagrams: Detail power, signal, and control wiring.

C. Source quality-control test reports.

D. Startup service reports.

E. Operation and maintenance data: For condensing boilers to include in emergency, operation, and maintenance manuals.

F. Certifications:

1. As required in Section 23 01 00 for burner startup and service.
2. Maryland State Boiler Inspection Certificate.
3. CSD-1 Forms: Confirm and complete forms. Leave a copy with each boiler.
4. CG-500 Form: Complete form. Leave a copy with each boiler.

G. Service agreement specified in “Maintenance Service” below, executed to the Owner and notarized.

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1.40 QUALITY ASSURANCE

A. Product options: Drawings indicate size, profiles, and dimensional requirements of condensing boilers and are based on the specific system indicated. Refer to Division 01.

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

C. ASME compliance: Fabricate and label condensing boilers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

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

E. UL compliance: Test condensing boilers to comply with UL 795, "Commercial-Industrial Gas Heating Equipment."

F. Flue gas composition and temperature shall meet the requirements specified in Section 23 01 00, Operation and Maintenance of HVAC.

G. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

H. Gas regulators shall have emergency exposure rating of 15 psi. Regulator shall not suffer internal damage at this overpressure.

1.42 REGULATORY REQUIREMENTS

A. Before construction begins, obtain and complete forms, and apply for the permit and registration of the burners and boilers with the authority having jurisdiction.

B. Components and installation, including sequences of operation, shall comply with the applicable requirements of ASME CSD-1, Controls and Safety Devices for Automatically Fired Boilers.

C. Costs of complying with these and other applicable regulatory requirements shall be included in the Contract sum.

1.49 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

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B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

1.92 MAINTENANCE SERVICE

A. In addition to the startup service specified in Section 23 01 00, the qualified service and maintenance organization shall provide a 5-year service agreement covering all parts and labor for regular service, emergencies, and repairs.

B. Regular service: One visit at annual startup of boilers and a second visit at the end of the heating season.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.30 FIRE-TUBE CONDENSING BOILERS (HIGH-MASS TYPE)

A. Manufacturers:

1. Aerco
2. Fulton Boiler Works, Inc.
3. Viessmann

B. Description: Factory-fabricated, -assembled, and -tested condensing boiler with stainless steel heat exchanger sealed pressure-tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.

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C. Combustion boiler components:

1. Heat exchanger: Type 316L, stainless-steel primary and secondary combustion chamber.
2. Pressure vessel: Carbon steel with welded heads and tube connections.
3. Exhaust decoupler: Fiberglass composite material in a corten steel box.
4. Burner: Natural gas, self-aspirating and self-venting after initial start.
5. Gas train: Combination gas valve with manual shutoff and pressure regulator. Include 100 percent safety shutoff with electronic flame supervision.
6. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
7. Casing:

    a. Jacket: Sheet metal, with snap-in or interlocking closures.
    b. Control compartment enclosure: NEMA 250, Type 1A.
    c. Finish: Baked-enamel protective finish.
    d. Insulation: Minimum 2-inch- (50-mm-) thick fiberglass insulation surrounding the heat exchanger.
    e. Draft hood: Integral.
    f. Combustion-air connection: Inlet duct collar and sheet metal closure over burner compartment.

8. Condensate trap: Cast-iron body with stainless-steel internal parts.
9. PH neutralization kit: Polyethylene container, 6-1 lb. bags of magnesium oxide neutralizing medium, 1.5 inch NPT plastic pipe fittings.

2.32 HOT-WATER BOILER TRIM

A. Include devices sized to comply with ANSI B31.9, “Building Services Piping.”

B. Aquastat controllers: Operating, firing rate, and high limit.

C. Safety relief valve: ASME rated. 100 psig (690 kPa).

D. Altitude and temperature gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is at approximately 50 percent of full range.

E. Boiler air vent: Automatic.

F. Drain valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.

2.33 BURNER OPERATING CONTROLS

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

1. High cutoff: Automatic reset stops burner if operating conditions rise above maximum boiler design temperature.

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2. Low-water cutoff switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be automatic-reset type.
3. Blocked inlet safety switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
4. Alarm bell: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

2.34 BOILER OPERATING CONTROLS

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

1. Control transformer: 115 V.
2. Sequence of operation: Electric, factory-fabricated, and field-installed panel to include automatic, alternating-firing sequence for multiple boilers.

B. Building management system interface:

1. Each boiler shall be provided with a "master" control arrangement, capable of receiving a 0-10 VDC signal from the building automation system for adjustment of boiler firing rates. Use of "master-slave" arrangements for multiple boilers is not acceptable.
2. Provide BACnet protocol for each boiler for remote monitoring through the building automation system.

2.35 INTAKE AND VENT

A. Vent kit: ASTM A 959, Type 29-4C, double-wall stainless-steel, vertical vent terminal, roof passage thimble, indoor wall plate, vent adapter, condensate trap, and sealant.

B. Intake: Schedule 40 PVC. Pipe, fittings, and solvent cement shall conform to ANSI and ASTM standards.

2.70 ACCESSORIES

A. Device plate for emergency boiler switch: As specified in Section 23 05 00, engraved plastic, red letters on white background, reading “EMERGENCY BURNER DISCONNECT.”

2.90 SOURCE QUALITY CONTROL

A. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code: Section I, for high-pressure boilers and Section IV, for low-pressure boilers.

PART 3 - EXECUTION

3.02 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

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1. Final boiler locations indicated on drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed. Proceed with installation only after unsatisfactory conditions have been corrected.

3.20 BOILER INSTALLATION

A. Install boilers level on concrete base. Concrete base is specified in Section 23 05 29 and concrete materials and installation requirements are specified in Division 03.

B. Concrete bases: Anchor boilers to concrete base.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Cast-in-place concrete materials and placement requirements are specified in Division 03.

C. Vibration isolation: Rubber pads with a minimum static deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration Control Supports for HVAC."

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

E. Assemble and install boiler trim.

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

3.22 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 23 Section "HVAC Piping Specialties."

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

D. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

E. Install piping from safety relief valves to nearest floor drain.

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F. Connect breeching full size to boiler outlet.

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

H. Ground equipment according to Division 26 Section “Grounding and Bonding.”

I. Connect wiring according to Division 26 Section “Wires and Cables.”

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

3.61 STARTUP SERVICE

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

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

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

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

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

F. Adjust initial temperature set points.

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

H. Occupancy adjustments: When requested within 24 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

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

3.81 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain condensing boilers. Refer to Section 23 05 00.

B. Submit training itinerary to Owner at a minimum of two-weeks prior to training.

C. Training shall be held at the HCPSS facilities location (Columbia, MD) during normal work hours. As a minimum, two days of classroom training shall be provided. Provide competent instructors to give full instruction to designated personnel in the adjustment, operation, and maintenance of the system installed, rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are trying to teach. Training

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details (location of training, number of days, number of courses, number of people, type of training, etc.) shall be coordinated with HCPSS. This training is in addition to and should not be confused with the onsite demonstration, instruction time, and/or functional testing.

D. In addition to classroom training, provide four 4-hour days of onsite instruction time for Owner's operating personnel. Coordinate with the Building Services Manager through the Owner for time and location. Onsite demonstration and training shall include:

1. Explanation of drawings, operations, and maintenance manuals.
2. Walk-through of the job to locate control components.
3. Control components, including set-up and adjustment procedures.
4. Explanation of adjustment, calibration, and replacement procedures.

END OF SECTION

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SECTION 23 63 13 - AIR-COOLED REFRIGERANT CONDENSING UNITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Air-cooled condensing units designed for installation outdoors.

1.14 RELATED SECTIONS

A. Refrigeration piping: Section 23 23 00.

B. Equipment supports: Section 23 05 29.

C. Motor: Section 23 05 13.

D. Vibration control supports: Section 23 05 48.

E. Refrigeration equipment service, warranty, and maintenance: Section 23 01 00.

F. Air-handling units: Section 23 73 22.

G. Dedicated outdoor air system units: Section 23 72 00.

H. Commissioning requirements: Divisions 01 and 23.

1.27 PERFORMANCE REQUIREMENTS

A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under the article “Acceptable Manufacturers,” ascertain that it will:

1. Perform to the scheduled and specified capacities.
2. Make no additional demands on other systems such as domestic, heating and chilled water, or electricity.
3. Meet or exceed all specified requirements.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data:

1. Condensing unit and accessories.
2. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
3. Product data shall verify compliance with CEE efficiency requirements.

C. Shop drawings:

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1. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans and sections showing any changes in wiring, arrangement, or access made necessary to accommodate the unit proposed.
2. Shop drawings shall show complete dimensions of complete assembled unit with accessories. Include dimensions and configuration as required to coordinate with roof structure and deck.
3. Include wiring diagrams showing factory- and field-wiring for each unit.
4. Provide design of refrigeration piping prepared by manufacturer of the refrigeration compressor. Show oil traps and accessories specified in Section 23 23 00, Refrigerant Piping, as well as those required by the manufacturer.
5. Provide equipment balance curve graph showing balance point of condensing unit in connection with the DX coil specified in the associated air-handling equipment.

1.40 QUALITY ASSURANCE

A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

B. Regulatory requirements:

1. ICC: HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.
2. COMAR 14.26.03: Packaged equipment with over 20 tons of cooling capacity shall meet the Tier 2 requirements for minimum efficiencies for unitary commercial air conditioners or heat pump units of the Consortium for Energy Efficiency (CEE), in effect on 1 January 2002.
3. EPA: Refrigerant: HFC-410a.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

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D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide the specified or scheduled Aaon product, or comparable product by one of the following:

1. Aaon
2. Carrier Corporation.
3. McQuay International.
4. Trane Co.

B. Comply with requirements of article “Performance Requirements” above.

2.21 AIR-COOLED CONDENSING UNITS

A. Factory-assembled and -tested, designed for use with the specified refrigerant, and ARI certified.
B. Performance:

1. Meet scheduled performance requirements and comply with regulatory requirements for efficiency.
2. With standard controls, unit shall operate at capacity shown on drawings when ambient air (air entering condenser) is within the range from 95 degrees F (35 degrees C) to low ambient temperature shown on drawings.

C. Coil: Nonferrous, with aluminum plate fins mechanically bonded to seamless copper tubes. Coil shall be circuited for subcooling.

1. Provide hail guard protection for all coils.

D. Condenser fans and motors:

1. Fans: Arranged for vertical discharge. Provide safety guard for each fan.
2. Motors: Permanently lubricated, with Class B motor insulation and inherent protection. Mount on resilient supports.
3. Include controls to cycle fan for intermediate season operation.

E. Compressor: Accessible or fully hermetic design, with external or internal spring isolators and reversible oil pump. Compressor shall have mechanical unloading down to the percentage of full capacity, in a minimum number of steps for partial load operation, scheduled on the drawings.

F. Controls: Factory-wired.

1. Safety devices: High- and low-pressure switches and compressor overload devices.
2. Short-cycle protection: Positively acting timer shall prevent compressor from restarting for 3 minutes.
3. Operating low-pressure cutout (systems 10 tons and larger): When the system cycles off, shall pump out the low side.
4. Transformer for control circuit.
5. Devices:

    a. Discharge line thermostat.
    b. Oil pressure switch.
    c. Pressure relief valves.
    d. Capacity unloader.
    e. Hot gas muffler.
    f. Crankcase heater.

6. Power panel: Factory-installed, containing the main circuit breaker.
7. Control cabinet: Factory-installed, containing starters with overload protection and control devices.

G. Casing: Fully weatherproof for outdoor installation, made of galvanneal steel, zinc-phosphatized and finished with baked enamel. Provide openings for power and refrigerant connections, removable panel allowing access for servicing, and a hinged access door on the control panel.

H. As noted on the equipment schedule, provide for field-mounting a hot-gas bypass capacity control valve with solenoid for injecting hot gas into the air unit liquid line between the expansion valve and the DX coil distributor.

I. Unit supplier shall cooperate with automatic temperature control subcontractor to implement the control sequence shown on the drawings and required by the manufacturer.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Provide refrigerant equipment startup and service by a factory-authorized agent during the correction period as specified in Section 23 01 00.

B. Set condensing unit on equipment supports with vibration control supports. Securely attach unit to its support.

C. All relief valves shall be vented to atmosphere with steel pipe or copper tubing in accordance with applicable codes.

D. Install hot-gas loading system on compressor where scheduled.

3.81 OPERATING INSTRUCTIONS

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A. As specified in Section 23 05 00, provide operating instructions.

END OF SECTION

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SECTION 23 64 19 - POSITIVE DISPLACEMENT CHILLERS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Screw compressor air-cooled chiller.

1.14 RELATED SECTIONS

A. Motors: Section 23 05 13.

B. Refrigerant piping: Section 23 23 00.

C. Refrigeration service and maintenance: Section 23 01 00.

D. Controls: Sections 23 09 01 through 23 09 23.

E. Foundations: Section 23 05 29.

F. Alternates: Division 01.

G. Commissioning requirements: Divisions 01 and 23.

1.20 REFERENCES

A. ARI 550/590: Water-Chilling Packages Using the Vapor Compression Cycle.

B. ASHRAE 15: Safety Code for Mechanical Refrigeration.

C. NFPA 70: National Electrical Code.

D. UL 1995: Standard for Safety for Heating and Cooling Equipment.

E. ASME Boiler and Pressure Vessel Code (BPVC): Rules of safety governing the design, fabrication, and inspection of boilers, pressure vessels and subsystems.

1.27 PERFORMANCE REQUIREMENTS

A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under 2.01, “Acceptable Manufacturers,” below, ascertain that it will:

1. Perform to the scheduled and specified capacities.
2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
3. Meet or exceed all specified requirements.

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1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings for each chiller:

1. Dimensioned plan and elevation view drawings, required clearances, and locations of field connections.
2. Unit capacity and electrical characteristics showing ratings in accordance with ARI 550/590.
3. Single-line schematic drawing of field-installed electrical connections, indicating chiller components and accessories.
4. Schematic diagram of control system indicating points for field connection. Diagram shall fully delineate field and factory wiring.
5. Identify changes in wiring, arrangement or access made necessary to accommodate proposed unit.

C. Product data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

D. Certifications:

1. Factory run test signed by company officer.
2. Factory authorization of service and maintenance agency.

E. Maintenance data: Installation instructions and operation and maintenance manuals as required in Division 01 and Section 23 01 01.

F. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit.

1.40 QUALITY ASSURANCE

A. ASME compliance: Comply with ASME BPVC Section VIII for constructing and testing evaporator and condenser pressure vessels. Stamp with ASME label.

B. Comply with ASHRAE 15 for chiller design, construction, leak testing, and installation.

C. Comply with NFPA 70.

D. Comply with UL 1995.

E. Chiller equipment shall meet the energy performance requirements of ASHRAE 90.1. Submit with shop drawings, product data that verifies compliance or provide certified performance ratings by a qualified independent testing agency.

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1.50 DELIVERY, STORAGE, AND HANDLING

A. Ship unit with protective covering on compressor motor, control center, and unit controls. Cap water nozzles with fitted closures.

1.80 WARRANTY

A. Provide special warranty as required in Section 23 01 00 for refrigeration equipment, including compressors.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

1.92 MAINTENANCE SERVICE

A. Specified in Section 23 01 00, Operation and Maintenance of HVAC Systems.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Scheduled units are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article “Product Options” in Section 23 01 01, and submit shop drawings as specified in article 1.30 above.

1. Carrier Corporation
2. Daikin McQuay
3. York; Johnson Controls

4. Trane
5. Smardt

2.10 MATERIALS

A. Refrigerant compatibility: Seals, O-rings, motor windings and internal water parts exposed to refrigerants shall be fully compatible with refrigerants and pressure components shall be rated for refrigerant pressures.

2.20 DESCRIPTION

A. Chillers shall be air-cooled with screw compressors suitable for outdoor use.

B. The contractor shall provide any special accessories required by the manufacturer for the chiller installation that are not shown on the drawings.

2.23 SCREW COMPRESSORS

A. Description: Semihermetic-refrigerant cooled with force feed lubrication system, oil heater, and suction and discharge line service valves.

1. Capacity control: Each unit shall be continuously modulating. Throttling range: 100 to 10 percent of full load.
2. Oil lubrication system: Refrigerant pressure oil pump, oil separator rated for refrigerant pressure of 320 psi (2210 kPa), sight glass, filling connection, and filter with magnetic plug.
3. Use of turbo-core oil-free compressors is acceptable.

B. Refrigerant: HFC-134a or HFC 410a; full operating charge of refrigerant and oil.

2.24 EVAPORATOR

A. Shell and tube type heat exchanger:

1. Design: Direct-expansion with refrigerant in shell, water in tubes.
2. Shell material: Carbon steel.
3. Removable carbon-steel heads with baffle to ensure oil return.
4. Designed, tested, and stamped in accordance with the requirements of ASME BPVC Section VII.
5. Tube construction: Expanded into tube sheets.

a. Material: Seamless copper.
b. Internal finish: Smooth.

6. Refrigerant working pressure: 300 psig (2070 kPa).
7. Water-side working pressure: 150 psig (104 kPa).

B. Insulation: Factory applied to evaporator, suction lines, and other surfaces where condensation might occur, with 3/4-inch-(19-mm-) thick, flexible closed cell insulation.

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C. Evaporator heater: Factory-installed electric heater with capacity to protect evaporator to minus 20 deg F (minus 29 deg C) ambient temperature. Heater shall be on separate 110V power circuit independent of main unit power.

2.25 REFRIGERANT CIRCUIT ACCESSORIES

A. Multicompressor units shall have minimum of two refrigerant circuits, each with the following specialties:

1. Suction and discharge shutoff valves.
2. Refrigerant charging connection.
3. Solenoid valve in liquid line.
4. Filter/dryer with replaceable core.
5. Sight glass and moisture indicator in liquid line.
6. Pressure-relief valve.
7. Expansion valves, one per circuit.

2.27 AIR-COOLED CONDENSER

A. Exterior casing: Manufacturer's standard equipment casing coated with corrosion-resistant exterior finish and with removable doors or panels for service and inspection.

B. Coils: Seamless copper tubing mechanically bonded to aluminum fins and coated with corrosion-resistant coating. Factory test coils for leaks to minimum test pressure of 425 psig (930 kPa).

C. Coil grilles: Louvered, galvanized steel mesh.

D. Fans: Directly driven, statically and dynamically balanced, with fan guards.

E. Fan motors: Three-phase, integral overload protection, and permanently lubricated bearings.

2.28 CONTROL PANEL

A. Manufacturer's standard microprocessor-based chiller controls; unit mounted, and factory wired with single-point power connection and control circuit transformer.

B. Status display: Alphanumeric multi-line display terminal with touch-pad interface. Include the following conditions:

1. Date and time.
2. Operating or alarm status.
3. Operating hours.
4. Entering-chilled-water temperature.
5. Leaving-chilled-water temperature.
6. Evaporator refrigerant temperature.
7. Evaporator pressure.
8. Condenser pressure.
9. Electronic expansion valve position.
10. Control set points.

11. Oil temperature pressure.
12. Percent of maximum motor amperage.
13. Current limit setpoint.
14. Number of compressor starts.

C. Control functions: Include the following:

1. Manual or automatic startup and shutdown time schedule.
2. Leaving-chilled-water temperature reset from entering-chilled-water temperature for soft load starting at high fluid temperatures.
3. Proof of chilled water flow before chiller start.

    a. Differential pressure sensor shall provide proof of flow.

4. Electric demand limiting through compressor lockout.
5. Anti-recycling timing-out to prevent rapid compressor cycling.
6. Automatic lead-lag switching.
7. Chilled-water temperature reset based on outdoor-air or space temperature.
8. Automatic cycling of condenser fans through head pressure control.
9. Start and run during low ambient air temperature to a minimum of 0 degrees F (-18C).

D. Automatically reset safety controls: The following conditions shall shut down chiller and chiller shall automatically restart :

1. No chilled-water flow.
2. Control device failure.
3. Low voltage or power failure.

E. Manually reset safety controls: The following conditions shall shut down chiller and require manual reset:

1. Refrigerant low pressure.
2. Evaporator low temperature.
3. Refrigerant high pressure.
4. Low oil flow or pressure.
5. Compressor motor current-overload protection.

F. Control system interface: Factory installed connections shall allow the following functions to be displayed or reset through a dry contact or 4-20mA remote signal:

1. Start/stop command
2. Chiller alarm status
3. Leaving chilled water temperature.
4. Chilled water setpoint adjustment.

G. Building management system interface: Provide BACnet protocol for interface with the DDC system. Factory-installed hardware and software to enable building management system to monitor and control chilled-water setpoint and chiller-control displays and alarms. Interface shall be through a twisted-pair RS-232 connection.

H. Flooded-evaporator chiller control: Chiller packaged controls shall provide operation of the chilled-water pump when the chiller is not operating to protect evaporator from freezing.

2.29 ELECTRICAL POWER

A. Power connection: Single-point power connection with unit-mounted lockable, nonfused disconnect for all power (excluding evaporator heater).

B. Three-phase solid-state overload protection for each compressor.

C. Part-wind or wye-delta starting on all compressors.

D. Wired grounding lug.

E. Convenience outlet: 115V GFI female receptacle wired into control circuit.

F. Separate power connection for evaporator heater.

2.70 CHILLER ACCESSORIES

A. Sound attenuation: Acoustical covers provided by chiller manufacturer.

1. Performance: Attain minimum sound level reduction of 6 to 8 dBA beyond the manufacturer's baseline sound power levels.
2. Construction:

a. 1 or 2 inch thick removable covers.
b. Fill: Inert fiberglass needle mat that is mildew resistant, vermin-proof, and incombustible.
c. Inner and outer jackets shall be oil and water-resistant of PTFE impregnated fiberglass cloth.
d. Raw cut edges shall not be exposed using PTFE cloth binding with PTFE coated fiberglass thread.
e. Each section labeled for identification and location.
f. Fasteners: Secure covers with 304 stainless-steel hardware and removable straps sewn onto mating flaps.
g. Design of covers and fasteners shall withstand vibration, air temperature, equipment temperature not exceeding 450 degrees F (232 degrees C), or humidity with the passage of time.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Provide refrigeration equipment start-up and service by a factory authorized agent during the project correction period as specified in Section 23 01 00.

B. Chiller shall be mounted on a housekeeping pad and vibration isolators as indicated on the drawings.

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C. Piping connected to the chiller shall be properly supported and designed to permit thermal expansion of piping without undue stress on the piping connections. Each connection shall have valves with unions or flanges so installed that tubes and heads on chiller can be easily removed without draining the entire chilled water system or altering any piping.

D. Connect refrigerant piping according to Section 23 23 00 “Refrigerant Piping.” Connect to suction and liquid tappings with shutoff valve and union or flange at each connection.

E. Vent relief valves or bursting disks to atmosphere with steel pipe or copper tubing in accordance with ASHRAE 15. Provide insect screen at termination. Provide drip leg and drain valve.

F. Install chillers level and plumb, and anchor to base.

G. Install and connect chilled water flow switches.

H. Insulate evaporator, suction lines, and other surfaces where condensation might occur.

I. Maintain manufacturer’s recommended clearances for service and maintenance.

J. Electrical wiring: Install electrical components, devices, and accessories furnished loose by manufacturer, including remote flow switches and remote chiller control panel.

K. Acoustical sound attenuation covers: Install as recommended by manufacturer.

3.60 FIELD QUALITY CONTROL

A. Manufacturer’s field service: Engage a factory-authorized service representative to inspect field-assembled components and chiller installation, including piping and electrical connections. Report results in writing.

3.75 CLEANING

A. After completing installation, including outlet fittings and devices, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

3.80 SYSTEM STARTUP

A. Verify that installation complies with the contract documents.

B. Engage a factory-authorized service representative to perform startup service.

1. Fill out startup checklists and attach copy with contractor startup report.
2. Complete installation and startup checks according to manufacturer’s written instructions and check for the following items:

a. No physical damage to unit.
b. Unit is level.

c. Chiller vibration isolation and flexible pipe connections are installed.
d. Clearances have been maintained and piping is installed for easy removal for service and tube cleaning.
e. Chilled-water pipes have been connected to correct ports.
f. Labels and safety instructions are clearly visible.
g. Oil levels are as recommended by manufacturer.
h. Refrigerant charge is sufficient and chiller has been leak tested.
i. Shipping skids, blocks, and straps are removed.
j. Refrigerant pressure relief is vented to outside.
k. Thermometers and pressure gages are installed.
l. Controls and safety interlocks are installed and connected.
m. Pumps are installed, connected, and operational.
n. Check and record performance of chiller protection devices.

3. Check and record performance of chilled-water flow and low-temperature interlocks.
4. Operate chiller for run-in period as recommended by manufacturer.
5. Check static deflection of vibration isolators, including deflection during chiller startup and shutdown.
6. Check refrigerant charge. Check oil level.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

B. Provide at least 4 hours of additional instruction time for the equipment specified in this section.

END OF SECTION

SECTION 23 72 00 – DEDICATED OUTDOOR AIR SYSTEM UNITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Custom rooftop outdoor-air-handling units with energy recovery.

1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Disconnects for units not provided with factory-installed disconnects: Division 26.

1.14 RELATED SECTIONS

A. Refrigeration service: Section 23 01 00.

B. Roof curbs: Section 23 05 06.

C. Vibration isolation: Section 23 05 48.

D. Efficiency and power factor of motors: Section 23 05 13.

E. Variable frequency drive: Section 26 29 23.

F. Filters: Section 23 41 00.

G. Controls: Sections 23 09 01 through 23 09 23.

H. Commissioning requirements: Divisions 01 and 23.

I. Refrigerant piping: Section 23 23 00.

J. Condensing units: Section 23 63 13.

1.20 REFERENCES

A. ARI 410: Forced-circulation Air-cooling and Air-heating Coils.

B. ARI 430: Central Station Air-Handling Units.

C. ARI 1060: Performance Rating Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment.

1.27 PERFORMANCE REQUIREMENTS

A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under “Acceptable Manufacturers,” below, ascertain that it will:

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1. Perform to the scheduled and specified capacities.
2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
3. Meet or exceed specified requirements.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings: Wiring diagrams prepared for this installation, including factory and field wiring of units, accessories, and equipment.

C. Product data: Each type of unit and each component, including manufacturer's installation instructions.

D. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing laboratory.

E. ATC contractor submittals shall be prepared and submitted after all HVAC equipment submittals have been approved and shall incorporate the approved equipment submittals into the ATC contractor submittals.

F. Certifications: Factory test reports, including test of casing insertion loss performance.

G. Service agreement specified in "Maintenance Service" below, executed to the Owner and notarized

H. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space.

1. "Fit in the available space" means that space allows clearances required for service and for overhaul or removal of components.
2. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit.
3. Include shop drawings and product data sufficient to show compliance with the article "Performance Requirements" above.

I. Shop drawings shall show complete dimensions and configuration of complete assembled unit with accessories, including dimension and configuration, as required to coordinate with framing and bracing roof structure and deck.

J. Submit fan curves for each unit, with operating points indicated.

K. Certifications: Fan performance; unit energy performance. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

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L. Coordinate ATC submittals indicating compliance with sequence of operation shown on the drawings.

1.40 QUALITY ASSURANCE

A. Unit construction and fan and coil performance shall be certified in accordance with ARI 430 and 410.

B. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC. Each unit shall be UL listed.

C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

D. Make fan selections to the right of the peak static pressure point and not on any flat portion of the fan curve. Generally, fan selection shall be in the 50 to 80 percent range of wide open volume.

E. Provide OSHA-approved fan drive guard where required.

1.50 DELIVERY, STORAGE, AND HANDLING

A. Follow manufacturer's instructions for protecting units during shipping, storage, and handling.

B. Protect coils and pipe connections with temporary covering until the unit is installed.

1.80 WARRANTY

A. In addition to general project warranty and correction period, provide manufacturer's special warranties.

1. Compressors shall be warranted for five years, as specified in Section 23 01 00.
2. Enthalpy type energy recovery wheels shall be warranted for 5 years on all wheel, cartridge, and drive components. Warranty shall include total cost of repairs and/or replacement, including both labor and parts.

B. Unit operation:

1. Refrigerant circuit shall operate at specified minimum ambient temperature, flow, and water temperature conditions.
2. Unit shall start and operate within scheduled tolerance of nameplate voltage.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning

documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Scheduled units are the basis for design of the project. The manufacturers listed also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article “Product Options” in Section 23 01 01, and submit shop drawings and product data as specified in Part 1 above.

1. Munters, Des Champs Technology
2. Engineered Air
3. Innovent
4. Venmar

B. Comply with requirements of Article 1.27 above.

2.10 MATERIALS

A. Galvanized steel: Hot dipped, ASTM A 123, no less than 0.90 oz. zinc per square foot.

B. Stainless steel: Type 304.

C. Insulation: Minimum of R-8 and complying with the requirements of NFPA 90A when installed between metal panels.

1. Option 1: ASTM 1071, rigid fiberglass, 1.5 lb per cubic foot density, with coated mat facing, meeting the requirements of NFPA 90A.
2. Option 2: Insulating polyurethane foam injected between interior and exterior panels.

2.21 ENERGY RECOVERY UNITS, GENERAL

A. Fans and coils shall be removable without dismantling the structural framing.

B. Weatherproof construction:

1. Roof sloped no less than 0.25 inch in one foot.
2. Base adaptable for installation on roof curb.

C. Base: Welded structural steel channel with integral steel lifting lugs, with manufacturer's standard primer and industrial enamel finish. Provide supplemental steel supports as required to obtain proper operation heights for cooling coil condensate drain trap as shown on drawings.

1. Unit(s) shall be completely self-supporting for installation on concrete housekeeping pad, curb, steel support pedestals, or suspended, as shown on drawings.

D. Casing: Two-inch double walls, steel.

1. Nonloadbearing panels: Exterior 18 gauge and interior 22 gauge.
2. Loadbearing panels: Exterior 16 gauge and interior 18 gauge.
3. Floor: 18 Gauge galvanized steel with sub-floor assembly.
4. Insulation: Walls, floor, and roof, 2 inches thick, completely enclosed in panel construction. Floors shall be insulated to achieve minimum R13. No insulation shall be exposed in the air stream.
5. Access doors: Same construction as walls, insulated, with stainless-steel piano hinges, at least two compression latches, and minimum 24 inches clear opening width.

    a. Supply and exhaust air streams shall not be accessed via a single door.
    b. Provide access to filters, fans, heat exchangers, and other areas requiring access for maintenance.
    c. Gaskets: Automotive style neoprene, full perimeter, preventing air leakage.
    d. Latches: "Ventlock" style, noncorrosive alloy, operable from the inside and outside of the unit. If access doors do not open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.

6. Finish: Interior and exterior galvanized G90. Exterior finished with 1.5-mil industrial enamel or 2-part epoxy primer with urethane modified enamel top coat shown to withstand ASTM B 117 salt spray test for a minimum of 500 hours with no deterioration.

    a. Provide unit in a factory custom-painted finish with color to be selected by Architect.

7. Drain pans: Sealed, double wall, constructed of minimum 18-gauge galvanized steel exterior and minimum 18-gauge stainless steel interior. Fill space between exterior and interior walls with insulation.

    a. Slope: Drain pans shall be sloped in 2 planes no less than 0.25 inch in one foot; cross break interior pans and pitch toward drain connections; ensure complete, positive condensate drainage.
    b. Cooling coils and energy recovery coils shall have drain pans under the entire coil module.
    c. Connections shall be to the side of the unit and shall enable proper trapping.

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2.22 PLATE AND FRAME HEAT EXCHANGERS

A. Counterflow or crossflow flat-plate heat exchangers with performance as scheduled on the drawings. ARI certified and listed in the ARI 1060 directory of certified air-to-air energy recovery ventilation equipment.

B. Maximum operating differential pressure: No less than 10 inches wg at 70 degrees F across heat exchanger.

C. Maximum operating temperature: No less than 400 degrees F.

D. Construction:

1. Aluminum frame and 99.5 percent pure aluminum plates no less than 0.008 inch thick.
2. Entire heat exchanger surface shall be visible for inspection and cleaning without disassembling the heat exchanger.
3. Drain pans: Under entire heat exchanger, terminated through the side of the unit and properly trapped.

2.24 ENTHALPY TYPE ENERGY RECOVERY WHEEL

A. Certified thermal performance in accordance with ASHRAE Standard 84 and ARI 1060.

B. Media: Corrugated aluminum coated with 3A Molecular Sieve, non-migrating, water selective desiccant.

C. Rotor Frame: Solid aluminum center hub with internal spokes welded to an outer aluminum band.

1. For frames 96-inches and larger: Center hub, full depth demountable spokes, and outer band shall be galvanized for corrosion resistance and of bolted construction to allow for field assembly and disassembly.

D. Wheel bearings: L-10 life in excess of 200,000 hours.

E. Cassette Frame: Galvanized steel face panels with sheet metal connectors, with a single, continuous central post at each face for mounting in multiple air flow positions.

F. Rotor Seals: Multiple pass with four layers at each of the perimeter and cross sealing locations. Material shall be polypropylene with brush outer layers and wiper style inner layers. Seals may be adjusted for either contact location (maximum sealing) or non-contact locations (minimum turning resistance of the wheel) per application.

1. Deck-to-deck differential pressure shall not exceed 4-inches.

G. Latent energy transfer: Entirely in vapor phase.

H. Enthalpy wheel motor shall meet the requirements of Section 23 05 13 and be suitable for use with variable frequency drive controllers.

1. Variable frequency drive controllers shall meet the requirements of Section 26 29 23 and shall be factory installed and wired by the dedicated outdoor air system manufacturer.

2.25 BLOWER AND MOTOR

A. Unhoused plenum fans: Airfoil centrifugal type, designed for industrial duty and continuous operation, performance based on testing in accordance with AMCA 210, single-width, single-inlet, Arrangement 3 plenum fans, sizes scheduled.

1. Selection: Each fan pressure/volume curve shall be steep.
2. Impeller diameters: Comply with the recommendations of AMCA 99.
3. Blades: Hollow airfoil, double skin welded to the center and wheel-side plates.
4. Hubs: Cast or welded, with straight bores and keyways, screwed to the shaft with no fewer than two set screws.
5. Wheels: Statically and dynamically balanced.
6. Shafts: Solid AISI 1040 or 1045 steel; straight; turned, ground and polished to minimum 16 micro-inch finish; sized to run at a minimum of 20 percent greater fan speed than the maximum in accordance with the AMCA Class.
7. Bearings: Pillow block, self-aligning, ball or roller type, grease lubricated, minimum L-10 life of 40,000 hours. Both bearings shall be of the same bore, type, and manufacturer; one shall be fixed. Provide lubrication lines extended to the drive side of the fan.
8. Inlet cones: Steel, formed by spinning; aerodynamically matched to the wheel side plate to provide streamlined air flow to the wheel and fully load the blades; securely attached to the wheel.
9. Provide discharge safety cages and inlet screens.

B. Motors:

1. Provide low-temperature brushless DC electronically commutated motor (ED-Motor) with external rotor and integrated electronic circuitry and electronic for all fans. The motor shall be manufactured with maintenance-free, long-time lubrication ball bearings and shall be statically and dynamically balanced in accordance with ISO 1940 Part 1. The motor shall be closed, protection level IP 54, thermal class 155 with permissible operating temperature of minus 13 degrees F to 140 degrees F. Motor efficiency class shall comply with IE4.
2. Each fan motor (or fan array motors) shall be factory mounted and wired as a single point power panel with an external disconnect and motor starter protection for each fan, and a 100VA, 24 VAC transformer to provide power for field mounted controls. The panel shall be UL or ETL listed.
3. Motor shall be capable of receiving a 0-10 VDC output signal for fan control, (1) digital output for fan array enable, and (1) digital input for alarm from the building automation system.

C. Drives: Direct drive for all fans.

D. Motor and blower shall be mounted on a unitary base with spring isolators with one inch static deflection.

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E. Fan performance certified in accordance with ARI 430.

2.26 DAMPERS

A. Motorized low-leakage dampers with aluminum frame, formed aluminum blades, vinyl edge seals, metal jamb seals, and stainless-steel bearings.

1. Outdoor-air face damper: Opposed-blade type, modulating actuator.
2. Outdoor-air bypass damper: Opposed-blade type, modulating actuator.
3. Isolation dampers: Opposed-blade type.
4. Recirculation (bypass) damper: Opposed-blade type

2.27 HEATING AND COOLING

A. Heating water coil: ARI 410 rated, drainable, non-trapping, 0.02-inch-wall seamless copper tubes and 0.0075-inch-thick aluminum fins, tested and guaranteed for 250 psi working pressure.

B. Cooling coil (DOAS-2 and 3): Direct-expansion, ARI 410 rated, 0.02-inch-wall seamless copper tubes and 0.0075-inch-thick aluminum fins, tested and guaranteed for 250 psi working pressure, two circuits, face interlaced, maximum face velocity 500 fpm. Sloped drain pan, coated with bituminous mastic, shall extend under and past the coil. Stub suction line through unit casing (distributor to remain inside unit).

C. Condensing unit: Integral air-cooled system, factory-piped and -wired, factory-tested and dehydrated and provided fully charged with refrigerant and oil R-410A. Each unit shall have a minimum of two compressors with independently piped refrigerant circuits. Condensing unit shall be an integral part of the unit.

1. Compressors: Hermetic scroll type with suction and discharge service valves, reverse rotation protection, sight glass, oil level adjustment, oil filter, rotary dirt trap, nonshort-cycling control, and high and low pressure limits. Provide minimum one digital scroll or variable speed compressor for each unit.
2. Condenser coils: Galvanized casing, seamless copper tubes, and aluminum fins.
3. Condenser fans: Directly driven, with fan guards.

D. Chilled water cooling coil (DOAS-1 and 4 through 12): ARI 410 rated, drainable, non-trapping, 0.02-inch-wall seamless copper tubes and 0.0075-inch-thick aluminum fins, tested and guaranteed for 250 psi working pressure.

2.29 FILTERS

A. Provide temporary throwaway filters for use until disposable filters are installed for regular service as specified in Section 23 41 00.

B. For regular service, provide filter banks for 2-inch-thick, MERV 8, pre-filters and 4-inch-thick, MERV 13, final filters at the outdoor air inlet of the heat exchanger, mounted in a side-access slide rack.

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C. For regular service, provide filter bank for 2-inch-thick, MERV 8, filters at the exhaust air inlet of the heat exchanger, mounted in a side-access slide rack.

2.30 ELECTRICAL SYSTEM

A. Wiring: Meeting requirements of NEC, unit factory-wired with a single-point power connection. Unit wiring in liquidtight conduit. Entire unit shall be ETL listed, and each major component shall be UL listed.

B. Provide fused disconnect, variable frequency drives, fan motor, contactors, control transformer, control circuit fusing, service switch, and terminal block.

C. Control panel: NEMA 250 Type 3R.

D. Factory tests shall include test of wiring system.

2.31 SYSTEM CONTROLS

A. System of field-installed direct digital temperature controls with electronic actuation: Control sequences of operation are indicated on contract drawings.

B. For units with DX cooling, unit manufacturer shall provide controls for refrigeration cycle and refrigeration safeties. Refrigeration controls shall be suitable for use with digital scroll type compressors. Refrigeration controls shall be provided with BACnet protocol for monitoring through the building automation system.

2.32 ACCESSORIES

A. Provide curbs for roof-mounted units as specified in Section 23 05 06, Curbs and Flashings.

2.90 SOURCE QUALITY CONTROL

A. Casing insertion loss: The insertion loss, per octave band, for the casing shall not be less than the following:

Frequency:	63	125	250	500	1000	2000	4000	8000
Insertion loss, dB:	24.8	24.1	22.3	24.7	26.1	29.0	31.2	33.1

Provide verifying test results from lab accredited by the U.S. Dept. of Commerce and the National Institute of Standards and Technology (NIST). Insertion loss verification shall be in accordance with ISO 3746: 1975 Acoustics-survey (comparison) method.

PART 3 - EXECUTION

3.05 PREPARATION

A. Coordinate installation with the automatic temperature controls subcontractor so that the system and each unit operate in accordance with schedules and sequence of operations.

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3.20 INSTALLATION

A. Install unit in accordance with the manufacturer's instructions and as indicated on drawings.

B. Install units level and plumb, firmly anchored, in locations indicated and so as to maintain manufacturer's recommended clearances. Provide vibration isolation as specified in Part 2 above and in Section 23 05 48.

C. Connections: Connect supply and return piping, drains, ducts, and electrical devices in accordance with drawings and manufacturer's instructions. Ground equipment.

D. Test each drain pan and assure that installed slope is as specified and pan drains completely.

E. Install filters provided with unit before energizing the unit supply and exhaust fans. For units so designed, remove side panel of filter holder to permit access to filter.

F. Prior to air balancing, remove filter and install new filters as specified in Section 23 41 00, Particulate Air Filtration.

G. Coordinate with air balancing and provide the proper drive and belts for fan speed to obtain the airflow and static pressure indicated on the drawings.

1. ATC Contractor shall assist with obtaining required fan speed setting during testing and balancing.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

B. Provide at least 4 hours of additional instruction time for the equipment specified in this section.

END OF SECTION

SECTION 23 73 22 - AIR-HANDLING UNITS WITH COILS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Modular air-handling units (AHUs), installed outdoors.

1.14 RELATED SECTIONS

A. Motors: Section 23 05 13.

B. Roof curbs: Section 23 05 06.

C. Filters: Section 23 41 00.

F. Commissioning requirements: Divisions 01 and 23.

1.20 REFERENCES

A. ARI 410: Forced-Circulation Air-Cooling and Air-Heating Coils.

B. ARI 430: Central-Station Air-Handling Units.

1.27 PERFORMANCE REQUIREMENTS

A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted in the article “Acceptable Manufacturers” below, ascertain that it will:

1. Perform to the scheduled and specified capacities.
2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
3. Meet or exceed all specified requirements.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data:

1. As required in the article “Quality Assurance” below.
2. For air-handling unit complete with all equipment, options, and accessories, showing compliance with specification.

C. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer’s unit should be proposed, ascertain that it will fit in the available space.

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1. "Fit in the available space" means that space allows clearances required for service and for overhaul or removal of components.
2. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit.
3. Include shop drawings and product data sufficient to show compliance with the article "Performance Requirements" above.

D. Shop drawings shall show complete dimensions and configuration of complete assembled unit with accessories, including dimension and configuration, as required to coordinate with framing and bracing roof structure and deck.

1. For units with direct-expansion coils, include design of refrigeration piping prepared by manufacturer of the refrigeration compressor. Show oil traps and accessories specified in Section 23 23 00, Refrigerant Piping, as well as those required by the manufacturer.
2. Wiring diagrams: For power, signal, and control systems, differentiating between factory- and field-installed wiring.

E. Submit fan curves for each air-handling unit, with operating points indicated.

1. If required in accordance with the article "Quality Assurance" below, submit test results showing the effect on unit capacities.

F. Certifications: Fan performance; unit energy performance. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

1.40 QUALITY ASSURANCE

A. Unit construction and fan and coil performance shall be certified in accordance with ARI 430 and 410.

B. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

D. Make fan selections to the right of the peak static pressure point and not on any flat portion of the fan curve. Generally, fan selection shall be in the 50 to 80 percent range of wide open volume.

1. If it should be necessary to provide fan wheels not described in the manufacturer's standard catalog, factory-test the air-handling unit to determine the effect on capacities.

E. Provide OSHA-approved fan drive guard where required.

F. AGA certification: Gas-fired units shall be certified and labeled.

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G. Qualifications of firm or installer who will perform startup and adjustment of equipment: Trained or recognized by the manufacturer, as indicated by the submitted certification.

1.49 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 23 05 06, Curbs and Flashings for HVAC Piping and Equipment.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled units or comparable models of one of the following:

1. Carrier Corporation.
2. McQuay, Daikin Industries.
3. Trane Co.
4. York, Johnson Controls.

B. Units mounted outdoors that are not shipped in one piece (with shipping splits dictated by rigging or shipping constraints), and are not manufactured with standing seam design, shall be rigged and assembled under factory-certified site-service supervision. Supervision shall include detailed review of unit assembly and assurance of compliance with manufacturers' installation instructions and written authorized approval at completion of unit installation.

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2.10 MATERIALS

A. Galvanized steel: Hot dipped, ASTM A 123, no less than 0.90 oz. zinc per square foot.

B. Stainless steel: Type 304.

C. Insulation: Minimum of R-8 and complying with requirements of NFPA 90A when installed between metal panels.

1. Option 1: ASTM C 1071, rigid fiberglass, 1.5 lb per cubic foot density, with coated mat facing, meeting the requirements of NFPA 90A.
2. Option 2: Insulating polyurethane foam injected between interior and exterior panels.

2.30 AIR-HANDLING UNITS (AHUS)

A. General: Units shall be modular double-wall construction of the types, module arrangement, and capacities shown and scheduled on the drawings.

B. Weatherproof construction:

1. Roof sloped no less than 0.25 inch in one foot.
2. Base adaptable for installation on roof curb.
3. Insulated piping chase integral to unit.

C. Base: Galvanized steel, minimum 5 inches high, supporting AHU components. Base shall be constructed of wide-flange I-beams or channels, minimum 12-gauge steel. Provide supplemental steel supports as required to obtain proper operation heights for cooling coil condensate drain trap as shown on drawings.

1. AHUs shall be completely self-supporting for installation on concrete housekeeping pad, steel support pedestals, or suspended, as shown on drawings.

D. Casing (including walls, floor, and roof):

1. Frames: Free-standing, minimum 16-gauge galvanized steel, capable of supporting the weight of the casing and equipment without deflection.
2. Wall panels: Minimum 2 inches thick, double-wall construction, nonload-bearing and removable from exterior. Removing panels shall permit removal of coils and internal components, and cleaning of interior.

a. Exterior: Minimum 18-gauge galvanized steel.
b. Interior: Galvanized steel, minimum 20 gauge.

3. Sections located upstream of supply fan: Construct for operation at minimum 4 inches wg (1 kPa) negative static pressure.
4. Sections located downstream of supply fan: Construct for operation at minimum 6 inches wg (1.5 kPa) positive static pressure.
5. Joints between casing sections: Seal with closed-cell foam gaskets, water- and air-tight, and providing thermal and acoustical break.

6. Access doors:

    a. Hinged, removable, designed as specified and as indicated on the drawings.
    b. Construction: Double wall, same as the unit casing.
    c. Gaskets: Automotive style neoprene, full perimeter, preventing air leakage.
    d. Latches: "Ventlock" style, noncorrosive alloy, operable from the inside and outside of unit. If access doors do not open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.

7. Insulation: Insulate casing sections, including access doors and structural framing, completely filling the space between interior and exterior walls. Insulation shall not be exposed to the airstream.
8. Drain pans: Sealed, double wall, constructed of minimum 18-gauge galvanized steel exterior and minimum 18-gauge stainless steel interior. Fill space between exterior and interior walls with insulation.

    a. Slope: Drain pans shall be sloped in 2 planes no less than 0.25 inch in one foot; cross break interior pans and pitch toward drain connections; ensure complete, positive condensate drainage.
    b. Cooling coils shall have drain pans under the entire coil module.
    c. Connections shall be to the side of the unit and shall enable proper trapping.

E. Coil module:

1. Heavy-duty coil tracks extending the full width of the unit shall hold slip-in coils. Where cooling coils are stacked, they shall have intermediate stainless-steel drain pans, with copper drop tubes at each end to drain condensate to the main drain pan without flooding the lower coil.
2. Coils: Cartridge type, meeting construction and testing standards of ANSI B9.1 Safety Code for Mechanical Refrigeration, performance in accordance with ARI 410. Coils shall be copper tubes with aluminum plate fins and nonferrous headers, no more than 144 fins per foot (305 mm). Fins shall include collars, belled and firmly bonded to the tubes by having the tubes mechanically expanded into the fins.
3. Water coils: Drainable, with nontrapping circuits and threaded connections for drainage and air venting as well as supply and return connections. Tube wall thickness shall not be less than 0.024 inch (0.6 mm).
4. Direct-expansion coils: Provide with pressure-type brass distributors with solder-type connections. Coils shall have a minimum of two distributors or the number required for capacity steps of condensing unit, and hot-gas injection connections upstream of the distributors.
5. Provide pipe enclosure with electric heater as shown on drawings.

F. Fan module: Fan, motor, and casing panels mounted on steel base. Fan scroll and bearings shall be mounted on an A or H frame structure rigidly secured to the base. Provide access doors on both sides of the module, large enough to permit removal of the fan wheel, motor, and drive.

1. Fan performance: Certified in accordance with ARI 430.

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2. Bearings: Self-aligning, pillow block, regreasable ball types selected for an average life of 200,000 hours at design operating conditions. Bearings shall be provided with grease line extending to the drive side of the fan. Shafts: Steel, turned, ground, and polished.
3. Fan wheels: Keyed to the shaft and designed for continuous operation at the maximum rated fan speed and motor horsepower. Fans and shafts shall be selected to operate 25 percent below the first critical speed. Fan wheels and shafts shall be statically and dynamically balanced as an assembly. Factory-test the entire unit after final assembly, for vibration. Wheels shall be double-width, double-inlet centrifugal type with backward-inclined airfoil blades unless otherwise noted in schedule. Finish: Zinc-molybdate primer and enamel finish coat.
4. Motors:

    a. Provide low-temperature brushless DC electronically commutated motor (ED-Motor) with external rotor and integrated electronic circuitry and electronic for all fans. The motor shall be manufactured with maintenance-free, long-time lubrication ball bearings and shall be statically and dynamically balanced in accordance with ISO 1940 Part 1. The motor shall be closed, protection level IP 54, thermal class 155 with permissible operating temperature of minus 13 degrees F to 140 degrees F. Motor efficiency class shall comply with IE4.
    b. Each fan motor (or fan array motors) shall be factory mounted and wired as a single point power panel with an external disconnect and motor starter protection for each fan, and a 100VA, 24 VAC transformer to provide power for field mounted controls. The panel shall be UL or ETL listed.
    c. Motor shall be capable of receiving a 0-10 VDC output signal for fan control, (1) digital output for fan array enable, and (1) digital input for alarm from the building automation system.

5. Drive package: Direct drive, variable pitch for below 30 hp, fixed pitch for 30 hp and above and selected with a service factor of 1.5 based on motor horsepower.

    a. Guards: Meet OSHA and MOSHA safety requirements.

6. Vibration isolation: Fan and motor assembly shall be mounted on minimum 16-gauge galvanized steel base and internally isolated from unit casing with spring isolators, furnished and installed by unit manufacturer. Spring isolators shall be 2-inch static deflection with thrust restraints. Fan scroll shall be attached to the unit casing by a flexible canvas duct.

G. Filter module:

1. Provide temporary throwaway filters for use until filters for regular use are installed.
2. Module shall include tracks for the types of filters indicated. Provide full-height access doors on both sides of module. Provide block-offs as required to prevent air bypass around filters. Provide combination filter/mixing box as scheduled on the drawings.

H. Damper modules:

1. Dampers: Airfoil design, galvanized steel, blades minimum 14 gauge and frames minimum 16 gage, opposed-blade action with metal compressible jamb seals and extruded

vinyl blade edge seals. Blades shall rotate on stainless steel sleeve bearings. Damper blade lengths shall not exceed 60 inches. Leakage rate shall not exceed 8 cfm per sq ft at one inch wg and 12 cfm per sq ft at 4 inches wg.

2. Outdoor air, return air, and exhaust air dampers internally mounted in mixing box filter/mixing box and economizer modules as scheduled on drawings.

I. Access module: Provide access modules as indicated or scheduled on the drawings. Locate access doors on both sides of module, full height and not less than 12 inches wide.

J. Airflow monitoring station: Provide a factory-mounted airflow monitor, ASHRAE Standard 62, and control station in the minimum outdoor air opening of the economizer module. The monitor shall track the variable outdoor air quantity for ventilation demand flow control and ventilation flow control documentation. The airflow monitoring station shall be factory mounted and calibrated and installed as recommended by the manufacturer.

1. The air-handling unit economizer module shall include a modulating outdoor air damper equal to Ruskin IAQ 50, mounted in series with the airflow monitor.
2. Provide linkages, crank arms, jack shafts, and mounting hardware.
3. Airflow monitoring station shall be calibrated to measure the variable airflow from 10 percent of nominal airflow (air handler cfm) to 100 percent design flow, maintaining an accuracy of plus or minus 5 percent of actual cfm, for air measuring between minus 40 degrees F to plus 158 degrees F. The station shall compensate for outdoor air temperature fluctuations that affect mass flow rate of air.

K. Provide electric strip heater within mixing box or economizer module, as scheduled on the drawings.

2.35 INDIRECTLY FIRED GAS FURNACE

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces;" and NFPA 54, "National Fuel Gas Code."

1. AGA approval: Designed and certified by and bearing label of AGA.
2. Burners: Stainless-steel

a. Gas control valve: Modulating 18:1 turndown ratio.
b. Fuel: Natural gas.
c. Minimum thermal efficiency: 80 percent
d. Ignition: Electronically controlled electric spark with flame sensor.

B. Pilot: Electrically ignited by spark rod through high-voltage-ignition transformer.

C. Power vent: Integral, motorized centrifugal fan interlocked with gas valve.

D. Heat exchanger: Series 300 stainless-steel primary drum and 400 series stainless-steel tubes.

E. Heat-exchanger drain pan: Stainless steel.

F. Safety controls:

1. Vent flow verification: Differential pressure switch to verify open vent.
2. Control transformer: 24-V ac.
3. High limit: Thermal switch or fuse to stop burner.
4. Gas train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
6. Gas manifold: Safety switches and controls to comply with ANSI standards and FMG and GE GAP/CSD-1.
7. Airflow proving switch: Differential pressure switch senses correct airflow before energizing pilot.
8. Automatic-reset, high-limit control device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
9. Safety lockout switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.80 FABRICATION AND ASSEMBLY

A. Factory assemble AHUs in accordance with the arrangement shown on the drawings. Units shall be assembled into the largest sections possible subject to shipping and rigging restrictions. On units not shipped fully assembled, the manufacturer shall tag each section and indicate air flow direction to facilitate assembly at the jobsite. Provide lifting lugs or shipping skids for each section to allow for field rigging and final placement of unit. The AHU manufacturer shall provide the necessary materials authorized for assembly.

PART 3 - EXECUTION

3.01 ACCEPTABLE INSTALLER

A. The manufacturer shall provide a local representative at the job site to supervise the assembly and to assure the units are assembled to meet manufacturer’s recommendations and requirements indicated on the drawings.

3.20 INSTALLATION

A. Assemble and set air-handling units in place as shown on drawings. Provide necessary additional structural members for support from above or below.

B. Provide duct and piping connections to units in a manner which allows access to removable panels. Piping assemblies shall be arranged to provide full clearance in front of access doors.

C. Provide connection flanges for ductwork to unit casing in a manner which maintains the structural integrity of the unit and does not interfere with removability of adjacent casing panels.

D. Install dielectric pipe nipples at water coil connections where dissimilar metals are joined.

E. Install throwaway filter provided with unit prior to energizing the unit supply fan.

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F. Prior to air balancing, remove throwaway filter and install new MERV 8 and MERV 13 disposable filter as specified in Section 23 41 00.

G. Coordinate with air balancing and provide the proper drive and belts or fan speed to obtain the airflow and static pressure indicated on the drawings.

1. ATC Contractor shall assist with obtaining required fan speed setting during testing and balancing.

H. Install gas-fired units according to NFPA 54, National Fuel Gas Code.

I. Install roof-mounted units on curbs complying with requirements in Section 23 05 06.

J. Gas piping: Comply with applicable requirements in Division 23 section for gas piping. Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Provide AGA-approved flexible connectors.

3.80 SYSTEM STARTUP

A. Engage a factory-authorized service representative to perform startup service, per manufacturer's recommendations.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

B. Provide at least 4 hours of additional instruction time for the equipment specified in this section.

END OF SECTION

SECTION 23 74 13 - PACKAGED ROOFTOP AIR-CONDITIONING UNITS (BID ALTERNATE)

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Institutional rooftop air-conditioning and heating units.

1.14 RELATED SECTIONS

A. Refrigeration service, warranty, and maintenance: Section 23 01 00.

B. Curbs and flashings: Section 23 05 06.

C. Sound deadening at roof: Section 23 05 06.

D. Motors: Section 23 05 13.

E. Filters: Section 23 41 00.

1.27 PERFORMANCE REQUIREMENTS

A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under the article "Acceptable Manufacturers" below, ascertain that it will:

1. Perform to the scheduled and specified capacities.
2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
3. Meet or exceed all specified requirements.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings: Each type of rooftop unit included in the work.

1. Wiring diagrams: Power, signal, and control wiring.

C. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit on the existing curb and duct connections, and weigh the same as the existing unit.

1. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit.
2. Include shop drawings and product data sufficient to show conformance to the article "Performance Requirements" above.

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D. Shop drawings shall show complete dimensions of complete assembled unit with accessories. Include all details necessary for framing supports and openings in roof structure and deck.

E. Submit fan curves for each air-handling unit, with operating points indicated.

1. If required in accordance with the article "Quality Assurance" below, submit test results showing the effect on unit capacities.

F. Product data:

1. Rooftop unit and accessories.
2. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
3. Product data shall verify compliance with CEE efficiency requirements.

1.40 QUALITY ASSURANCE

A. Power factor correction shall be factory-installed as required in Section 23 05 13, Common Motor Requirements for HVAC Equipment.

B. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

C. Make fan selections to the right of the peak static pressure point and not on any flat portion of the fan curve. Generally, fan selection shall be in the 50 to 80 percent range of wide open volume.

1. If it should be necessary to provide fan wheels not described in the manufacturer's standard catalog, factory test the air-handling unit to determine the effect on capacities.

D. Regulatory requirements:

1. ICC: HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.
2. COMAR 14.26.03: Packaged equipment with over 20 tons of cooling capacity shall meet Tier 2 requirements for minimum efficiencies for unitary commercial air conditioners of the Consortium for Energy Efficiency (CEE), in effect on 1 January 2002.
3. EPA: Refrigerant: R-410a.

1.50 DELIVERY, STORAGE, AND HANDLING

A. Units shall be shipped fully charged with refrigerant.

B. Units that have remote condensing units shall be shipped with holding charge in condensing unit and evaporator.

1.71 COORDINATION

A. Coordinate installation on existing roof curb, and roof penetrations.

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PART 2 - PRODUCTS

2.30 EQUIPMENT

A. General: Units shall have vertical air flow off the air-cooled condenser.

2.31 INSTITUTIONAL ROOFTOP UNITS

A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled unit, or comparable product by one of the following:

1. Aaon, Incorporated

B. Performance:

1. Meet scheduled performance requirements and comply with regulatory requirements for efficiency.
2. Do not propose or provide units modified to meet the capacity by providing oversized refrigeration equipment with fewer rows of coil than scheduled, which cannot meet the scheduled efficiency and sensible latent heat ratio.

C. Unit shall consist of the sections to complete the unit with accessories. Capacity and current characteristics shall be as scheduled on the drawings.

D. Unit shall be completely factory-assembled, -piped, -wired, and -tested, and shipped in one piece.

1. Units shall be completely factory-assembled with all accessories and sections as indicated on the drawings.
2. Units shall be specifically designed for outdoor rooftop application and shall include a weatherproof cabinet constructed so that rainwater will not stand on top nor collect at any point on the unit.
3. Provide gasketed, hinged doors or panels removable using simple hand tools for access to all parts of the unit requiring service.
4. All sections exposed to return air, mixed air, and supply air shall be insulated with fiberglass of sufficient thickness to prevent condensation during summer operation and which meets NFPA 90A flame-spread and smoke-generation requirements. Insulation shall be enclosed in double-wall construction.
5. Cabinet framing and supports shall be of sufficient rigidity for handling without spreader bars.

E. Cabinet, casing, and frame construction:

1. Unit shall be constructed of steel, hot-dip galvanized after fabrication, or with manufacturer's standard painted finish.
2. Hail guards of galvanized steel, painted to match casing.
3. Decals and tags shall indicate caution areas and aid unit service.
4. Electrical wiring diagrams shall be attached to control panels.
5. Installation and maintenance bulletins shall be supplied with each unit.

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F. Curb: Existing to remain.

G. Compressor: Scroll type, directly driven, 360 rpm, with isolated mounting, integral suction accumulation, centrifugal oil pump, oil filter screen, oil-level sight glass, oil-changing valve, crankcase heater and well, suction inlet screen, suction and discharge valves. Provide suction-gas-cooled motor with voltage utilization range plus or minus 10 percent of nameplate voltages. Two thermostats imbedded between the motor windings shall protect against excessive temperatures. Safety controls shall include high- and low-pressure cutouts, and reset relay.

H. Evaporator coil: Seamless copper tubing of 0.5-inch OD, mechanically bonded to heavy-duty aluminum fins of manufacturer's standard configuration. Dual circuited coils with independent thermal expansion valves. Factory pressure- and leak-tested at 300 psi.

1. Drain pan: In evaporator section, internally sealed and insulated with copper drain connections.

a. Stainless-steel construction.
b. Slope to drain in two directions, minimum 0.25 inch in one foot, to 0.75-inch drain connection.
c. Provide access for cleaning.

I. Condenser coil: Aluminum fin in manufacturer's standard configuration, secondary surface mechanically bonded to primary surface of 3/8-inch OD seamless copper tubing. Sub cooling circuit(s) with liquid accumulator(s) standard. Factory-tested at 450 psig air pressure.

J. Unit shall be provided with factory-installed means of disconnect in compliance with NEC and local codes. In the event a factory-installed disconnect is not available as an option, an approved means of disconnect shall be provided for field mounting.

K. Condenser fans and motors: Vertical-discharge, direct-drive fans, statically and dynamically balanced, with steel blades and zinc-plated steel hubs. Three-phase motors with permanently lubricated ball bearings, built-in current and thermal-overload protection, and weathertight slingers over bearings. Horizontal discharge units not permitted.

L. Supply fan: Two, double-inlet, forward-curved fans mounted on common shaft with adjustable-sheave drive. All fans statically and dynamically balanced and tested in factory. Run supply fan in unit as part of unit test. Unit shall reach rated rpm before fan shaft passes through first critical speed. Fan shaft mounted on two grease-lubricated ball bearings designed for 200,000 hours average life. Extended grease lines allow greasing of bearings through the filter access door. Fan motor and fan assembly mounted on common base to allow consistent belt tension with no relative motion between fan and motor shafts. Entire assembly completely isolated from unit and fan board by double-deflection, rubber shear isolators on motor sizes larger than five hp. Variable volume units shall be provided with variable frequency drives (VFD).

M. Filters: Provide filter racks for 2-inch deep MERV 8 pre-filters and 4-inch deep MERV 11 final filters. Provide full height hinged access panels.

1. Provide filters as specified in Section 23 41 00.

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N. Motor and variable frequency drive: Motors provided on supply and exhaust fans shall be energy efficient as specified in Section 23 05 13, Common Motor Requirements for HVAC Equipment. Variable frequency drives and accessories shall be as specified in Section 26 29 23, Variable Frequency Drives.

O. Return air: Provide return air setup as indicated on drawings.

1. Modulating 100 percent exhaust return fan: Two, double-inlet, forward-curved fans mounted on common shaft with adjustable sheave drive. All fans statically and dynamically balanced and tested in factory. Exhaust fan test run in unit as part of unit test. Unit reaches rated rpm before fan shaft passes through first critical speed. Fan shaft mounted on two grease-lubricated ball bearings designed for 200,000-hour average life. Extended grease lines allow greasing of bearings from unit filter section. Fan motor and assembly mounted on common base to allow consistent belt tension with no relative motion between fan and motor shafts. Entire assembly completely isolated from unit and fan board by double-deflection, rubber-in-shear isolators. VFD shall modulate in response to both outdoor air dampers position and supply fan VFD speed on VAV units. Units with return air fan, VFD, and return air, fresh (outdoor) air, and exhaust air motorized modulating dampers are acceptable.

P. Outdoor air: Provide outdoor-air setup as indicated on drawings.

1. Economizer cycle: Operated through the primary temperature controls to automatically use outdoor air for cooling.

a. Automatically modulated return and outdoor air dampers maintain proper temperature into the conditioned space.
b. Automatic lockout operates when the outdoor enthalpy temperature is too high for proper cooling.
c. Adjustable minimum-position control located on the damper motor.
d. Spring return motor ensures closure of outdoor air dampers during unit shutdown or power interruption.
e. Mechanical cooling available to aid the economizer cycle at any ambient temperature.
f. Mixed-air low limit begins modulating dampers closed at discharge temperature of 62 degrees F. Minimum damper position shall be reached at 50 degrees F discharge temperature.
g. Ultra-low-leak economizer dampers shall have a leakage rate of no more than one percent based on testing data completed in accordance with AMCA 575 at AMCA Laboratories.

Q. Gas-fired heating: Completely assembled and wired gas-fired heating system integral with unit, UL and GSA approved specifically for outdoor applications downstream from refrigerant cooling coils, fire-tested prior to shipment. Provide threaded connection with plug, and gas supply through side or bottom of unit.

1. Heat exchanger: Tubular two-pass design with stainless-steel 16-gauge primary and 18-gauge secondary heat exchanger surfaces, factory pressure- and leak-tested. Design shall prevent stress from expansion, contraction, and associated noise. Provide gasketed cleanout plate for cleaning tubes and turbulators, if required.

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2. Burner: Modulating industrial-type with air-proving switch which prevents operation if burner is open for maintenance or inspection, minimum turndown ratio 15:1, equal to Eclipse "Ratiomatic" RM 100.

    a. Remote indicating and modulating electronic controller for control of discharge air temperature, equal to Honeywell R7380L.

3. Combustion blower: Centrifugal-type fan provides air for combustion; fan motor has built-in thermal-overload protection.
4. Units over 400 MBH shall have GE GAP/CSD-1 gas trains.

R. Gas-fired heating controls: Manufacturer's packaged controls complying with the unit's UL and GSA listings and compatible with the sequence of operation indicated on the drawings.

S. Provide a 115-V convenience outlet with its transformer connected to the line side of the power supply, sized to handle a small power load or service light.

2.32 SYSTEM CONTROLS

A. System of field-installed direct digital temperature controls with electronic actuation: Control sequences of operation are indicated on contract drawings.

B. For units with DX cooling, unit manufacturer shall provide controls for refrigeration cycle and refrigeration safeties. Refrigeration controls shall be suitable for use with digital scroll type compressors. Refrigeration controls shall be provided with BACnet protocol for monitoring through the building automation system.

2.33 CONTROL SYSTEM (VARIABLE VOLUME)

A. System consists of single-zone variable-volume heating and cooling rooftop unit complete with return fan. Each zone has its own normally open variable-volume air terminal. Controls for variable-volume air terminals are provided with unit or as specified for automatic temperature control system (ATC). Rooftop unit provided with following factory-provided features:

1. OA damper
2. RA damper
3. EA damper
4. Return-air fan
5. Heating, cooling, safety, and operating controls
6. Hot-gas bypass control
7. Supply-air low-limit control
8. Control power transformer
9. Terminal contacts for ATC use
10. Freeze detector

B. ATC shall provide the following:

1. Provide all field-wiring and -mounting of all control instruments as required by manufacturer and control sequence indicated on contract drawings.

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2. Provide emergency fan shutdown switch, mount and wire into unit.
3. All appurtenances required by the sequence and not factory-provided.

PART 3 - EXECUTION

3.11 SPECIAL REQUIREMENTS

A. Provide refrigeration and heating equipment startup and service by a factory-authorized agent during the correction period as specified in Section 23 01 00.

3.20 INSTALLATION

A. Securely attach curb to roof construction as specified in Section 23 05 06, Curbs and Flashings for HVAC Piping and Equipment.

B. Coordinate with air balancing to provide the proper drive and belts for fan speed to obtain the airflow and static pressure indicated on the drawings.

3.21 SOUND DEADENING FOR ROOFTOP AIR CONDITIONING EQUIPMENT

A. Install sound deadening materials as specified in Section 23 05 06, Curbs and Flashings for HVAC Piping and Equipment.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

B. Provide at least four hours of additional instruction time for the equipment specified in this section.

END OF SECTION

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SECTION 23 81 27 - DUCTLESS SPLIT-SYSTEM UNITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Ductless split system with interior and exterior units and refrigerant piping.

B. Air-conditioning units.

C. Heat pump units.

1.14 RELATED SECTIONS

A. Motors: Section 23 05 13.

B. Piping: Section 23 23 00.

C. Refrigeration service and compressor warranty: Section 23 01 00.

D. Filters: Section 23 41 00.

E. Controls: Sections 23 09 01 through 23 09 23.

F. Commissioning requirements: Divisions 01 and 23.

1.20 REFERENCES

A. ASHRAE 15: Safety Code for Mechanical Refrigeration.

B. ASHRAE 90.1: Energy Efficient Design of New Buildings Except Low-rise Residential Buildings.

1.27 PERFORMANCE REQUIREMENTS

A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under the article “Acceptable Manufacturers” below, ascertain that it will:

1. Perform to the scheduled and specified capacities.
2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
3. Meet or exceed all specified requirements.
4. Electrical power connections for the basis-of-design unit require the indoor unit to be wired through the outdoor unit. Other manufacturers may require separate power connections, which the contractor shall provide as required.

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1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Shop drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring diagrams: For power, signal, and control systems, differentiating between factory- and field-installed wiring.

C. Product data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model.

1. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
2. Submit precharged tubing description.

D. Samples: Color chips, showing manufacturer's complete line of finishes.

1.40 QUALITY ASSURANCE

A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

B. Fabricate and label refrigeration components to comply with ASHRAE 15.

C. Energy efficiency ratio and coefficient of performance: Equal to or greater than prescribed by ASHRAE 90.1.

1.81 SPECIAL WARRANTY

A. Besides general project warranty, provide manufacturer's five-year extended warranty for replacing compressors, for each system, executed to the Owner.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

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C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled Mitsubishi Electric Corporation P Series unit, or comparable product by one of the following:

1. Daikin AC
2. Mitsubishi Electric Corporation (P-Series units only)
3. Sanyo Air Conditioning Products

2.11 MATERIALS

A. Refrigerant: HFC 410a.

B. Refrigerant pipe: Precharged Type L soft drawn, preinsulated seamless copper tubing, ASTM B 280. Length: As short as possible.

2.30 UNITS, GENERAL

A. Each unit shall be provided with factory-installed means of disconnect in compliance with NEC (NFPA 70) and local codes. In the event a factory-installed disconnect is not available, provide an approved means of disconnect for field mounting.

B. Heat pump units: Include changeover valves and defrost controls. When heat is called for, the changeover valve reverses the refrigerant flow, the interior coil operates as a condenser, heat is circulated into the room, and the outdoor coil operates as an evaporator.

C. Air-conditioning units: Interior unit is an air conditioner and the outdoor coil is a condenser.

2.31 INTERIOR UNIT

A. Frames: Steel angles or aluminum extrusions, welded construction.

B. Panels:

1. Insulated with 0.5-inch (13-mm) thick, 2 lbs per cubic foot (32 kg per cubic meter) density glass fiber insulation, with an R value no less than 15.

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2. Fasteners: Concealed, captive, easily operated for access without tools.
3. Exterior finish: Manufacturer's standard baked enamel.

C. Grilles: Each one-piece construction, aluminum, brushed finish, with foam gasket providing airtight seal between grille and cabinet. Supply grille adjustable in three directions. Return air grille hinged for access to filter.

D. Drain pan: Insulated steel or plastic, with connections to exterior of cabinet.

1. Slope to drain in two directions, minimum 0.25 inch in 1 foot, to 0.75-inch drain connection.
2. Provide access for cleaning.

E. Cooling coil: Aluminum fins extruded on to copper tubing with quick connections to precharged tubing. Pressure tested at 1.5 times working pressure. Provide expansion device.

F. Fan: Centrifugal type with direct-connected controlled-speed motor mounted on vibration isolators.

G. Filter: Throwaway type.

2.34 EXTERIOR UNIT

A. Unit shall be factory-assembled and -tested, of capacity and current characteristics indicated on the drawings. Unit shall be packaged type. Cabinet: weatherproof construction, steel, with baked enamel finish.

B. Refrigeration circuit: Completely pre-piped, equipped with refrigerant; access valves in suction and liquid lines; filter dryer, sight glass, and pressure fittings for charging and evacuation.

C. Compressors: Welded shell; reciprocating hermetic, rotary screw or scroll type; high efficiency.

D. Condenser coil: Constructed of copper tube and aluminum fins, factory leak-tested at 1.5 times working pressure, dehydrated, and provided with full charge of refrigerant. Provide subcooler and accumulator.

1. Low ambient control: Include head pressure control, designed to operate at temperatures down to 0 degrees F (minus 18 degrees C).

E. Fans: Propeller, direct drive, dynamically balanced, speed-controlled motor.

2.35 CONTROLS

A. Wall-mounted hard-wired controls shall incorporate the following features:

1. Operation mode setting (Heat, Auto, Cool)
2. Temperature setting: The LCD indicator displays the set temperature in units of 2 degrees F.
3. Room temperature (intake air) display

4. 24-hour on/off timer: Operation can be set to start or stop after a specified time in 1-hour increments from 1 to 24. The remaining time is indicated on the LCD display.
5. Fan speed indicator: Displays the fan speed setting (high or low).
6. Vane control: The angle of the air outlet vanes can be adjusted to one of four positions by pressing the air discharge Up/Down button.
7. Auto air swing vanes: The air outlet vanes swing up and down for uniform air distribution.
8. Self-diagnostic display: When unit stops, the display indicates where the trouble is located.
9. Memory feature for storing instructions

PART 3 - EXECUTION

3.20 INSTALLATION

A. Assemble and set each unit in place in accordance with the manufacturer's instructions, plumb and level, firmly anchored, and maintaining manufacturer's recommended clearances.

B. Connect piping as shown on the drawings and in accordance with manufacturer's instructions.

C. Test each drain pan and ensure that installed slope is as specified and pan drains completely.

D. Install filter provided with unit prior to energizing the unit supply fan.

E. Prior to final acceptance, remove throwaway filter and install new filter as specified in Section 23 41 00.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

END OF SECTION

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SECTION 23 81 28 - VARIABLE-REFRIGERANT-VOLUME MULTIZONE SYSTEM

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Heat recovery type, variable-refrigerant-volume (VRV) system: Distributes refrigerant from the exterior unit to the indoor units to provide simultaneous heating and cooling.

1. Exterior unit: Air cooled.
2. Indoor units: Combination of ceiling mounted cassette type, console units, or fan-coil units.

1.14 RELATED SECTIONS

A. Motors: Section 23 05 13.

B. Piping: Section 23 23 00.

C. Refrigeration service and compressor warranty: Section 23 01 00.

D. Filters: Section 23 41 00.

E. Controls: Sections 23 09 01 through 23 09 23.

F. Commissioning requirements: Divisions 01 and 23.

1.20 REFERENCES

A. ASHRAE 15: Safety Code for Mechanical Refrigeration.

B. ASHRAE 90.1: Energy Efficient Design of New Buildings Except Low-rise Residential Buildings.

1.27 PERFORMANCE REQUIREMENTS

A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under the article “Acceptable Manufacturers” below, ascertain that it will:

1. Perform to the scheduled and specified capacities.
2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
3. Meet or exceed all specified requirements.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

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B. Shop drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring diagrams: For power, signal, and control systems, differentiating between factory- and field-installed wiring.

C. Product data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model.

1. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
2. Submit precharged tubing description.

D. Samples: Color chips, showing manufacturer's complete line of finishes.

1.40 QUALITY ASSURANCE

A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

B. Fabricate and label refrigeration components to comply with ASHRAE 15.

C. Energy efficiency ratio and coefficient of performance: Equal to or greater than prescribed by ASHRAE 90.1.

1.81 SPECIAL WARRANTY

A. Besides general project warranty, provide manufacturer's five-year extended warranty for replacing compressors, for each system, executed to the Owner.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and

participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

1.91 EXTRA MATERIALS

A. Furnish one additional washable filter for each indoor variable refrigerant terminal.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide the specified Mitsubishi Electric Corporation product, or comparable product by LG Corporation.

2.11 MATERIALS

A. Refrigerant: HFC-410a.

B. Refrigerant pipe: Refer to Section 23 23 00, Refrigerant Piping.

2.20 UNITS, GENERAL

A. Each unit shall be provided with factory-installed means of disconnect in compliance with NEC (NFPA 70) and local codes. In the event a factory-installed disconnect is not available, provide an approved means of disconnect for field mounting.

2.21 INTERIOR VARIABLE REFRIGERANT TERMINALS AND BRANCH CONTROLLERS

A. Ceiling-mounted and wall-mounted cassette fan-coil unit with R-410A refrigerant; equipped with an electronic expansion valve; ceiling cavity type installation with an air panel grille; and capacity as scheduled.

1. Factory assembled to include:

a. Expansion valve.
b. Control circuit board.
c. Fan motor thermal protector.
d. Condensate drain pan.
e. Condensate drain pump.
f. Auto-restart function.
g. Fused time delay.
h. Test run switch.
i. Return air thermistor.

2. Cabinet: Constructed with sound absorbing foamed polystyrene and polyethylene insulation.
3. Fan: Direct drive type with high and low fan speeds.
4. Coil: Copper tubes expanded into aluminum fins to form a mechanical bond.
5. Supply air: 4-way airflow with capability to change to 3-way and 2-way airflow to accommodate various field installations as described on the drawings.
6. Return air: Flow through the concentric panel to include a washable filter as described on the drawings.
7. Shipping: Indoor unit and refrigerant pipes shall be charged with dehydrated air prior to shipment from the factory.

B. Provide branch controller units for variable-refrigerant terminals to allow independent heating and cooling operation.

1. Provide shut-off valve at each refrigerant piping connection to branch controller unit.

2.22 EXTERIOR UNIT

A. Condensing unit: Modular design to allow side-by-side installation with minimum spacing. Factory assembled and pre-wired with all the necessary electronic and refrigerant controls.

1. Safety devices shall include:

a. High pressure switch.
b. Control circuit fuses.
c. Crankcase heater.
d. Fusible plug.
e. Overload relay.
f. Inverter overload protector.
g. Thermal protector (overload) for compressor motor.
h. Over current protection for the inverter.
i. Anti-recycling timer.

2. Cabinet: Corrosion resistant, constructed from rust-proofed, mild steel panels coated with a baked enamel finish.
3. Compressor: Variable speed controlled scroll type compressor(s), capable of changing speeds with variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit.
4. Heat exchanger: Stainless-steel brazed plate type.
5. Features:

a. Automatic oil recovery cycle.
b. Automatically restart operation after a power failure without losing programmed settings.
c. Subcooling feature in circuit: Ensure the liquid refrigerant does not flash when it is being supplied to the various indoor units.

2.23 CONTROLS

A. The entire system shall be provided with all required controls and shall be designed and installed by the equipment manufacturer.

1. Operating temperature setpoints shall be factory- or field-programmed in accordance with the requirements indicated on Drawing M-7.1.
2. Coordinate system interface (including room occupancy sensors) requirements and general system enable/disable parameters with the approved automatic temperature control system manufacturer.

B. Each indoor unit shall be provided with a wall-mounted remote controller provided by the unit manufacturer. Controller shall be provided with an LCD display for local adjustment and hard-wired to the associated indoor unit. Controller shall support limited space temperature setpoint adjustment, occupancy sensor interface, provide fan on/off control, display alarm conditions, and permit automatic changeover of heating or cooling operation depending on room setpoint. Room temperature shall be sensed directly at the unit controller and not through the indoor unit's return air path.

C. Provide a centralized system controller for each system for operation of all indoor and outdoor units associated with the system. System controller shall be provided with an LCD display and located at the main second floor mechanical room. Provide hardware contacts for interface with the DDC system for enabling and disabling system operation, as described on the ATC drawings. Include manufacturer's service tool for accessing, diagnosing, and troubleshooting.

2.24 ACCESSORIES

1. High efficiency air filters: 65 percent.
2. High efficiency air filters: 90 percent.
3. Filter rack for high efficiency filters.
4. Fresh air intake and supply air duct connections.
5. Provide remote "in-room" sensor kit as described on the drawings.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Assemble and set each unit in place in accordance with the manufacturer's instructions, plumb and level, firmly anchored, and maintaining manufacturer's recommended clearances.

B. Connect piping as shown on the drawings and in accordance with manufacturer's instructions.

C. Test each drain pan and ensure that installed slope is as specified and pan drains completely.

D. Install filter provided with unit prior to energizing the unit supply fan.

E. Prior to final acceptance, remove throwaway filter and install new filter as specified in Section 23 41 00.

3.81 OPERATING INSTRUCTIONS

A. Coordinate instruction period with requirements of Section 23 05 00. Submit training itinerary to Commissioning Agent at a minimum of two-weeks prior to training.

B. Training shall be held at the HCPSS services facility in Columbia, Maryland during normal work hours (7:30 a.m. to 4:00 p.m. weekdays). As a minimum, two days of classroom training shall be provided. Provide competent instructors to give full instruction to designated personnel in the adjustment, operation, and maintenance of the system installed, rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are trying to teach. Training details (location of training, number of days, number of courses, number of people, type of training, etc.) shall be coordinated with HCPSS. This training is in addition to and should not be confused with the onsite demonstration, instruction time, and/or functional testing.

C. Provide four 4-hour days of instruction time for Owner's operating personnel. Coordinate with the Building Services Manager through the Owner or Construction Manager for time and location. Training shall include:

1. Explanation of drawings, operations, and maintenance manuals.
2. Walk-through of the job to locate control components.
3. Control components, including set-up and adjustment procedures.
4. Explanation of adjustment, calibration, and replacement procedures.

D. Provide 4 hours of additional instruction time quarterly for a period of one year from final completion of the project.

E. The Owner may require personnel to have more comprehensive understanding of the hardware and software. Additional training shall be available from the installer, after completion of the work of the project. Provide description of available local and factory customer training.

END OF SECTION

SECTION 23 82 19 - FAN-COIL UNITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Fan-coil units with water coils for heating and cooling.

1.14 RELATED SECTIONS

A. Motors: Section 23 05 13.

B. Commissioning requirements: Divisions 01 and 23.

1.20 REFERENCES

A. ARI 350: Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment.

B. ARI 410: Forced-Circulation Air-Cooling and Air-Heating Coils.

C. ARI 440: Room Fan-Coil Air-Conditioners.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit.

C. Shop drawings shall show complete dimensions of complete assembled unit with accessories.

D. Product data: Fan-coil units.

E. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

F. Samples: For selection, manufacturer's complete line of colors and textures.

G. Wiring diagrams: For power, signal, and control systems, differentiating between factory- and field-installed wiring.

1.40 QUALITY ASSURANCE

A. Unit capacity shall be certified in compliance with ARI 440.

B. Unit shall be tested and sound rated in accordance with ARI 350.

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C. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

D. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

1.50 DELIVERY, STORAGE, AND HANDLING

A. Ship units with piping capped to prevent entry of foreign matter.

B. Keep each unit in its carton until installation.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide specified International Environmental units, or comparable units by one of the following:

1. Carrier Corp., Model 42DC
2. International Environmental (IEC), Model HPY
3. Rittling, Model FDHP

2.20 FAN-COIL UNITS BASIC REQUIREMENTS

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A. Units shall be type, size, configuration, capacity and current characteristics indicated on the drawings.

B. Provide each unit with factory-installed means of disconnect in compliance with NFPA 70 (NEC) and applicable local codes. In the event a factory installed disconnect is not available, provide an approved means of disconnect for field mounting.

C. Exposed parts of cabinet shall be fabricated of 18-gauge (1.37-mm-thick) galvanized steel.

1. Finish:

a. Applied to factory-assembled and -tested unit before shipping.
b. Bonderize, phosphatize, and coat with baked-on primer with manufacturer's standard enamel.

D. Coils as scheduled on drawings.

1. Chilled and heating water coils: Aluminum fins with copper tubes bonded by mechanical expansion, rated for 350 psig (2415 kPa) minimum air pressure and suitable for working pressures up to 250 psig (1725 kPa). Include automatic air vent. Coil performance: as tabulated in the schedule.

E. Drain pan: For each coil, insulated, no unprotected metal part in contact with water, minimum slope 0.25 inch per foot (20 mm per meter) in two directions, to NPS 0.75 (DN 20) drain connection. See specifications below for additional drain pan requirements.

F. Fan assembly:

1. Fans: DWDI forward curved, centrifugal type, directly driven unless otherwise indicated.
2. Housing: Galvanized steel, two-piece construction with removable front half for complete access to fans.

G. Motors: Units shall have sleeve bearing motors with oilers, inherent thermal overload protection with automatic reset, and resilient mounts.

1. Provide electronically commutated (EC) type fan motors complying with requirements of Section 23 05 13.

H. Speed controller: Units shall have an internal unit-mounted and concealed three-speed and off switch, or an internal unit-mounted and concealed solid-state variable-speed controller with integral On-Off switch which provides uniform unlimited fan speed from high to low. It shall include a voltage compensating circuit and RFI filter circuit.

I. Cabinet insulation: Provide one type, at least 0.5 inch (13 mm) thick, R value no less than 2.2 (3.8):

1. Glass fiber with foil face: ASTM C 665 and UL 181, with edges exposed to airstream sealed.

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2. Elastomeric with erosion-proof face: Closed-cell, exposed faces and edges high density suitable for use in airstreams up to 4500 fpm (22.8 m/s).

2.24 HORIZONTAL UNITS

A. Units meeting the basic requirements specified above and the additional requirements for horizontal configuration.

B. Equal to International Environmental Corporation model HPY for concealed configuration.

C. Condensate drain pan fabricated of 18-gauge (1.3-mm) galvanized steel, with removable pan extensions at the coil header end of the unit.

D. Cabinet panels, enclosure, and plenum shall be insulated.

1. Provide neoprene grommets at all support points for vibration isolation.

E. Bottom panel: Removable.

F. Grilles:

1. Outlet: Double deflection type on exposed unit.
2. Inlet: Where exposed, stamp grille in bottom access panel.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Place unit in position and make sure that it is level. Leveling is critical to ensure proper drainage and operation.

B. Install unit in accordance with the drawings and the manufacturer’s instructions.

C. Provide dielectric pipe nipples at water-coil connections where dissimilar metals are joined.

D. Coordinate with air balancing to provide the proper drive and belts or adjust fan speed to obtain the air flow and static pressure indicated on the drawings.

E. Provide flexible ductwork connections at inlet and outlet of all horizontal fan-coil units.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

B. Provide at least 2 hours of additional instruction time for the equipment specified in this section.

END OF SECTION

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SECTION 23 82 33 - CONVECTORS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Heating water convectors.

1.14 RELATED SECTIONS

A. Piping: Section 23 21 13.

B. Controls: Sections 23 09 01 through 23 09 23.

C. Commissioning requirements: Divisions 01 and 23.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Convectors.

C. Samples: Manufacturer’s complete line of color chips.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

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PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide scheduled Airtherm units, or comparable product by one of the following:

1. Airtherm
2. Dunham-Bush, Inc.
3. Rittling
4. Sterling
5. Trane Company.
6. Vulcan Radiator Corporation.

2.31 CONVECTORS

A. Convectors shall be surface type as indicated on drawings.

B. Cabinets for surface-mounted convectors shall be institutional type constructed of 14-gage steel fronts and tops, 16-gage sides and 18-gage backs with sloping tops and open bottoms. Front and top shall be constructed with the front panel separate and secured with tamperproof flush screws.

C. Heating elements shall be suitable for use with a heating water system. They shall consist of 0.5-inch (13-mm) outside diameter round seamless copper tubes, aluminum fins, and 1.25-inch (32-mm) seamless steel headers. Fins shall have flanged collars to space them equally and to provide maximum and permanent contact with the tubes. Tubes shall be hydraulically expanded into the fin collars and brazed to the header with silver solder. The fin and tube assembly shall be encased in a steel frame with intermediate stiffeners. Standard connections shall be top and bottom in one header and top or bottom in the opposite header. Heating elements shall be tested at 250 psi hydrostatic pressure.

D. Dampers shall be knob type, screw operated for face outlet convectors, and butterfly for sloping top convectors. The knob or key hole shall be located in the top grille of face outlet convectors; on the right hand end of sloping top convectors.

E. Access doors shall be flush mounted and have slotted head latches. Access door openings shall be reinforced with angle stiffeners. The doors shall be louvered when installed in the inlet or outlet grille.

F. Convectors where indicated shall have four-inch end pocket as part of cabinet for use as valve compartment. Provide cam lock access door.

G. Convectors shall be factory-finished in manufacturer’s standard enamel, color to be selected.

H. Panels shall be sealed with polyurethane gaskets to prevent air leakage.

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PART 3 - EXECUTION

3.20 INSTALLATION

A. Coordinate with other trades to assure that recess sizes are correct.

B. Securely anchor convectors in locations shown. Snugly fit cabinet and trim. Piping connections shall be concealed.

C. Provide partially recessed or recessed units mounted on exterior walls with 0.5-inch-thick insulation board behind units.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00 provide operating instructions.

B. Provide at least 2 hours of additional instruction time for the equipment specified in this section.

END OF SECTION

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SECTION 23 82 36 - FINNED-TUBE RADIATION HEATERS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Finned tube radiation.

1.14 RELATED SECTIONS

A. Piping: Section 23 21 13.

B. Controls: Section 23 09 01 through 23 09 23.

C. Commissioning requirements: Divisions 01 and 23.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Finned tube radiation.

C. Samples: Color chips for finish selection, manufacturer's complete line of colors and textures.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

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PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide scheduled and specified units, or comparable product by one of the following:

1. Dunham-Bush, Inc.
2. Mark II
3. Modine
4. Rittling
5. Shaw-Perkins
6. Slant-Fin Corporation
7. Sterling
8. Ted Reed Thermal, Inc.
9. Trane Company
10. Vulcan Radiator Corporation

2.30 GENERAL REQUIREMENTS

A. Provide access sections for control valve, shutoff valve, and balancing valve for each independent length of heating element, and additional sections where shown on drawings.

2.31 FINNED TUBE

A. Finned tube radiation for heating system shall be size and capacity as shown on the drawings and equal to the Vulcan types described below.

B. Heating element:

1. Full-hard aluminum plate fins not less than 0.020 inch thick, embedded in seamless copper tube, guaranteed for working pressure of at least 150 psi at 300 degrees F.
2. Where noted on the drawing, provide Model G-14 heavy continuous aluminum extrusion grille, deep etched and hard anodized, complete with wall support bracket and splash back support angle with vandalproof fasteners.

C. Enclosure Type Dura-vane II:

1. Enclosures and accessories: Fabricated from 14-gauge zinc-coated, bonderized steel. Top of enclosures and 90-degree corners shall consist of a continuous aluminum extrusion, etched and anodized 204 R-1, with vanes sloped toward room, factory-assembled to steel front skirts. Aluminum extrusion on enclosure top shall have pencil-proof air discharge slots. Bottom of enclosure skirt shall have a double break for lateral stiffness, top shall be provided with deep-web gussets, and vertical stiffeners with 0.5 inch deep flanges shall be provided at enclosure joints. Enclosures and 90-degree corners shall have flush joints with no exposed fasteners. End enclosures and end trims shall have roll-flanged edges, allowing enclosures to telescope within, and shall have concealed fasteners.

2. Support components shall consist of continuous mounting channel Type A and bracket and element hangers installed every three feet. Mounting channel: 20-gauge, roll-formed, fabricated from zinc-coated, bonderized steel, holding the top 0.75 inch from wall.
3. Support brackets: Die-formed from 0.1875 inch thick steel, 1.5 inch wide, and lanced to receive bottom flange of enclosure, which shall be held securely with set screw. 16-gauge die-formed saddle shall positively position heating element away from brackets and enclosure joints and allow 1.625 inch lateral movement for expansion and 1.5 inch height adjustment for pitch. Nylon-coated support arm shall allow free sliding of saddle. Include hanger for piping as well as heating element, Type PH.
4. Enclosures and all accessories shall be factory finished in manufacturer's standard enamel.

PART 3 - EXECUTION

3.20 INSTALLATION

A. Securely anchor radiation to the wall as shown on the drawings, arranging for proper fit of enclosure. Piping shall be concealed. Install expansion joints where required.

END OF SECTION

SECTION 23 82 38 - ELECTRIC RESISTANCE TERMINAL UNITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Electrical resistance heating equipment and devices.

B. Wall heaters.

1.14 RELATED SECTIONS

A. Electric heat tracing: Section 23 05 33.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Each type and size of heater included in the project.

C. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

D. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, plan and sections, showing any changes in wiring, arrangement or access made necessary to accommodate the unit furnished.

E. Shop drawings shall show dimensions of complete assembled unit with accessories.

F. Samples: Manufacturer's complete line of colors and textures for cabinets and casings.

1.40 QUALITY ASSURANCE

A. Each unit, and components as applicable, shall be UL listed and labeled.

1. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

B. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

PART 2 - PRODUCTS

2.30 ELECTRIC HEATING EQUIPMENT, GENERAL

A. Capacities and current characteristics of each unit are scheduled on the drawings.

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2.39 CEILING OR WALL FAN HEATERS

A. Unit shall be 120-volt, single-phase type.

1. Basis-of-design product: Subject to compliance with requirements, provide QMark CWH, or comparable product by one of the following:

a. Berko Electric Heating
b. General Electric Co.
c. Markel Products, Inc.
d. Vulcan Radiator Corp.

B. Unit shall be for recessed ceiling or wall mounting with housing constructed of minimum 20 gauge steel. Grille shall be aluminum with louver designed for a downflow pattern.

C. Electric heating element shall be nickel-chrome with automatically reset thermal overheat protection and controlled by integral snap-action thermostat. Provide hole plug for tamper-resistant thermostat installation.

2.40 WALL FAN HEATERS

A. Unit shall be for recessed mounting and constructed of minimum 16-gauge steel. Front plate shall be steel with supply and return louver.

1. Basis-of-design product: Subject to compliance with requirements, provide QMark AWH, or comparable product by one of the following:

a. Berko Electric Heating
b. General Electric Co.
c. Markel Products, Inc.
d. Vulcan Radiator Co.

B. Louver shall be designed for a downflow pattern.

C. Electric heating element shall be shock resistant, steel sheath enclosed, fin tube type with automatic reset thermal overheat protection and controlled by integral thermostat to de-energized fan motor and heating element.

D. Built-in fan delay switch energizes fan motor only after elements are heated, preventing discharge of unheated air. When heat shuts off, switch de-energizes fan motor after residual heat has been dissipated.

E. Integral thermostat (range 40 to 90 degrees F.)

F. Integral tamper-resistant thermostat (range 40 to 90 degrees F) adjustable only by inserting narrow blade screwdriver through front bar grill.

G. Motor shall be of the totally enclosed, continuous fan-duty, sleeve-bearing type with built-in thermal overload protection. Fan shall be aluminum construction, dynamically balanced and

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direct connected on motor shaft. Unit shall be provided with resiliently-mounted fan/motor guard.

PART 3 - EXECUTION

3.02 EXAMINATION

A. Examine roughing-in for electric units to verify actual locations of electrical connections before beginning installation.

3.05 PREPARATION

A. Coordinate with other trades to ensure that recess or bracing in walls is constructed in locations and with dimensions required for installation of recessed or surface-mounted units.

3.20 INSTALLATION, GENERAL

A. Install level and plumb.

1. Install manufacturer's access fitting for access to electrical connections, controls, and other fittings.

3.23 INSTALLATION, WALL-MOUNTED UNITS

A. Install convectors located under windows with heating element and enclosure horizontally centered under windows.

B. Cabinet units: Install with electrical connections concealed.

1. Recessed units:

a. In masonry walls: Bottom of unit shall be one masonry course above floor unless noted otherwise on the drawings.
b. In exterior walls: Insulate back of unit with asphalt-impregnated fiberboard insulation.

3.30 CONNECTIONS

A. Ground equipment and connect wiring in accordance with requirements of Division 26.

3.60 FIELD QUALITY CONTROL

A. Operate electric heating elements through each stage to verify proper operation and electrical connections.

B. Test and adjust controls including safety controls. Replace damage or malfunctioning controls and equipment.

END OF SECTION

SECTION 23 82 39 - UNIT HEATERS

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Unit heaters with water coils.

B. Cabinet unit heaters.

C. Propeller unit heaters.

1.14 RELATED SECTIONS

A. Supports: Section 23 05 29.

B. Motors: Section 23 05 13.

C. Filters: Section 23 41 00.

D. Controls: Sections 23 09 01 through 23 09 23.

E. Commissioning requirements: Divisions 01 and 23.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

B. Product data: Each type of heater included in the work.

C. Samples: Color chips for finish selection, manufacturer's complete line of colors and textures.

D. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, if necessary, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit. Show complete dimensions of complete assembled unit with accessories.

E. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

1.40 QUALITY ASSURANCE

A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

B. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

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C. Components and installation shall comply with NFPA 70 (NEC).

D. Components and assembled units shall be listed and labeled.

1.85 COMMISSIONING REQUIREMENTS

A. All equipment and systems covered by this Section shall be subject to verification and testing as part of a formal commissioning process as specified in Division 23, Section 23 08 00 and 23 08 10; and Division 01, Sections 01 91 00 and 01 91 10.

B. Work of this section includes documentation of the work associated with the commissioning process, coordination with the Commissioning Authority to prepare commissioning documentation and execution of commissioning procedures, submission of completed documentation in specified electrical format, and submission of information regarding the work of this section to support the commissioning process.

C. Contractors and vendors associated with work of this section shall submit startup documentation as required by the specifications, the manufacturer, and/or their own quality control procedures, and complete pre-functional documentation required by the commissioning process. Contractors and vendors shall review all functional performance test plan scripts and documentation and participate in functional testing as required in Division 01, Division 23, and Division 26 specifications.

D. Refer to Division 01 for requirements for electronic submission of shop drawings, product data, work plans, manufacturer startup and installation requirements, Operation and Maintenance data, testing documentation, and record documents.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled Airtherm Manufacturing Company units, or comparable product by one of the following:

1. Cabinet unit heaters:

a. Airtherm Manufacturing Company
b. American Air Filter
c. McQuay, Daikin Industries
d. Rittling
e. Sterling
f. Trane Company
g. Vulcan Radiator Corporation

2. Propeller unit heaters:

a. Airtherm Manufacturing Company
b. American Air Filter
c. Dunham-Bush, Inc.

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d. McQuay, Daikin Industries
e. Rittling
f. Sterling
g. Trane Company
h. Vulcan Radiator Corporation

2.31 CABINET UNIT HEATER

A. Arrangement, capacities, and current characteristics are indicated on the drawings.

B. Unit shall be complete with fan, motor, heating element, and cabinet with inlet and outlet grilles.

C. Cabinet: Steel, at least 16-gage, phosphatized and finished with baked enamel in a color to be selected.

1. Cabinet front or bottom on horizontal units, shall be removable for access to motor, fans, heating element and appurtenances.
2. Vertical cabinet shall be without openings in top, bottom, sides, and back.
3. Cabinet front for recessed and semi-recessed units shall have overlap trim on all four sides.
4. Provide 4-inch-high subbase for surface-mounted units.

D. Fan: Forward-curved, double-inlet type, designed for quiet operation, directly driven.

E. Heating element: Constructed of copper tubes with non-ferrous fins.

F. Motor: Resiliently mounted, three-speed, tap-wound with built-in overload protection, suitable for operation on 115-V, single phase, 60-cycle current, permanent split-capacitor type. Generally, capacities are to be selected at medium or low speed. Motors shall comply with requirements of Section 23 05 13.

G. Unit controls: Unit-mounted fan-speed switch.

H. Each unit shall have a filter rack to accommodate at least a 1/2-inch-thick filter, arranged to provide at least one sq. ft. of filter medium surface for each 300 cfm air delivery. Provide throwaway filter with each unit.

I. Provide each unit with factory-installed means of disconnect in compliance with NFPA 70 (NEC) and applicable local codes. In the event a factory installed disconnect is not available, provide an approved means of disconnect for field mounting.

2.32 PROPELLER UNIT HEATER

A. Type, capacity, and current characteristics are indicated on the drawings.

B. Casing: Steel, phosphatized and finished with baked enamel.

1. Horizontal units: Furnished with double-deflection louver to allow for horizontal and vertical deflection of air pattern.
2. Vertical units: Diffuser shall provide widespread discharge air pattern.

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C. Heating element: Copper or copper alloy tube, welded or brazed. Extended surfaces shall be aluminum plate fins with tube expanded into collar.

D. Fan: Directly connected to single-speed electric motor and provided with wire guard. Motors shall comply with requirements of Section 23 05 13.

PART 3 - EXECUTION

3.05 PREPARATION

A. Coordinate with work of other trades to ensure that substrates, supports, and openings for recessed and semi-recessed unit heaters, meet requirements for installation tolerances and other conditions.

3.20 INSTALLATION, GENERAL

A. Install unit as shown on drawings, according to manufacturer's instructions, and in accordance with NFPA 90A.

B. Set each unit plumb and level and ensure that coils drain properly.

C. Install securely fastened in place.

3.21 INSTALLING CABINET UNIT HEATERS

A. Recessed and semi-recessed heaters:

1. Install eight inches or one block course above floor unless otherwise shown on the drawings.
2. On exterior walls, provide 0.5-inch rigid fiberglass insulation behind the heater.

B. Surface-mounted heaters:

1. Install at least four inches above floor with subbase.
2. Secure to wall with no fewer than four bolts.

C. Install piping and electrical connections concealed.

D. Filters:

1. Install throwaway filter provided with unit before energizing the unit fan.
2. Before air balancing, remove throwaway filter and install disposable, medium-efficiency filter specified in Section 23 41 00, Particulate Air Filtration.

E. Ensure that all components are accessible when front panel is open.

3.22 INSTALLING PROPELLER UNIT HEATERS

A. Suspend from structure above with hanger rods not less than 0.5 inch in diameter.

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B. Install in a manner and, if necessary, with vibration control devices so that vibration is not transmitted to the structure.

3.70 ADJUSTING

A. For cabinet unit heaters, coordinate with air balancing subcontractor to adjust fan speed to obtain the airflow and static pressure shown on the drawings. If necessary, provide belts, sheaves, or other parts required to complete balancing.

END OF SECTION

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