SECTION 23 00 00

HVAC GENERAL

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. Refer to Division 1 - General Requirements and any and all Supplementary or Special Requirements, all of which apply to work described in Division 23 - HVAC as if written in full herein.

B. The scope of work described in these Specifications and/or indicated on the Drawings shall include the furnishing of all materials, equipment, appurtenances, accessories, connections, labor, etc. required and/or necessary to completely install, clean, inspect, adjust, test, balance and leave in safe and proper operating condition all HVAC systems. All HVAC work shall be accomplished by workmen skilled in the various trades involved.

C. The Drawings and Specifications are complementary to each other and what is called for by one shall be as binding as if called for by both. If a discrepancy exists between the Drawings and Specifications, the higher implied cost shall be included in the bid, and the Architect shall be notified of the discrepancy in writing.

D. All work performed under this specification shall be accomplished in accordance with the requirements and provisions of the following sections:

1.02 CODES AND STANDARDS

A. All HVAC work shall conform to all ordinances and regulations of the City, County and State where the work will take place, including the requirements of all authorities having jurisdiction. The following codes, standards and references shall be observed as a minimum:

1. 2023 Florida Building Codes

2. State Amendments and City of Tallahassee Amendments to the Code

3. National Fire Protection Association (NFPA) Standards and Guidelines

4. Local and State Fire Marshal requirements

5. Local Building and Inspection Department requirements

6. Local adopted codes, standards, ordinances (including noise ordinances), or amendments

7. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE)

a. Standard 90.12019 – Energy Standard for Buildings Except Low-Rise Residential Buildings

b. Standard 90.2-2018 Energy-Efficient Design of Low-Rise Buildings

c. Standard 62.12019 – Ventilation for Acceptable Indoor Air Quality

d. Standard 62.2-2019 – Ventilation and Acceptable Indoor Air Quality in Residential Buildings

e. Standard 55 2020 – Thermal Environmental Conditions for Human Occupancy

f. Other Standards and Guidelines as applicable

8. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA) Manuals

9. Air Conditioning, Heating, and Refrigeration Institute (AHRI)

10. Air Conditioning Contractors of America (ACCA)

11. American Society of Mechanical Engineers (ASME)

12. Underwriters Laboratories Inc. (UL)

13. Americans with Disabilities Act (ADA)

B. If Code or other requirements exceed the provisions shown on the Contract Documents, the Engineer shall be notified in writing. Where requirements of the Contract Documents exceed Code requirements, work shall be furnished and installed in accordance with the Contract Documents. Any work done contrary to these requirements shall be removed and replaced at the Contractor's expense.

1.03 NOISE CRITERIA DESIGN GOALS

A. Mechanical equipment, air distribution systems and devices shall be designed to not exceed the following noise criteria (NC) levels:

1. Public Space Areas: NC <35

2. Utility/All Other Areas: NC <40

1.04 MISCELLANEOUS DEFINITIONS

A. Terms: The following definitions of terms supplement those of the Division 01- General Requirements and are applicable to Division 23 – Heating, Ventilation, and Air Conditioning (HVAC):

1. Contractor: As used herein the term shall mean "the person or entity referred to throughout the Contract Documents as if singular in number. The Contractor shall designate in writing a representative who shall have express authority to bind the Contractor with respect to all matters under this Contract. The term "Contractor" means the Contractor or the Contractor's authorized representative."

2. Furnish: As used herein shall mean "supply and deliver to Project site, unload and inspect for damage."

3. Install: As used herein the term shall mean “to place in position for service, temporarily store, unpack, assemble, erect, apply, place, protect, clean, start up, and make ready for use.”

4. Owner: As used herein the term shall mean “the person or entity identified as such and is referred to throughout the Contract Documents as if singular in number. The Owner shall designate in writing a representative who shall have express authority to bind the Owner with respect to all matters requiring the Owner’s approval or authorization. The term “Owner” means the Owner or the Owner’s authorized representative.”

5. Product: As used herein shall include materials, systems, and/or equipment, machinery, components, and fixtures forming the work result. Not materials or equipment used for preparation, fabrication, conveying, or erection and not incorporated into the work result. Products may be new, never before used, or re-used materials or equipment.

6. Provide: As used herein shall mean “furnish and install, complete and ready for the intended use.”

7. The Work: As used herein the term shall mean “the construction and services required by the Contract Documents, whether completed or partially completed, and includes all other labor, materials, equipment, and services provided or to be provided by the Contractor to fulfill the Contractor’s obligations. The Work may constitute the whole or a part of the Project.

8. Experienced: When used with an entity or individual, “experienced” means having successfully completed a minimum of five previous projects similar in nature, size, and extent to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

1.05 WORK INCLUDED

The HVAC Systems installed and work performed under this Division of the Specifications shall include, but not necessarily be limited to:

A. Airside Systems

1. Equipment: including fans, unitary air conditioners, air handling units, fan-coil units, make-up air units, dedicated outdoor air units, furnaces, split systems, etc.

2. Ductwork and Accessories: including sheet metal, duct-board, kitchen hood and dishwasher exhausts, flexible ductwork, fire and smoke dampers, access doors, etc.

3. Air Terminal Devices: including powered induction units, variable air volume valves, etc.

4. Air Distribution Devices: including louvers, registers, grilles, diffusers, etc.

B. Refrigerant and Water Systems

1. Equipment: including pumps, air separators, expansion tanks, water chillers, cooling towers, filtration systems, chemical treatment, heat exchangers, boilers and space heating water heaters, feed-water systems, condensing units, etc.

2. Piping, Tubing and Accessories: including pipe, refrigerant tubing, valves, solenoids, thermal expansion valves, strainers, air vents, pipe and equipment drains, condensate drains, expansion devices, etc.

C. Equipment, Ductwork and Piping Supports

1. Equipment Mounts: including roof curbs, concrete housekeeping pads, equipment rails, miscellaneous steel, etc.

2. Hangers and Support Devices: including inserts, hanger rods, strut channel, cross-bracing, anchor bolts, pipe anchors, restraints, etc.

3. Vibration Isolation and seismic restraint: including inertia bases, flexible couplings, expansion devices, snubbers, springs, waffle pads, seismic restraints, etc.

D. Insulation

1. Ductwork Insulation: including exterior duct wrap, internal duct liner, fire wrap, etc.

2. Piping and Equipment Insulation: including preformed, board and wrap.

E. Miscellaneous HVAC Equipment: electric heaters, roof hoods, heat tracing, etc.

F. Automatic Temperature Controls

1. Building Automation System (BAS)/Facility Management System (FMS): same as above but networked to a central human-machine computer interface, including all software and programming, display graphics, etc.

G. Labor and Equipment: including project management, supervision, tradesmen, lifts, fork-trucks, cranes, scaffolding, saws, wrenches, etc.

H. Equipment and Valve Identification

I. Start-up and Commissioning

J. Demonstration and Owner Training

K. Testing, Adjusting and Balancing

1.06 ENGINEER'S DRAWINGS

A. The locations, arrangement and extent of equipment, devices, ductwork, piping, and other appurtenances related to the installation of the HVAC work shown on the Drawings are approximate and define the intent of the design. The Contractor shall not scale Engineer's Drawings, but shall refer to the architectural drawings for exact dimensions of building components. Should a conflict exist between the architectural and engineering drawings regarding dimensions and scale, the Contractor shall notify the Architect of the discrepancy.

B. Materials, equipment or labor not indicated but which can be reasonably inferred to be necessary for a complete installation shall be provided. Drawings and Specifications do not undertake to indicate every item of material, equipment, or labor required to produce a complete and properly operating installation.

1.07 EQUIPMENT, MATERIALS AND BID BASIS

A. Manufacturers' names, model numbers, etc. cited on the Drawings and in the Specifications are for the purpose of describing type, capacity, function and quality of equipment and materials required. All project design and coordination between disciplines has been performed as if the named manufacturer and specific piece of equipment will be provided to the project by the Contractor.

B. Alternate equipment and/or materials other than that named on the Drawings and in the Specifications may be proposed for use, but all equipment and materials shall conform entirely to the specified base items. Proposed alternate equipment shall be substantially equal in size, weight, construction and capacity. Alternate equipment and materials shall be submitted only as full equivalent to the equipment and materials specified, with sufficient supportive documentation and technical literature to demonstrate quality, performance, and workmanship without doubt or question. Requests for prior approval of alternate products shall be made at least ten (10) days prior to the bid date and as required by Division 1 - General Requirements. The Engineer shall consider the use of the alternate equipment based on the supportive documentation made available to him, and shall approve or disapprove any proposed alternates. Major exceptions to these specifications will be considered sufficient cause for rejection of the submittal. The decision of the Engineer shall, in all cases, be final.

1. The ten (10) day prior approval submittal shall include a Compliance Review of the Specifications and Addenda (if any). The Compliance Review shall be paragraph-by-paragraph review of the Specifications with the following information; "C", "D" or "E" marked in the margin of the original Specifications and any subsequent Addenda.

2. "C": Comply with no exceptions.

3. "D": Comply with no deviations. For each and every deviation, provide a numbered footnote with reasons for the proposed deviation and how the intent of the Specification can be satisfied.

4. "E": Exception, does not comply. For each and every exception, provide a numbered footnote with reasons and possible alternatives.

5. Manufacturer shall provide complete paragraph-by-paragraph compliance document detailing unit conformance to the specification. The Engineer will not review the proposal for equipment compliance.

Unless a deviation or exception is specifically noted in the Compliance Review, it is assumed that the bidder is in complete compliance with the plans and specifications. Deviations or exceptions taken in cover letters, subsidiary documents, by omission or by contradiction do not release the bidder from being in complete compliance, unless the exception or deviation has been specifically noted in the Compliance Review. The bidder may submit the latest state-of-the-art components in lieu of specified components at no additional cost, where latest state-of-the-art components perform better than what is specified. All deviations from the specifications must be approved by the Architect/Engineer and the Owner.

C. The Contractor shall coordinate the installation of all HVAC equipment proposed for use in this project with all building trades (architectural, structural, electrical, etc.). Coordination shall be accomplished prior to, and shall be reflected in, the equipment submittals for approval. When the Contractor requests substitution of alternate equipment, it is with the knowledge that he shall be responsible for any and all costs required by the substitution, including necessary engineering and construction revisions in his or any other contract or trade to satisfy the design intent shown on the Plans and described in the Specifications.

D. All materials exposed within HVAC plenums shall have a flame-spread index of not more than 25 and a smoke-developed rating index of not more than 50 unless otherwise allowed by code.

1.08 SUBMITTALS

A. The Contractor shall prepare, submit and obtain Engineer's review of all manufacturers' data on the HVAC equipment and systems prior to ordering, purchasing or installing any equipment or materials. Shop drawings shall be submitted electronically in a portable document format (pdf). An acceptable alternate would be to submit six (6) hard copies of the complete submittal, five of which will be reviewed and returned. Submittals shall be as described in Division 01 - General Requirements. Prior to submitting to the engineer, the contractor shall review and subsequently place his approval stamp on the shop drawings indicating conformance with the contract documents. Submittals shall be transmitted simultaneously in a single .zip file or, in the case of hard copies, three-ring ring binders with the associated specification sections cited and the items submitted clearly identified. The engineer will review the submittals one time for conformance with the contract documents and return them with their approval stamp indicating "Reviewed", Reviewed as Noted", "Returned for Corrections-Resubmit", "Rejected, See Comments" or "Reviewed for Coordination Only". For submittals requiring a resubmittal, one additional review will be performed at no charge. Subsequent re-reviews will be made after the engineer notifies the Architect/Owner that an hourly charge will occur for time expended performing the re-review. Submittals lacking the contractor's approval stamp and partial submittals will be returned without review. Submittals, as a minimum, shall include:

1. All HVAC items scheduled on the Drawings

2. Equipment arrangement, ductwork and piping drawings. Contractor drawings shall be prepared at a minimum scale of 1/8" = 1'-0". A scale of 1/4" = 1'-0" scale is preferred. Drawings shall be indicative of actual equipment purchased and shall show all offsets, transitions, fittings, dampers, valves, hanger locations, etc. Sections are required in spatially tight areas (e.g. kitchens, laundries, central plants, mechanical rooms, etc.) The following will guide the Contractor as to minimum drawing detail required:

   a. Clearly indicate top and bottom of duct and pipe elevations. All elevations shall be coordinated as to not conflict with structural, plumbing, electrical and architectural trades.

   b. Indicate all offsets (both vertical and horizontal).

   c. Indicate graphically all duct and pipe joints and their lengths.

d. Submit duct and pipe-work fabrication schedule indicating duct size range with minimum duct material gauges, pipe schedule being used, duct and pipe connection joint types, section lengths, duct reinforcement type and spacing, etc.

e. Indicate graphically all ductwork to be fabricated with internal duct liner.

f. Indicate all insulation for ductwork and piping.

g. Indicate all dampers and valves as shown on design documents and called for in the specifications.

h. Indicate all flexible connectors where required by specifications and notes.

3. Flexible ductwork, duct-board, insulation and linings

4. Ventilation controllers, dampers, louvers, air distribution devices, wall terminations (wall caps), roof terminations (roof caps, hoods, jacks, etc.)

5. Manufacturer's cut sheets of all piping and tubing materials

6. Where split systems are used in a "long line application," submit manufacturer's refrigerant line set routing drawings and engineered calculations supporting installed line lengths and recommended suction and liquid line sizes (deviations in the installed lengths and sizes shall be recorded on the as-built drawings and coordinated with the manufacturer to reconfirm that long line guidelines are being met).

   a. Identify and provide cut sheets of any and all accessories required to make the system complete, functional and reliable.

   b. Any split system with 75 feet of separation between the outdoor unit and the indoor unit requires that the contractor obtain a warranty approval letter from the equipment manufacturer certifying the long line length distances shown on the submitted shop drawings are acceptable.

   c. Refer to the EQUIPMENT INSTALLATION - COMMON REQUIREMENTS paragraph below.

7. Refrigerant type and charge (lbs.) for each item of equipment utilizing refrigerant.

8. AHRI Certificates

9. Valves, thermometers, pressure gauges

10. Thermal expansion/contraction piping system design including complete layout drawings indicating anchor loads, points, and method of structural support.

11. Roof curbs, equipment supports, hanger systems, vibration isolators, seismic restraints

12. Control equipment, systems and diagrams

13. Test and balance reports

B. All submittal approvals required by any code or enforcement authority, insurance underwriter, etc. shall be obtained prior to being submitted to the Engineer.

C. Review of submittals by the Engineer does not relieve the Contractor from responsibility for complying with all requirements of the Contract Documents. Furthermore, it shall be the responsibility of the Contractor to coordinate the requirements (roof penetrations, wall penetrations, floor penetrations, curbs, electrical, etc.) of all approved equipment with the other trades and disciplines.

D. All submittals shall be identified by the equipment mark or tag identification numbers shown on the Contract Drawings. Each individual submittal item shall be marked to show which specification section pertains to the item.

E. The Contractor shall provide a written statement confirming coordination of voltage requirements for all HVAC equipment requiring an electrical connection. Statement shall bear the names and signatures of the HVAC and electrical contractors. A photocopied reproduction of the below statement is acceptable.

VOLTAGE COORDINATION STATEMENT

This statement is to confirm that the voltages of the equipment provided under this specification have been coordinated with the Electrical Drawings, as well as with the Electrical Contractor.

HVAC Contractor:

Project Manager Name:

Project Manager Signature/Date:

Electrical Contractor:

Project Manager Name:

Project Manager Signature/Date:

1.09 PERMITS

A. The Contractor shall obtain all permits and inspections required for the installation of the HVAC work and pay all charges incident thereto. He shall deliver copies of all certificates of permit and inspection to the Architect.

1.10 COORDINATION OF TRADES

A. The Contractor shall give full cooperation to other trades, and shall furnish all information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.

B. Piping and other HVAC equipment shall not be installed without first coordinating the installation of same with other trades. The Contractor, at his own expense, shall relocate

all uncoordinated ductwork, piping and other HVAC equipment installed should they interfere with the proper installation and mounting of electrical, plumbing equipment, ceilings and other architectural or structural finishes.

C. The Contractor shall coordinate the elevations of all ductwork, piping and equipment above ceilings and in exposed areas with the work of all other disciplines prior to installation.

D. In areas where more than one trade is required to use common openings in beams, joists, chases, shafts and sleeves for the passage of conduits, raceways, piping, ductwork and other materials, the Contractor must coordinate the positions of all piping and equipment to be furnished under this section so that all items including the materials and equipment of other trades may be accommodated within the space available.

E. The HVAC Contractor shall confirm that his work does not interfere with the clearances required for finished columns, pilasters, partitions, walls or other architectural or structural elements as shown on the Contract Documents.

F. Work that is installed under this Contract which interferes with the architectural design or building structure shall be removed and relocated as required at no additional cost to the Contract.

G. Coordinate power and fire alarm requirements of all combination fire/smoke dampers and smoke dampers with the electrical contractor.

H. The General Contractor shall coordinate service access paths for roof-mounted equipment requiring routine maintenance. Provide code compliant galvanized steel crossing structure (e.g. stairs with handrails, ladders, etc.) for any obstruction (ductwork, piping, etc.) that exceeds 1'-6" in height x 1'-6" in width. In addition, refer to Part 3 below - EQUIPMENT INSTALLATION - COMMON REQUIREMENTS. Details of such crossings shall be included with piping and ductwork layout and coordination drawings.

I. Coordinate with the roof system used so that a minimum of 8" of the roof curb is above the finished roof for flashing purposes. The top of the curb shall be level and the slope of the roof shall be compensated for by the curb.

J. Roof curbs for equipment located in seismic or high wind areas will require the design (including attachments to the roof and equipment) to be certified by a licensed structural engineer.

1.11 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall prepare a minimum of two (2) instruction manuals, one of which shall be submitted to the Architect for the Engineer’s review. Manuals shall describe installation, operation and maintenance of all HVAC equipment and shall include copies of control schematics, sequences of operation, function and operations of all components, as well as the Contractor’s name, address, and telephone number. Manuals shall also contain one copy of all manufacturers’ drawings, pamphlets, data, parts lists, and instruction manual for each piece of equipment. Upon approval, one copy shall be delivered to the Owner; one copy shall be kept by the Contractor. The pamphlets and drawings are to be neatly bound in (a) 3-ring binder(s). In addition to the hard copy, provide electronic files (PDF format) of the manuals.

1.12 AS-BUILT DRAWINGS

A. The Contractor shall maintain a record of all changes in the work from that shown in the Contract Documents. The record shall be by red-line mark-up on the most current set of Engineer's Drawings kept in the field office. After all work is completed, the Contractor shall prepare a set of "as-built" reproducible drawings of similar type and quality as the Engineer's Drawings. As an alternate to hard copy drawings, provide electronic files (PDF format) of the as-built conditions. As-built drawings shall accurately depict actual final arrangement of all HVAC items. As-built drawings shall be delivered to the Architect.

1.13 WARRANTY

A. All equipment furnished and installed under this Contract shall be provided with the manufacturer's standard warranty unless otherwise noted.

B. All reciprocating, rotary and scroll air conditioning compressors shall be provided with an extended 5-year parts warranty.

C. The Contractor shall make good all defects in material, equipment, or workmanship disclosed within a period of one (1) year from date of building acceptance by the Owner. The phrase "make good" shall mean to furnish promptly, without charge, all work necessary to remedy the defects to the satisfaction of the Engineer.

1.14 COMMISSIONING

A. This project requires commissioning per the requirements of the (city, code, and/or specific energy program). Commissioning shall be by applicable contractor and either the engineering firm of record or a 3rd party commissioning agent. Refer to the commissioning (specifications, plan, checklists, and/or additional on drawing notes) for additional information.

PART 2 - PRODUCTS

2.01 GENERAL

A. All equipment, materials, accessories, etc. used shall be new and of current production unless specified otherwise. Equipment not specified in the Engineer's Drawings shall be suitable for the intended use and shall be subject to approval by the Engineer.

B. All equipment, products and materials shall be free of defects and shall be constructed to operate in a safe manner without excessive noise, vibration, leakage, or wear.

C. All equipment shall bear the inspection Label of Underwriters Laboratories Inc.

D. All equipment and material for similar applications or systems shall be provided from the same manufacturer unless noted otherwise.

E. The VOC content of all products in this section shall not exceed the VOC limits established in Section 01 81 13 Sustainable Design Requirements.

F. VOC Content: Submit adhesive and sealants product information or MSDS showing VOC Content information for all applicable products specified under this section. All applicable products in this section must meet low VOC content as specified by LEED Specification Section 01 81 13 Sustainable Design Requirements.

2.02 ELECTRICAL WORK

A. Except as otherwise specified or noted, electrical equipment used for HVAC systems shall be as specified herein.

B. Motor controls, system controls, starters, disconnects, pilot lights, push buttons, etc. shall be furnished by the HVAC Contractor compatible with the apparatus that it operates. Electrical equipment shall be wired for the voltage shown on the Electrical Drawings.

C. The Contractor shall be responsible for coordinating and furnishing equipment of voltage shown on the electrical documents.

D. Electric motors shall be NEMA Premium Efficiency open drip proof type. Motors shall meet NEMA MG1 Tables 12-11 and 12-12 of EISA, 2021. Motors shall be selected with a minimum of 15% safety factor greater than the fan brake/horsepower (e.g. 4.75 BHP would require a nominal 7½ HP motor). The motor service factor shall not be used as part of the safety factor. All motors shall have thermal overload protection. Motors shall be capable of operating at + 10% of the design voltage without voiding the manufacturer's warranty. Motors that drive equipment that will run continuously shall be IEC 60034-1 continuous duty rated.

E. Motors controlled by a variable frequency drive (VFD) shall be inverter duty motors designed according to the requirements of NEMA MG 1, Part 31, "Definite Purpose, Inverter Fed Motors" and shall be compatible with the particular manufacturer's drive that is used.

1. Shaft Grounding Rings - All motors controlled by variable frequency drives shall be equipped with a maintenance free, conductive micro fiber, shaft grounding ring with a minimum of two rows of circumferential micro fibers to discharge damaging shaft voltages away from the bearings to ground.

    a. Motors up to 100HP shall be provided with one shaft grounding ring installed either on the drive end or non-drive end. Motors over 100HP shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor. Grounding rings shall be provided and installed by the motor manufacturer or contractor and shall be installed in accordance with the manufacturer's recommendations.

    b. Shaft grounding rings shall be AEGIS bearing protection ring by Electro Static Technology-ITW or approved equal.

2. High Frequency Grounding Straps - All motors controlled by variable frequency drives shall be bonded from the motor foot to the system ground with a high frequency ground strap fabricated of flat braided, tinned copper with terminations to accommodate motor foot and system ground connection.

    a. Proper grounding of motor frame for all inverter-driven induction motors shall be in accordance with ABB Technical Guide No. 5 and Allen Bradley Publication 1770-4.1 Application Data Industrial Automation Wiring and Grounding Guidelines

    b. High frequency bonding strap shall be AEGIS high frequency ground strap by Electro Static Technology-ITW or approved equal.

F. Starters for motors ⅓ HP and smaller shall be manual type, and for ½ HP and larger, shall be magnetic type. Starters shall be minimum size 0, combination type (with disconnect

and lockable handle) with molded case circuit breaker. Starters for motors with remote or automatic control shall be magnetic. Relays, interlocks and auxiliary contacts shall be provided as specified and required.

G. Magnetic motor starters shall be across-the-line, full voltage, non-reversing type unless otherwise indicated on the Drawings or specified herein. Starters for motors 75 HP and greater shall be solid state, reduced voltage type.

H. Motor controls shall be either “Hand-Off-Auto” switches or “On-Off” push buttons with one indicating light. “Hand-Off-Auto” switches shall be provided for automatically controlled apparatus.

I. Motor starters that are not an integral part of HVAC equipment shall be installed in conformance with Division 26 - Electrical Requirements.

J. All “loose” disconnects and starters shall be installed by Division 26.

K. Power wiring to disconnects, starters, and equipment shall be provided and installed by Division 26. All equipment requiring electrical power shall be provided with a disconnect switch at each piece of equipment. Coordinate switch type (fused or non-fused) with equipment characteristics, manufacturer’s recommendations and the electrical drawings.

L. Provide all system controls and associated control and interlock wiring for complete and operable systems. 120 volt and higher wiring shall be MC cable or in conduit in accordance with local codes and the materials and installation requirements of Division 26 - Electrical.

M. Coordinate power and fire alarm requirements of all combination fire/smoke dampers and smoke dampers with the electrical contractor.

N. All starters and variable frequency drives shall be labeled on the face of the device with a semi-rigid plastic laminate nameplate with 1" high white letters on a black background securely affixed to the equipment. The label shall indicate equipment served (equipment tag used on the Drawings). Labels shall be furnished and installed by the Contractor.

O. All starters for 3-phase equipment shall have overload devices in each phase.

P. Wiring diagrams shall be furnished by the Contractor.

Q. Coordinate with the electrical drawings for the calculated available fault current at the panelboard serving multi-motor and combination-load equipment or the calculated available fault current indicated at the equipment. This fault current value shall be utilized to determine the correct Short Circuit Current Rating (SCCR) for the equipment. The equipment nameplate shall bear a rating of no less than the panelboard rating or the calculated fault current.

R. Acceptable manufacturers shall be General Electric, Square D, Eaton, Siemens and Allen Bradley.

2.03 AIR FILTERS

A. All filters shall be U.L. 900 classified.

B. Filters shall be pleated disposable type (MERV 6 minimum) unless specified otherwise.

C. Install one set of new filters in air handling equipment during construction and install a new set prior to test and balance. Fan powered induction units shall have a temporary roll filter media installed at the plenum air inlet during construction. Remove temporary filter media prior to test and balance. Clean and vacuum all inlets prior to test and balance.

D. Temporary roll filter media shall be provided at the inlets to all air handling equipment operated during construction. Remove temporary filter media prior to test and balance. Clean and vacuum all inlets prior to test and balance.

2.04 HVAC WATER SYSTEMS BREACH CONTROL

A. Any HVAC system requiring a make-up water connection shall be provided with an automatic breach containment valve as manufactured by Cla-Val. The valve shall detect a breach downstream, via differential pressure, and close to reduce the potential of catastrophic water damage to the building and furnishes.

PART 3 - EXECUTION

3.01 GENERAL

A. All equipment and materials shall be completely installed, adjusted, and fully operational with all accessories and connections.

B. Equipment, piping, ductwork, etc. shall fit into the spaces provided in the building and shall be installed at such time and in such a manner as to avoid damage and as required by the job progress. In general, ductwork, piping, equipment, etc. shall be installed tight to structure above. The Contractor shall coordinate work with other trades and locate work described herein to avoid interferences with structural, electrical and architectural work. Shop drawings shall clearly indicate any conflicts with other trades. Equipment, accessories and similar items requiring normal servicing or maintenance shall be accessible.

C. The Engineer reserves the right to direct the removal of any item which, in his opinion, does not present an orderly and reasonably neat or workmanlike appearance. Such removal and replacement shall be done when directed by the Engineer and without additional cost to the Owner.

D. Listed mounting heights are to the finished bottom of the device unless otherwise noted.

E. All work shall be designed and installed to comply with the requirements for the seismic design category and use group for the area in which the building is constructed.

F. Expansion in piping systems shall be compensated for using u-bends, z-bends or expansion joints as indicated. U-bends (loops) and z-bends shall be complete with pipe guides and anchors. Expansion compensation in piping risers over 100 feet in length shall be made with engineered systems; either spring type isolators and central anchor system (by Mason Industries) or flexible hose expansion loops (Metraloop as manufactured by the Metraflex Company). Refer to specification Section 23 21 13 for additional requirements.

3.02 STORAGE AND PROTECTION OF STORED MATERIALS

A. During construction, all equipment shall be properly protected against damage, defacing and freezing with shipping cartons, plastic sheeting, shipping covers, etc.

B. All open ends of piping and equipment shall be sealed with nipples and caps, plugs, and test plugs until final connection to system is made.

C. All equipment, piping and ductwork shall be protected to prevent entrance of foreign matter and debris by covering exposed openings during construction.

D. Handle and store materials in accordance with manufacturer's and supplier's recommendations and in a manner to prevent damage to materials during storage and handling. Replace damaged materials.

E. Equipment and materials shall not be installed until such time as the environmental conditions of the job site are suitable to protect the equipment or materials. Equipment or materials damaged, or which are subjected to these elements, are unacceptable and shall be removed from the premises and replaced.

3.03 PROTECTION OF HVAC SYSTEMS IN OCCUPIED BUILDINGS

A. Protect equipment and air distribution systems as outlined in SMACNA's IAQ Guidelines for Occupied Buildings Under Construction, latest edition.

3.04 BUILDING DRY-OUT DURING CONSTRUCTION

A. HVAC equipment shall not be used to dehumidify the building interior and dry-out construction materials. The HVAC system does not have the capacity to perform a building dry-out. The HVAC equipment shall not be operated until the building is completely dried-in and construction is substantially complete.

B. Coordinate with the general contractor to provide industrial grade desiccant type dehumidifiers to perform building dry-out. Propane or diesel space heaters are not acceptable as the combustion process adds moisture to the air.

3.05 CUTTING, PATCHING, AND SEALING

A. The work shall include all cutting and patching required as part of the HVAC installation. Refer to Division 1 - General Requirements.

B. All penetrations in walls, ceilings, and partitions required by mechanical work shall be sealed with an appropriate pliable sealant or fire caulking to make the penetration airtight. Penetrating items shall include, but not be limited to, ductwork, piping, conduit, cables, control wiring (especially for thermostats and sensors), hangers, mounting hardware, etc.

3.06 CONCRETE WORK

A. Construct curbs, pads and similar supports for equipment where required.

B. Provide 4" (min.) thick housekeeping pads for all floor mounted equipment, extending 6" beyond the area occupied by the equipment. Dowel pads to structural slab.

C. Perform concrete work in accordance with applicable portions of Division 3 - Concrete. Minimum compressive strength of concrete shall be same as specified for slabs on grade.

D. Mix and install grout for HVAC equipment base bearing surfaces and anchors. Provide forms as necessary and place grout to completely fill equipment bases.

3.07 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right-of-way for piping to be installed with the required slope.

E. For roof and attic mounted equipment requiring routine maintenance, allow for an unobstructed path from the roof/attic service entry point to the equipment. The path area shall be a minimum of 6'-0" high by 3'-0" wide.

F. Split system outdoor unit equipment has been shown indicating matched systems of the indoor unit with its associated outdoor unit. While the location of the outdoor units are approximate, the importance of unit locations relative to the refrigerant line set penetration through a wall or roof is critical for the project. Prior to ordering equipment, the contractor shall carefully coordinate the line set routing and requirements with the split system manufacturer to insure installation guidelines, especially for long line applications, are being followed. Refrigerant line sets shall be routed to reduce the system total equivalent length and minimize system capacity losses due to elbows, fittings, valves, etc. After the coordinated routing drawings have been approved and certified by the split system manufacturer, they shall be submitted for review along with the equipment and any required accessories. During installation, the contractor is responsible for keeping as-built refrigerant piping installation drawings noting any deviations to the proposed routing. Deviations that may affect proper system operation or performance shall be reviewed by the manufacturer immediately and corrective action implemented as required.

3.08 EQUIPMENT SUPPORTS

A. Major equipment supports (structural steel frames, framed structural slab and wall openings, etc.) shall be furnished and installed by others; however, the HVAC work shall include furnishing and installation of all miscellaneous equipment supports, structural members, rods, clamps and hangers required to provide adequate support of all HVAC equipment.

B. Unless otherwise shown on the Drawings, all HVAC equipment, piping, and accessories shall be installed level, square, and plumb.

C. All equipment, piping, etc. supported by structural bar joists shall be supported only by the top chord of the joists. Hangers shall not be attached to the bottom chord of any joists.

3.09 PIPE AND DUCTWORK PENETRATIONS

A. Sleeves shall be installed in all masonry or concrete walls, floors, roofs, etc. for pipe and ductwork penetrations. Sleeves for pipe shall be schedule 40 black steel pipe. Sleeves for ductwork shall be 20-gauge galvanized steel. Ductwork sleeves shall be sized to provide a minimum of ¼" clearance between the sleeve and duct. For insulated ducts, the clearance shall be between the sleeve and the insulation.

B. As far as possible, all pipe and ductwork penetrations shall be provided for at the time of masonry or concrete construction. Where drilling is required, only core drills shall be used. Star drills shall not be used.

C. Piping entering the building below grade and passing through cast-in-place concrete walls or floors shall be fitted with a mechanical rubber seal inside of a 12" long schedule 40 steel pipe sleeve with integral water-stop. The sleeve shall be sized to house the mechanical rubber seal and carrier pipe. The mechanical rubber seal shall be constructed of EPDM and stainless-steel hardware and provide a hydrostatic seal of up to 20 psi and up to 40 feet of head. Products shall be Metraseal as manufactured by The Metraflex Company or equal by Link-Seal.

D. All pipes passing through masonry walls shall be fitted with schedule 40 steel pipe sleeves. Sleeves shall be of the first possible size larger than the outside diameter of the pipe to be sleeved or the insulation jacket on covered pipes. Sleeves shall be flush on either side of the masonry walls.

E. All pipes passing through the masonry floors shall be fitted with schedule 40 steel pipe sleeves of the first size larger than the pipe to be sleeved. All sleeves on these floors shall extend 1" above the finished floor and 1" below the bottom of the slab. All pipe sleeves through the floors of the mechanical room shall be 16-gauge galvanized steel extending 2" above the finished floor. After the pipes are installed, the annular space shall be packed with fiberglass to ½" from the top of the sleeves, and then topped off with a ½" depth of sealant such as PRC-Rubber Caulk 7000 or other such approved sealant.

F. All pipes penetrating walls or floors of any construction shall be installed with escutcheon plates on both sides of the penetration securely fastened to the wall or floor with a clamping device for holding the escutcheon in position.

G. In exposed areas, escutcheon plates shall be chrome plated. All escutcheon plates shall be sized to completely conceal the penetration.

H. Ductwork penetrating walls or floors of any material shall be installed with closure plates on both sides of the penetration.

I. All pipe and duct penetrations of fire, smoke, or fire and smoke-rated assemblies shall be fire-stopped as required to retain the integrity of the UL-rated assembly. Fire barrier products shall be as manufactured by Tremco, Hilti, 3M, Metacaulk, Nelson, STI or approved equal. Refer to Division 7 - Thermal and Moisture Protection.

J. Ensure that materials used for fire-stopping, caulking, sealing, pest/rodent proofing, etc. are compatible with the piping material used. Some materials are known to react with certain piping systems causing premature failure.

3.10 FLASHING

A. All piping and ductwork penetrating roofs shall be flashed in an approved manner, shall be watertight, and shall conform to the requirements detailed in Division 7 - Thermal and Moisture Protection.

3.11 EQUIPMENT LABELING

A. All HVAC equipment shall be labeled. This shall include all central plant, air handling or air conditioning equipment, air terminals, and other similar and miscellaneous equipment.

B. Labels for air terminals or other devices shall be located for optimum visibility through access panel or removed ceiling tiles.

C. Equipment labeling shall be one of the following, unless noted or specified otherwise:

1. Permanently attached plastic laminated signs with engraved 1" high lettering

2. Stencil painted identification, 2" high letters, with standard fiberboard stencils and standard black (or other appropriate color) exterior stencil enamel

D. Labels, stencils, and signs shall be legible, UV resistant and constructed to be long lasting.

3.12 VALVE TAGS

A. Each valve in the HVAC system is to be provided with an individually numbered valve tag.

B. Valve tags are to be brass or plastic laminate, 1½" minimum diameter with brass chain and hook for securing to the valve.

C. Valve tags will include a designation to indicate the appropriate system. Numbering shall be consecutive for each service of the hot, chilled, steam, condensate return, or condenser water systems.

D. A printed list or schematic drawing shall be compiled for each system indicating the location and detailed description of the system or equipment served.

E. One (1) copy of each list shall be framed and mounted at the location designated by the Building Engineer. An additional copy of each list is to be included in the Operations and Maintenance Manual.

3.13 CLEANING

A. At all times, the premises shall be kept reasonably clean and free of undue amounts of waste, trash and debris by periodic cleaning and removal. After completion, all foreign material, trash and other debris shall be removed from the job site.

B. After all equipment has been installed, but prior to testing and balancing, all equipment, piping, ductwork, etc. shall be thoroughly cleaned both inside and out.

C. All water piping shall be chemically flushed and cleaned prior to circulating water through equipment.

D. After cleaning, filters shall be installed where required and all systems shall be tested and balanced.

E. After testing and balancing and just prior to Owner review and acceptance, all systems shall be finally cleaned and left ready for use.

3.14 PAINTING

A. Painting will be done under Division 9 - Painting except as otherwise noted, but the HVAC Contractor shall leave all surfaces of work free of rust, dirt and grease.

B. The HVAC Contractor shall touch-up any equipment scratched in shipment or during installation to match the original finish. Touch-up painting of HVAC equipment shall be part of the HVAC work.

C. Any visible ductwork through grilles, registers and diffusers shall be painted flat black.

D. Provide one coat of rust preventive primer on all new structural steel supports and new ferrous surfaces not galvanized, including insulated and non-insulated HVAC piping. Rust preventive painting shall be part of the HVAC work. Rust preventive paint shall be “Rust Destroyer” by Advanced Protective Products, Inc., Fair Lawn, NJ, (800) RUST-007. Product shall have a 5-year warranty when applied directly over rust. Clean and prepare surface per manufacturer’s recommendations.

E. All painting and coating shall match the original finish and shall conform to the requirements detailed in Division 9 - Finishes.

F. Do not paint over equipment nameplates, nonferrous hardware, accessories or trim.

3.15 PRESSURE TESTING

A. Unless otherwise specified herein, all HVAC piping shall be tested as required by Code to 1½ times the rated system pressure or 100 psig, whichever is greater. Care shall be taken to isolate all equipment not suitable for this test pressure by installing pipe caps or blank flanges at the equipment connections. All valves and fittings shall be tested under pressure.

3.16 PERFORMANCE AND DEMONSTRATION TESTS

A. All testing and demonstration of any and all HVAC systems required for acceptance by any authorities having jurisdiction shall be included as part of the HVAC work. This shall include the furnishing of any and all testing equipment, smoke generation devices, and any other required equipment or accessories, and all necessary labor required to perform any required tests or demonstrations. The Contractor shall coordinate and verify all devices, equipment and sequence of testing and/or events with such authorities having jurisdiction. The Contractor shall perform a minimum of two (2) satisfactory preliminary tests or demonstrations prior to any formal tests and/or demonstrations for any code authorities and shall give a minimum of five (5) days advance notice to the Engineer of any and all preliminary tests and/or demonstrations, indicating the date and time of such tests.

B. For testing and demonstration of smoke control systems, the requirements in paragraph 3.16.A apply. In addition, coordinate with the owner/operator for witnessing of formal testing.

3.17 TRAINING

A. Upon completion of the work, the Contractor shall conduct operation and training session(s) for the Owner’s key operating personnel. These sessions shall be of sufficient length and duration to adequately explain the design intent and proper operating and maintenance techniques for all HVAC equipment and systems. After these sessions are completed, the Contractor shall provide a copy of a signed statement by the Owner that his personnel are thoroughly familiar with and capable of operating all HVAC equipment and systems.

END OF SECTION

SECTION 23 03 00

ROOF CURBS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. All work specified herein shall be accomplished in accordance with the applicable requirements of Section 23 00 00 - HVAC General.

B. Roof curbs for equipment located in seismic or high wind areas will require the design (including attachments to the roof and equipment) to be certified by a licensed structural engineer.

1.02 WORK INCLUDED

A. Receipt, unloading, handling, proper storage and protection from damage of all materials.

B. Layout and coordination of work with other trades.

C. The work included under this section shall include all labor, materials, accessories, services and equipment necessary to furnish and install curbs complete as indicated on the Drawings and as specified herein.

PART 2 - PRODUCTS

2.01 GENERAL

A. Prefabricated curbs for HVAC equipment located on the roof shall be manufactured by Canfab, Micrometl, Pate, Thycurb, Roof Products & Systems (RPS), Inc., or approved equal.

2.02 ROOF CURBS

A. Curbs shall be RPS Series ARC with integral fiber cant fabricated to match any roof slope and have a minimum height of 12". Coordinate with the roof system used so that a minimum of 8" of the curb is above the finished roof for flashing purposes. The top of the curb shall be level and the slope of the roof shall be compensated for by the curb.

B. Curbs shall be a minimum of 18-gauge galvanized steel construction (or as deemed necessary by the curb manufacturer to support unit load) with fully mitered and welded corners and self-flashing without cant. The curb shall not sag more than 1" in 240" + or - when supporting the unit at the corners of curb only. The curb shall be internally reinforced with angle iron, factory insulated with 1½", 3 lb./ft^3 density fiberglass insulation, and shall be complete with factory installed pressure treated wood nailers. Coordinate sizes to match frames provided by others. When the project is located within 5 miles of a sea coast, curbs shall be of aluminum construction.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation shall be in strict accordance with the manufacturer’s printed instructions and as detailed on the Drawings. Curb manufacturer shall coordinate with HVAC and General Contractor.

END OF SECTION

SECTION 23 05 48
NOISE AND VIBRATION CONTROL, SEISMIC AND WIND RESTRAINT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Furnish and install vibration control devices, materials, and related items. Perform all work as shown on the Drawings and as specified herein to provide complete vibration isolation systems in proper working order.

1.02 MATERIAL AND EQUIPMENT

A. Vibration isolation mounts shall be supplied by one of the following approved manufacturers:

1.	Amber/Booth Co. (Houston, TX)	A.B.
2.	Mason Industries, Inc. (Hauppauge, NY)	M.I.
3.	Kinetics Noise Control, Inc. (Dublin, OH)	K.N.C.
4.	Vibration Eliminator Co., Inc. (Copiague, NY)	V.E.
5.	Vibration Mountings & Controls, Inc. (Butler, NJ)	V.M.&C
6.	Vibro-Acoustics (Markham, ON, Canada)	V.A.

B. Unless otherwise specified, supply only new equipment, parts and materials.

C. Substitutions of equal equipment beyond the alternatives listed will be permitted only with the written permission of the Architect. Accompany each request for acceptance of substitute equipment with manufacturer's certified data proving the equivalence of the proposed substitute in quality and performance. The Architect shall be the final judge of the validity of the data submitted.

D. Unless otherwise approved by the Architect, field-installed vibration isolation equipment shall be furnished by a single manufacturer or his authorized representative, who shall also be responsible for all work specified in this section to be performed by the manufacturer.

1.03 REQUESTS FOR CHANGE

A. Any requests for changes to the specifications must be submitted in writing at least ten (10) days prior to bid closing. Approval will be given through a written addendum. Refer to Division 01 for additional requirements.

1.04 QUALITY ASSURANCE

A. Coordinate the size, location, and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.

B. Provide vibration isolators of the appropriate sizes, with the proper loading to meet the specified deflection requirements.

C. Supply and install any incidental materials such as mounting brackets, attachments and other accessories as may be needed to meet the requirements stated herein, even if not expressly specified or shown on the Drawings, without claim for additional payment.

D. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.

E. Should any rotating equipment cause excessive noise or vibration when properly installed on the specified isolators, the Contractor shall be responsible for rebalancing, realignment, or other remedial work required reducing noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

F. Upon completion of the work, the Architect or Architect's representative shall inspect the installation and shall inform the installing contractor of any further work that must be completed. Make all adjustments as directed by the Architect that result from the final inspection. This work shall be done before vibration isolation systems are accepted.

1.05 SUBMITTALS

A. Refer to related sections elsewhere for procedural instructions for submittals.

B. Before ordering any products, submit shop drawings of the items listed below. The shop drawings must be complete when submitted and must be presented in a clear, easily understood form. Incomplete or unclear presentation of shop drawings may be reason for rejection.

1. A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.
2. Detailed selection data for each vibration isolator supporting equipment, including:
   a. The equipment identification mark;
   b. The isolator type;
   c. The actual load;
   d. The static deflection expected under the actual load;
   e. The specified minimum static deflection.
3. Steel rails, steel base frames, and concrete inertia bases showing all steel work, reinforcing, vibration isolator mounting attachment method, and location of equipment attachment bolts.
4. Special details necessary to convey complete understanding of the work to be performed.

C. Submission of samples may be requested for each type of vibration isolation device. After approval, samples will be returned for installation at the job if requested. All costs associated with submission of samples shall be borne by the Contractor.

1.06 DESIGN REQUIREMENTS

A. Design isolators for equipment installed outdoors to provide adequate restraint to withstand the force as required by code to any exposed surface of the isolated equipment. Isolators for outdoor equipment shall have bolt holes for attachment to equipment and to supports. The vibration isolation Vendor shall submit verifying shear and over turning calculations, for their product and equipment installation arrangement, stamped by a licensed Professional Engineer. The design and supply of miscellaneous support steel above and below isolators will not be the responsibility of the vibration isolation manufacturer.

1.07 VIBRATION ISOLATION AND SEISMIC AND WIND RESTRAINT

A. Scope

1. Provide isolators, flexible connections, and equipment bases for all rotating, piston driven, or vibrating equipment.
2. Guarantee specified isolation system deflections.

3. Provide installation instructions, drawings, and field supervision to ensure proper installation and performance of all items specified in this section.
4. Design, furnish, and install attachment devices, anchor bolts, and seismic restraints that are required for seismic compliance for all equipment, apparatus piping, conduit and raceways, ductwork, and other components of the specified systems required by codes and standards. "Attachment Devices" are devices such as double-sided beam clamps, concrete inserts, and attachment plates that serve to secure the supported device into the structure.
5. Provide seismic and wind restraint types as described. If the item to be restrained is not listed, select appropriate restraint and submit for approval.
6. In addition, seismic bracing for Fire Protection systems shall conform to NFPA 13.

B. Definitions

1. "Attachment Devices" are devices such as double-sided beam clamps, concrete inserts, and attachment plates that serve to secure the supported device to the structure.
2. "Positive Attachment" is defined as a support location with a cast-in or wedge type expansion anchor, a double-sided beam clamp, or a welded or through bolted connection to the structure.
3. "Transverse Bracing" Restraint(s) applied to limit motion perpendicular or angular to the centerline of the pipe, duct, or conduit.
4. "Longitudinal Bracing" Restraint(s) applied to limit motion perpendicular or angular to the centerline of the pipe, duct, conduit, etc.
5. Life Safety Systems
   a. All systems involved with fire protection, including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, and fire dampers.
   b. All systems involved with and/or connected to emergency power supply, including all generators, transfer switches, transformers and all circuits to fire equipment.
   c. All systems involved with and/or connected to emergency power supply, including all generators, transfer switches, transformers and all circuits to fire protection, smoke evacuation and/or emergency lighting systems.

C. Reference Codes and Standards

1. 2020 Florida Building Codes
2. "SMACNA Guidelines for Seismic Restraint of Mechanical Systems" – Second Edition (1998) with Addendum No. 1 (September 2000)
3. Structural references for the specific project listed
4. Seismic Design Category as per the structural plans
5. Wind forces for all rooftop equipment

D. Submittal Data Requirements

1. Submittals
   a. Catalog cuts or data sheets on specific products utilized, which detail compliance with the specification. Reference "TYPE" as per "PRODUCTS" section of this specification.
2. Shop Drawings
   a. Show base construction for equipment; include dimensions, weights, structural member sizes and support point locations.
   b. Indicate isolation devices selected with complete dimensional and deflection data before condition is accepted for installation.

c. Calculate thrust for fan heads (axial and centrifugal fans) to determine whether thrust restraints are required.

E. Seismic and/or Wind Certification and Analysis

1. Seismic and/or wind restraint calculations shall be provided for all connections of equipment to the structure per the requirements of the structural plans and specifications. All performance of products (such as: strut, cable, anchors, clips, etc.) associated with restraints shall be supported with manufacturer's data sheets or certified calculations.
2. Seismic restraint calculations shall be based on the acceleration criteria required by local codes. Note: For roof-mounted equipment, both the seismic acceleration and wind loads shall be calculated; the highest load shall be utilized for the design of the restraints and isolators.
3. Calculations to support seismic or wind restraint design shall be stamped by a registered professional engineer with at least five years of seismic design experience.
4. Table elevations refer to the structural point of attachment of the equipment support system (i.e., use floor slab for floor supported equipment and the elevation of the slab above for suspended equipment).
5. Analysis shall indicate calculated dead loads, derived loads and materials utilized for connections to equipment and structure. Analysis shall detail anchoring methods, bolt diameter, embedment and/or weld length.
6. Certification and analysis report shall be submitted along with other HVAC submittals.

F. Manufacturer Inspection

1. Upon completion of installation of all vibration isolation and seismic restraint devices, a certification report prepared by the manufacturer shall be submitted in writing to the Contractor indicating that all systems are installed properly and in compliance with the specifications. The report must identify those areas that require corrective measures or certify that none exist. Any field coordination type changes to the originally submitted seismic restraint designs must be clearly defined and detailed in this report.

PART 2 - PRODUCTS

2.01 VIBRATION ISOLATOR TYPES

A. General

1. All metal parts installed out-of-doors shall be corrosion resistant after fabrication. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14.
2. Isolators installed out-of-doors shall have base plates with bolt holes for fastening the isolators to the support members.
3. Isolator types are scheduled to establish minimum standards. At the Contractor's option, labor-saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories and seismic restraint features must not degrade the isolation performance of the isolators.
4. Static deflection of isolators shall be as provided in the EXECUTION section and as shown on the Drawings. All static deflections stated are the minimum

acceptable deflection for the mounts under actual load. Isolators selected solely on the basis of rated deflections are not acceptable and will be disapproved.

B. Type FSN (Floor Spring and Neoprene)

1. FSN isolators shall be freestanding and laterally stable without any housing. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Springs shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately 1. Mounts shall have leveling bolts.
2. The spring element in the isolator shall be set in a neoprene cup and have a steel washer or a flat surface in contact with the neoprene to distribute the load evenly over the bearing surface of the neoprene. Alternatively, each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, a rectangular bearing plate of appropriate size shall be provided to load the pad uniformly within the manufacturer's recommended range. If the isolator is to be fastened to the building and the NP isolator is used, the holes in the isolator base plate shall be oversized and GROMMETS shall be provided for each base plate bolt hole.
3. If the basic spring isolator has a neoprene friction pad on its base and an NP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum bearing plate shall be used between the friction pad and the NP isolator. If the isolator is outdoors, bearing plates shall not be made of galvanized steel. The NP isolator, bearing plate and friction pad shall be permanently adhered to one another and to the bottom of the isolator base plate.
4. Type FSN isolators shall be one of the following products with the appropriate neoprene pad (if used) selected from Type NP or approved equal:
   a. Type SW A.B.
   b. Type SLF M.I.
   c. Type FDS K.N.C.
   d. Type OST V.E.
   e. Series AC V.M.&C.
   f. Type CM V.A.

C. Type FSNTL (Floor Spring and Neoprene Travel Limited)

1. FSNTL isolators shall be freestanding and laterally stable without any housing. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Spring shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately 1. Mounts shall have leveling bolts. Mounts shall have vertical travel limit stops to control extension when weight is removed. The travel limit stops shall be capable of serving as blocking during erection of the equipment. A minimum clearance of 1/4" shall be maintained around restraining bolts and between the limit stops and the spring to avoid interference with the spring action.
2. The spring element in the isolator shall be set in a neoprene cup and have a steel washer or a flat surface in contact with the neoprene to distribute the load evenly over the bearing surface of the neoprene. Alternatively, each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, a rectangular bearing plate of appropriate size shall be provided to load the pad uniformly within the manufacturer's recommended range. If the isolator is to be fastened to the building and the NP isolator is used, the holes in the isolator base plate shall be oversized and GROMMETS shall be provided for each base plate bolt hole.
3. If the basic spring isolator has a neoprene friction pad on its base and an NP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum

bearing plate shall be used between the friction pad and the NP isolator. If the isolator is outdoors, bearing plates shall not be made of galvanized steel. The NP isolator, bearing plate and friction pad shall be permanently adhered to one another and to the bottom of the isolator base plate.

4. Type FSNTL isolators shall be one of the following products, with the appropriate neoprene pad (if used) selected from Type NP or approved equal:
   a. Type CT A.B.
   b. Type SLR M.I.
   c. Type FLS K.N.C.
   d. Type KW V.E.
   e. Series AWR V.M.&C.
   f. Type CSR V.A.

   For regions where G force values exceed 0.5G (wind or seismic) a stronger (more rigid housing) isolator is required.
   g. Type SCSR V.A.

D. Type FN (Floor Neoprene)

1. NP isolators shall be neoprene-in-shear type with steel reinforced top and base. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed. Bolt holes shall be provided in the base and the top shall have a threaded fastener. The mounts shall include leveling bolts that may be rigidly connected to the equipment.
2. Type FN isolators shall be one of the following products or approved equal:
   a. Type RVD A.B.
   b. Type ND M.I.
   c. Type RD K.N.C.
   d. Type D44 V.E.
   e. Series RD V.M.&C.
   f. Type RD V.A.

E. Type FNC (Floor Neoprene Constrained)

1. FNC isolators shall incorporate bridge-bearing neoprene elements with all-directional restraint. The mount shall consist of a ductile iron casting containing two (2) separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. Bolt holes shall be provided in the base and the top shall have a threaded fastener.
2. Type FNC isolators shall be one of the following products or approved equal:
   a. Type BR M.I.
   b. Series RSM V.M.&C.
   c. Type SRD V.A.

F. Type PCF (Pre-compressed Fiberglass)

1. PCF isolator blocks shall be made of molded inorganic glass fiber that is individually coated and sealed with an impervious elastomeric membrane. Fiberglass shall be severely overloaded during the manufacturing process to stabilize the material into a product that is permanent and has consistent, predictable dynamic properties.
2. Type PCF isolators shall be one of the following products or approved equal:
   a. Type KIP K.N.C.

G. Type NP (Neoprene Pad)

1. NP isolators shall be one layer of 5/16" to 3/8" thick ribbed or waffled neoprene. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.
2. Type NP isolators shall be one of the following products or approved equal:

a.	Type NR	A.B.
b.	Type W	M.I.
c.	Type NPS	K.N.C.
d.	Type 200N	V.E.
e.	Series Maxi-Flex	V.M.&C.
f.	Type N	V.A.

H. Type DNP (Double Neoprene Pad)

1. DNP isolators shall be formed by two layers of 1/4" to 3/8" thick ribbed or waffled neoprene, separated by a galvanized steel, stainless steel, or aluminum plate. If the isolator is outdoors, the plate shall not be made of galvanized steel. These layers shall be permanently adhered together. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.
2. Type DNP isolators shall be formed from one of the following products or approved equal:

a.	Type NR	A.B.
b.	Type WSW	M.I.
c.	Type NPS	K.N.C.
d.	Type 200N (Multilayers)	V.E.
e.	Series Maxi-Flex	V.M.&C.
f.	Type NP	V.A.

I. Type HSN (Hanger Spring and Neoprene)

1. HSN isolators shall consist of a freestanding and laterally stable steel spring and a neoprene element in series, contained within a steel housing. Spring diameters and hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 degrees arc before contacting the housing. Alternatively, other provisions shall be made to allow for a 30 degrees arc of movement of the bottom hanger rod without contacting the isolator housing. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Spring elements shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. The neoprene element shall be designed to have a 0.3" minimum static deflection. The deflection of both the spring element and the neoprene element shall be included in determining the overall deflection of Type HSN isolators.
2. A pre-compressed glass fiber element may be substituted for the neoprene element.
3. Type HSN isolators shall be one of the following products or approved equal:

a.	Type BSR-A	A.B.
b.	Type 30N	M.I.
c.	Type SRH or SFH	K.N.C.
d.	Type SNRC	V.E.
e.	Type RSH 30A or RSHSC	V.M.&C.
f.	Type SHR	V.A.

J. Type HN (Hanger Neoprene)

1. HN isolators shall consist of a neoprene-in-shear element contained within a steel housing. A neoprene neck bushing shall be provided where the hanger rod passes through the hanger housing to prevent the rod from contacting the hanger housing.

2. A pre-compressed glass fiber element may be substituted for the neoprene element.
3. Type HN isolators shall be one of the following products or approved equal:
   a. Type BRD-A A.B.
   b. Type HD M.I.
   c. Type RH or FH K.N.C.
   d. Type 3C V.E.
   e. Type RHD V.M.&C.
   f. Type NH V.A.

2.02 EQUIPMENT BASES

A. Type BSR (Base - Steel Rail)

1. Steel rail bases shall consist of structural steel sections sized to provide a rigid beam that will not twist, deform, or deflect in any manner that will negatively affect the supported equipment or the vibration isolation mounts. Rail bases shall include mounting brackets for attachment of vibration isolators.
2. Type BSR bases shall be one of the following products or approved equal:
   a. Type C or CIS A.B.
   b. Type R or ICS M.I.
   c. Type KRB or KFB K.N.C.
   d. Type CS V.E.
   e. Type WFR V.M.&C.
   f. Type CS V.A.

B. Type BSF (Base - Steel Frame)

1. Steel frame bases shall consist of structural steel sections sized, spaced, and connected to form a rigid base which will not twist, rack, deform, or deflect in any manner which will negatively affect the supported equipment, or the vibration isolation mounts. Frames shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. The depth of steel frame bases shall be at least 1/10 the longest dimension of the base supported between isolators and not less than 6". The base footprint shall be large enough to provide stability for supported equipment.
2. Frame bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.
3. Type BSF bases shall be one of the following products or approved equal:
   a. Type WX A.B.
   b. Type WFSL M.I.
   c. Type SFB K.N.C.
   d. Type HB V.E.
   e. Series WFB V.M.&C.
   f. Type CIS V.A.

C. Type BIB (Base - Inertia Base)

1. Inertia bases shall be formed of stone-aggregate concrete (150 lb/cu. ft.) and appropriate steel reinforcing cast between welded or bolted perimeter structural steel channels. Inertia bases shall be built to form a rigid base that will not twist, rack, deform, deflect, or crack in any manner that would negatively affect the supported equipment or the vibration isolation mounts. Inertia bases shall be

Commented [JRH1]: Coordination with the structural engineer is required. Inertia bases impose significant mass to the structure. The depth of the base will determine the weight.

adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. Inertia base depth shall be at least 1/12 the longest dimension of the base supported between isolators and not less than 6". The base footprint shall be large enough to provide stability for supported equipment. Inertia bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment. Concrete may be provided by the General Contractor.

2. Frame and reinforcement for Type BIB bases shall be one of the following products or approved equal:

a.	Type CPF	A.B.
b.	Type KSL or BMK	M.I.
c.	Type CIB-L or CIB-H	K.N.C.
d.	Type SN	V.E.
e.	Series MPF or WPF	V.M.&C.
f.	Type CIB	V.A.

D. Type RC-1 (Roof Curb, Type 1)

1. Type RC-1 isolation bases shall be a prefabricated assembly consisting of an extruded aluminum frame and steel spring isolation system that fits over the roof curb and under the isolated equipment. The aluminum frame shall be sufficiently rigid to support the equipment load without detrimental twist or deflection. Spring isolators shall be selected and positioned along the curb to achieve the minimum static deflection called for in the schedule. The static deflection shall be constant around the entire periphery of the base. Springs shall be free standing, laterally stable with a diameter of not less than 0.8 times the compressed height, and have additional travel-to-solid that is at least 50% of the rated deflection. Resilient neoprene snubbers shall be provided at the corners of the base to limit equipment movement to 1/4" under wind load.
2. The isolation curb base shall be made weather tight by sealing all around the periphery with closed cell neoprene or flexible membrane that shall in no way inhibit the vibration isolation of the spring elements. Closed cell sponge gasketing or field caulking shall be used between the equipment unit and the isolation curb base and between the isolation curb and roof curb to form a weather-tight seal. Each spring isolator used in the curbs shall be weather-protected as described in the PRODUCTS section under General.
3. Type RC-1 vibration isolation curb bases shall be supplied by the isolator manufacturer and shall be one of the following products or approved equal:

a.	Type RTIR	A.B.
b.	Type CMAB	M.I.
c.	Type ASR	K.N.C.
d.	Type AR	V.E.
e.	Series AXR	V.M.&C.
f.	Type VCR	V.A.

E. Type RC-2 (Roof Curb, Type 2)

1. Type RC-2 isolation bases shall be a prefabricated assembly consisting of a structural steel frame and steel spring isolation system that also forms the roof curb under the isolated equipment. The steel frame shall be sufficiently rigid to support the equipment load without detrimental twist or deflection. Spring isolators shall be selected and positioned along the curb to achieve the minimum static deflection called for in the schedule. The static deflection shall be constant around

the entire periphery of the base. Springs shall be free standing, laterally stable with a diameter of not less than 0.8 times the compressed height, and have additional travel-to-solid that is at least 50% of the rated deflection. Spring isolators shall include travel limit stops that are capable of serving as blocking during erection of the equipment. A minimum clearance of 1/4" shall be maintained around restraining bolts as they pass through the limit stop brackets. Springs and limits stops shall be provided at the corners of the base to limit equipment movement to 1/4" under wind load.

2. The isolation curb base shall be made weather tight by sealing all around the periphery with closed cell neoprene, flexible membrane or light gauge spring metal loop, which shall in no way inhibit the vibration isolation of the spring elements. A closed cell sponge gasket or field caulking shall be used between the equipment unit and the isolation curb base and between the isolation curb and roof curb to form a weather-tight seal. Each spring isolator used in the curbs shall be weather-protected as described in the PRODUCTS section under General.
3. Type RC-2 vibration isolation curb bases shall be supplied by the isolator manufacturer and shall be one of the following products or approved equal:
   a. Type RSC M.I.
   b. Type SSR K.N.C.
   c. Vibrocurb ThyCurb
   d. ARTR/VCR V.A.

F. Type RP-1 (Low Profile Structural Roof Platform for Air Cooled Chillers and Cooling Towers)

1. Type RP-1 isolation platform bases shall be a prefabricated assembly consisting of a structural steel frame and steel spring isolation system that also forms the roof platform under the isolated equipment. The steel frame shall be sufficiently rigid to support the equipment load without detrimental twist or deflection. Spring isolators shall be selected and positioned along the curb to achieve the minimum static deflection called for in the schedule. Springs shall have appropriate wind and seismic restraint. The static deflection shall be constant around the entire periphery of the base. Springs shall be free standing, laterally stable with a diameter of not less than 0.8 times the compressed height and have additional travel-to-solid that is at least 50% of the rated deflection. Spring isolators shall include travel limit stops that are capable of serving as blocking during erection of the equipment.
2. A minimum clearance of 1/4" shall be maintained around restraining bolts as they pass through the limit stop brackets. Springs and limits stops shall be provided at the corners of the base to limit equipment movement to 1/4" under wind load.
3. A galvanized insulated and cross broken sloped solid top shall be provided to shed water. If project location is within 50 miles of a seacoast area, the top section shall be fabricated from Type 304 stainless steel.
4. Platform access doors or sections shall be installed as required for servicing curb components or accessories.
5. The platform shall be constructed to an appropriate height so as to match the pitch of the roof insulation with adequate height to meet code minimum of 10" above final roof membrane.
6. The isolation shall allow (¼") movement before resisting wind loads in any lateral direction.
7. The isolation platform shall be designed to meet all seismic loads and wind loading as defined by the building code having jurisdiction. Calculations shall be provided and stamped by a Professional Engineer.
8. Type RP-1vibration isolation Platform shall be supplied by the isolator manufacturer and shall be one of the following products or approved equal:
   a. VSPS V.A.

2.03 VIBRATION ISOLATOR SCHEDULE

Equipment Type	Base Type	Isolator Type	Minimum Deflection
Air Handling Units – Floor Mounted < 1 HP	-	DNPx2	1/10"
Air Handling Units – Floor Mounted > 1 HP	-	FNC	3/8"
Air Handling Units – Internally Isolated	-	DNPx2	1/10"
Air Handling Units (Including PIUs) – Suspended < 1 HP	-	HN	3/8"
Air Handling Units – Suspended > 1 HP	-	HSN	1"
Boilers	-	FSN	1"
Cooling Towers	-	FSNTL	4"
Cooling Towers (Low Profile Platform)	-	FSNTL	3"
Dedicated Outdoor Air Rooftop Units <25 Tons	-	RC-2	1"
Dedicated Outdoor Air Rooftop Units >25 Tons	-	RC-2	2"
Fan Coil Units – Floor Mounted	-	DNP	1/10"
Fan Coil Units – Suspended	-	HN	3/8"
Fans – Floor Mounted < 1 HP	BSF	DNPx2	1/10"
Fans – Floor Mounted > 1 HP	BSF	FNC	3/8"
Fans – Suspended < 1 HP	-	HN	3/8"
Fans – Suspended > 1 HP	-	HSN	1"
Generator	-	FSNTL	2.5"
Generator Exhaust Pipe	-	HSN	2"
Heat Exchangers	-	FSNTL	1"
Packaged Roof Top Units <25 Tons	-	RC-2	1"
Packaged Roof Top Units >25 Tons	-	RC-2	2"
Pumps - Floor Mounted < 1 HP	-	DNP	1/10"
Pumps - Floor Mounted < 5 HP	BIB	FN	3/8"
Pumps - Floor Mounted > 5 HP	BIB	FSN	2"
Pumps - Suspended Inline	-	HSN	2"
Pumps – Floor Mounted Inline	SIPS	FSNTL	2"
Split System Condensing Units < 5 Tons	-	NP	1/10"
Split System Condensing Units > 5 Tons	BSR	FSN	1"
Split System Heat Pump Units < 5 Tons	-	NP	1/10"
Split System Heat Pump Units > 5 Tons	BSR	FSN	1"
VRF/VRV		DNP	1/10"
Water-Cooled Self-Contained Units (Internally Isolated)	-	DNPx2	1/10"
Water Cooled Self Contained Units	-	FSN	2"
Water Source Heat Pumps – Floor Mounted < 5 Tons	-	NP	1/10"
Water Source Heat Pumps – Floor Mounted > 5 Tons	-	FSN	1"
Water Source Heat Pumps – Suspended < 5 Tons	-	HN	3/8"
Water Source Heat Pumps – Suspended > 5 Tons	-	HSN	1"

Commented [JRH2]: ASHRAE's selection guide for vibration isolators (2019 HVAC Applications Table 47) acknowledges internal isolation, but states that it is not always reliable due to short circuiting. They recommend external spring vibration isolators for any RTU's over 300 lb. Expect these to be VE'd on projects without an acoustical engineer.

Commented [JRH3]: Change to RC-1 for coastal environments.

Commented [JRH4]: Change to RC-1 for coastal environments.

Commented [JRH5]: ASHRAE recommends an inertia base for a generator, but springs should be sufficient. If an inertia base is required by the acoustical consultant, replace FSNTL with BIB and coordinate the required deflection with the manufacturer's rep.

Commented [JRH6]: ASHRAE's selection guide for vibration isolators (2019 HVAC Applications Table 47) acknowledges internal isolation, but states that it is not always reliable due to short circuiting. They recommend external spring vibration isolators for any RTU's over 300 lb. Expect these to be VE'd on projects without an acoustical engineer.

Commented [JRH7]: Change to RC-1 for coastal environments.

Commented [JRH8]: Change to RC-1 for coastal environments.

2.04 RESILIENT PENETRATION SLEEVE/SEAL

A. Resilient penetration sleeve/seals shall be field-fabricated from a pipe or sheet metal section that is l/2" to 3/4" larger than the penetrating element in all directions around the element, and shall be used to provide a sleeve through the construction penetrated. The sleeve shall extend 1" beyond the penetrated construction on each side. The space between the sleeve and the penetrating element shall be packed with glass fiber or mineral wool to within 1/4" of the ends of the sleeve. The remaining 1/4" space on each end shall be filled with acoustical sealant to form an airtight seal. The penetrating element shall be

able to pass through the sleeve without contacting the sleeve. Alternatively, prefabricated sleeves accomplishing the same result are acceptable.

2.05 RESILIENT LATERAL SUPPORTS

A. These units shall either be a standard product of the vibration isolator manufacturer, or be custom fabricated from standard components. These units shall incorporate neoprene isolation elements similar to Type FN that are specifically designed to provide resilient lateral bracing of ducts or pipes.

B. Resilient lateral supports shall be one of the following products or approved equal:

1.	Type Custom	A.B.
2.	Type ADA	M.I.
3.	Type RGN	K.N.C.
4.	Type VERG or VPL	V.E.
5.	Type MDPA	V.M.&C.
6.	Type RD	V.A.

2.06 FLEXIBLE DUCT CONNECTIONS

A. Flexible duct connections shall be made from coated fabric. The clear space between connected parts shall be a minimum of 3", and the connection shall have a minimum of 1.5" of slack material.

2.07 FLEXIBLE PIPE CONNECTIONS

A. Flexible pipe connections shall be fabricated of multiple plies of nylon cord, fabric, and neoprene, and shall be vulcanized so as to become inseparable and homogeneous. Flexible connections shall be formed in a double sphere shape, and shall be able to accept compressive, elongating, transverse, and angular movements.

B. The flexible connections shall be selected and specially fitted, if necessary, to suit the system temperature, pressure, and fluid type. In addition, suitable flexible connections should be selected, if possible, which do not require rods or cables to control extension of the connector.

C. Connectors for pipe sizes 2" or smaller shall have threaded female union couplings on each end. Larger sizes shall be fitted with metallic flange couplings.

D. Flexible pipe connections shall be one of the following or an approved equal:

1.	Type 2600 or 2655	A.B.
2.	Type Twin Sphere	Metraflex
3.	Type MFTNC or MFTFU	M.I.
4.	Double Sphere Flexible Connectors	V.E.
5.	Series VMT or VMU	V.M.&C.
6.	Type Twin Sphere	Twin City Hose

2.08 THRUST RESTRAINTS

A. Thrust restraints shall consist of a spring element in series with a neoprene pad. The unit shall be designed to have the same deflection due to thrust-generated loads as specified for the isolators supporting the equipment. The spring element shall be contained within a steel frame and be designed so it can be pre-compressed at the factory to allow for a

maximum of 1/4" movement during starting or stopping of the equipment. Allowable movement shall be field-adjustable. The assembly shall be furnished complete with rods and angle brackets for attachment to both the equipment and the adjacent fixed structural anchor. The thrust restraints shall be installed on the discharge of the fan so that the restraint rods are in tension. Assemblies that place the rods in compression are not acceptable. The holes in the spring restraint brackets through which the restraint rods pass must be oversized to prevent contact between the brackets and rods.

B. Thrust restraints shall be one of the following products or an approved equal:

1.	Type TRK	A.B.
2.	Type HSR	K.N.C.
3.	Type WB	M.I.
4.	Thrust Restraint	V.E.
5.	Type SHR	V.A.

2.09 GROMMETS

A. Grommets shall be made of neoprene or neoprene impregnated duct that is specially formed to prevent bolts from directly contacting the isolator base plate, and shall be sized so that they will be loaded within the manufacturer's recommended load range.

B. Grommets shall either be custom made by combining a neoprene washer and sleeve, or be one of the following products or an approved equal:

1.	Type Isogrommets	MBIS, Inc. (Bedford Heights, OH)
2.	Type WB	Barry Controls (Brighton, MA)
3.	Type HG	Mason Industries Inc. (Hauppauge, NY)
4.	Type GW	V.A.

2.10 ACOUSTICAL SEALANT

A. Sealants for acoustical purposes as described in this specification shall be silicone or one of the resilient, non-hardening sealants indicated below:

1.	Acoustical sealant	D.A.P.
2.	BR-96 or AC-20 (AC-20 FTR - Fire Rated)	Pecora
3.	Sonoloc	Sanborn
4.	Acoustical Sealant #834 (Acrylic Latex)	Tremco
5.	Acoustical sealant	U.S.G.

PART 3 - EXECUTION

3.01 APPLICATION

A. General

1. Refer to the PRODUCTS section of this specification for vibration isolation devices identified on the Drawings or specified herein.
2. The static deflection of all isolators specified herein is the minimum acceptable deflections for the mounts under actual load. Isolators selected solely on the basis of rated deflection are not acceptable and will be disapproved.

B. Major Equipment Isolation

1. Unless otherwise shown or specified, all floor-mounted major equipment shall be set on housekeeping pads. See architectural or structural drawings for details.
2. Types and minimum static deflections of vibration isolation devices for major equipment items shall be as scheduled on the Drawings or specified hereunder.
3. Flexible duct connections shall be installed at all fan unit intakes, fan unit discharges, and wherever else shown on the Drawings.
4. Flexible pipe connections shall be installed at all pipe connections to vibration-isolated equipment in the positions shown on the Drawings.
5. Electrical connections to vibration-isolated equipment shall be flexible, as called for in the electrical portion of the specification.
6. Thrust restraints shall be installed on all suspended fans and on all floor-mounted fans developing 4" or more of static pressure, unless the horizontal component of the thrust force can be demonstrated to be less than 10% of the equipment weight.

C. Miscellaneous HVAC Equipment Isolation

1. Miscellaneous pieces of HVAC equipment, such as converters, pressure reducing stations, dryers, strainers, storage tanks, condensate receiver tanks, and expansion tanks, which are connected to isolated piping systems, shall be vibration-isolated from the building structure by Type NP or Type HN isolators (selected for 0.1" static deflection), unless their position in the piping system requires a higher degree of isolation as called for under Pipe Isolation.

D. Pipe Isolation

1. All chilled water, condenser water, hot water, steam, refrigerant, drain and engine exhaust piping that is connected to vibration-isolated equipment shall be isolated from the building structure within the following limits:
   a. Within mechanical rooms;
   b. Within 50' total pipe length of connected vibration-isolated equipment (chillers, pumps, air handling units, pressure reducing stations, etc.);
   c. At every support point for piping that is greater than 4" in diameter.
2. Piping shall be isolated from the building structure by means of vibration isolators, resilient lateral supports, and resilient penetration sleeve/seals.
3. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than 1/2", Type FSN or HSN isolators shall be used. When the required static deflection is less than or equal to 1/2", Type FN or HN isolators shall be used. All other pipe support isolators within the specified limits shall be either Type FN or HN achieving at least 1/4" static deflection.
4. Where lateral support of pipes is required within the specified limits, this shall be accomplished by use of resilient lateral supports.
5. Pipes within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
6. Provide flexible pipe connections as called for under Major Equipment above and wherever shown on the Drawings.

E. Duct Isolation

1. All sheet metal ducts and air plenums that are within mechanical rooms or within a distance of 50' total duct length of connected vibration-isolated equipment (whichever is longer) shall be isolated from the building structure by Type FN, PCF or HN isolators. All isolators shall achieve 0.1" minimum static deflection.
2. Ducts within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.

3. Flexible duct connections shall be provided as called for above under Major Equipment and wherever shown on the Drawings.

3.02 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT

A. General

1. Locations of all vibration isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation.
2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.

B. Isolators

1. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.
2. Isolators for equipment with bases shall be located on the sides of the bases which are parallel to the equipment shaft unless this is not possible because of physical constraints.
3. Locate isolators to provide stable support for equipment, without excess rocking. Consideration shall be given to the location of the center of gravity of the system and the location and spacing of the isolators. If necessary, a base with suitable footprint shall be provided to maintain stability of supported equipment, whether or not such a base is specifically called for herein.
4. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.
5. Hanger rods for vibration-isolated support shall be connected to major structural members, not the floor slab between major structural members. Provide suitable intermediate support members as necessary.
6. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360 degrees about the rod axis without contacting any object.
7. Parallel running pipes may be hung together on a trapeze that is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze. Do not mix isolated and un-isolated pipes on the same trapeze.
8. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.
9. Resiliently isolated pipes, ducts and equipment shall not come in rigid contact with the building construction or rigidly supported equipment.
10. The installed and operating heights of equipment supported by Type FSNTL isolators or with Type RC-2 isolation bases shall be identical. Limit stops shall be out of contact during normal operation. Adjust isolators to provide 1/4" clearance between the limit stop brackets and the isolator top plate, and between the travel limit nuts and travel limit brackets.
11. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

C. Bases

1. No equipment unit shall bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators and such direct support is approved by the equipment manufacturer. This provision shall apply whether or not a base frame is called for on the schedule. In the case that a base frame is required for the unit because of the equipment manufacturer's requirements and is not specifically

called for on the equipment schedule, a base frame recommended by the equipment manufacturer shall be provided at no additional expense.

2. Unless otherwise indicated, there is to be a minimum operating clearance of 1" between steel rails, steel frame bases or inertia bases and the floor beneath the equipment. The isolator mounting brackets shall be positioned and the isolators adjusted so that the required clearance is maintained. The clearance space shall be checked by the Contractor to ensure that no construction debris has been left to short circuit or restrict the proper operation of the vibration isolation system.
3. Isolation bases shall be installed in strict accordance with the manufacturer's instructions.

D. Flexible Duct Connections

1. Prior to installation of the flexible connection, sheet metal ducts and plenum openings shall be squarely aligned with the fan discharge, fan intake, or adjacent duct section and the gap between connected parts shall be uniform. Flexible duct connections shall not be installed until this provision is met. There shall be no metal-to-metal contact between connected sections, and the fabric shall not be stretched taut.

E. Flexible Pipe Connections

1. Install flexible pipe connections in strict accordance with the manufacturer's instructions.

F. Thrust Restraints

1. Thrust restraints shall be attached on each side of the fan parallel to the thrust force. This may require custom brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Thrust restraints shall be adjusted to constrain equipment movement to the specified limit.

G. Grommets

1. Where grommets are required at hold down bolts of isolators, bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers shall be galvanized.

H. Resilient Penetration Sleeve/Seals

1. Maintain an airtight seal around the penetrating element and prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.

END OF SECTION

SECTION 23 05 93 –
TESTING, ADJUSTING AND BALANCING (TAB)

PART 1 - GENERAL

1.01 DESCRIPTION

A. Refer to specification section 23 00 00 - HVAC General, all of which applies to work described in this section as if written in full herein.

B. The work described by this section of the specifications consists of furnishing all materials, instruments, labor, and appurtenances to test, adjust and balance all of the HVAC systems furnished and installed under Division 23 of the specifications.

C. The TAB agency shall be a subcontractor of the General Contractor and shall not report to or be paid by the HVAC Contractor. The HVAC subcontractor shall be responsible to cooperate with and provide for the balancing subcontractor any and all materials, services, labor, etc. to facilitate completion of the balancing work.

1.02 QUALITY ASSURANCE

A. The TAB agency and its specialists shall be certified members of Associated Air Balance Council (AABC) or certified by the National Environmental Balance Bureau (NEBB) to perform TAB service for HVAC. The certification shall be maintained for the entire duration of duties specified herein. The TAB agency shall have been in business for at least the past five years and must be free of disciplinary action by either the AABC or the NEBB during that time.

B. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of 3 projects comparable in size and complexity of this project and must be certified so by the TAB agency in writing.

C. The basic instrumentation shall be calibrated to accuracy requirements by its manufacturer, AABC or NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems. Submit calibration history of the instruments to be used for test and balance purpose during the preliminary and final submittal phase.

D. One or more of the applicable AABC, NEBB or SMACNA publications, supplemented by the ASHRAE Handbooks and requirements stated herein shall be the basis for planning, procedures, tolerances and reports. Final report shall cite the exact names of publications used as a basis or reference for the TAB work or reports.

1.03 DEFINITIONS

A. Retain definition(s) remaining after this Section has been edited.

B. AABC: Associated Air Balance Council.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An entity engaged to perform TAB Work.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Provide plastic plugs to seal holes drilled in ductwork for test purposes.

B. Provide for repair of insulation removed or damaged for TAB work to match installation.

PART 3 - EXECUTION

3.01 TAB PROCEDURES

A. TAB shall be performed in accordance with the requirements of the Standard under which the TAB agency is certified, either AABC or NEBB.

B. During TAB all related system components shall be in full operation including the Automatic Temperature Controls system. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.

C. Adjustment of the temperature controls shall be coordinated by the TAB work specialist in conjunction with the Building Automation System/Automatic Temperature Control Company's Engineer. Both shall cooperate to simulate a complete cycle for every system in every mode of operation (automatic, economizer, fire emergency, etc.).

D. Coordinate TAB procedures with any phased construction completion requirements for the project. Provide TAB reports for each phase of the project prior to partial final inspections of each phase of the project.

E. Test and balance required in dwelling units must be completed and the TAB report submitted prior to occupancy. Coordinate with the general contractor, owner's representative, and mechanical subcontractor to schedule TAB well in advance of occupancy.

F. Record dates and time of day of all tests, and ambient conditions (dry bulb and wet bulb).

3.02 AIR SYSTEMS TAB

A. Systems shall be tested, adjusted and balanced so that air quantities and temperatures at outlets are as shown on the Contract Drawings and so that the distribution from supply outlets is uniform over the face of each outlet.

B. Direct reading velocity meters may be used for comparative adjustment of individual outlets, but air quantities in ducts having velocities of 1,000 feet per minute or greater shall be measured by means of pitot tubes and inclined gauge manometers. Instrument test opening enclosures shall be provided as required at the direction of the TAB agency.

C. Adjustments shall be made in such a manner that splitter and volume adjusters close to air outlets will have the least pressure drop consistent with volume requirements. Primary balancing shall be obtained by adjustment of the dampers at branch duct take-offs. Adjustable fan drives shall be used for making final adjustments of total air quantities. Additional dampers or other air volume adjusters required to accomplish the balancing and adjusting shall be furnished and installed as part of the HVAC work.

D. Artificially load air filters by partial blanking to produce air pressure drop of at least 90 percent of the design final pressure drop.

E. Check and readjust factory set minimum and maximum air terminal unit flow rates if necessary. Balance air distribution on full cooling maximum. Reset room thermostats and check operation from maximum to minimum cooling, to the heating mode, and back to cooling. Record and report the heating coil leaving air temperature when in the maximum heating mode.

F. Adjust fan speeds to provide design air flow. Adjust V-belt drives, including fixed pitch pulley requirements.

G. After completion of the testing, adjusting and balancing of the air systems, provide electronic files (e.g. PDFs, etc.) of the complete test report showing the minimum following information which shall be submitted to the Engineer for review:

1. Systems inspection narrative on equipment and installation for conformance with design
2. Duct Air Leakage Test Report
3. Systems Readiness Report
4. TAB report covering flow balance and adjustments, performance tests, required information:
   a. Location of each air outlet or inlet. This shall be presented in the form of a reduced size floor plan showing outlet number keyed to the outlet number in the report.
   b. Dimensions or size of each outlet or inlet
   c. Type and manufacturer of diffusers, grilles, registers. Indicate duty as supply, return, exhaust, etc.
   d. CFM of air as indicated on the Drawings for each outlet or inlet with corresponding velocity
   e. Velocity of air as measured and corresponding cfm at which system has been balanced and adjusted, for each outlet or inlet
   f. Velocity of air measured and corresponding cfm, after each complete system has been balanced and adjusted, for each main branch or zone duct at the supply fan, the return fan and the exhaust fan, as the case may be
   g. After each complete system has been balanced and adjusted, the total cfm at fan discharge, the total return air to the apparatus, the total outside air to the apparatus, the total outside air to the apparatus, static pressure at fan outlet, total static pressure for apparatus, fan speed, motor amperage for each phase and voltage
5. Narrative of uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.

H. The above testing, adjusting, and balancing shall be performed for the first season of the year, cooling season or heating season, which occurs at the completion of the building. Additional balancing and adjusting which may be required for the season of the year next following shall be performed as part of the work under this specification.

I. For air conditioning systems with adaptive dehumidification cycle, test equipment in the conventional cooling mode, the dehumidification (hot gas) mode and the cooling with enhanced dehumidification (warm liquid) mode and record leaving air temperatures (db/wb) for each mode.

J. Ventilation air distribution systems (outdoor air and exhaust air) shall be balanced to achieve the airflow rates indicated on the drawings. These airflow rates shall be considered minimum rates. The measured air balance tolerance for both outdoor air and exhaust air rates shall be -0% to +10%.

Commented [DS1]: See previous note. You will delete this most of the time UNLESS you provide specific criteria that the systems and equipment must meet.

K. Include TAB for all kitchen exhaust hoods, fans, make-up air systems, etc. Measure and record airflow, static pressure, and air temperatures at hood exhaust inlets, hood make-up air outlets and hood conditioned air outlets (if applicable).

3.03 WATER SYSTEMS TAB

A. Water circulating systems shall be adjusted and balanced so that water quantities circulated through the apparatus will be as specified.

B. Where no meters are provided, the adjustment of individual coil circuits shall be based on return water temperatures and pressure drops, provided air balancing and adjusting has been satisfactorily completed first. Temperature control valves shall be wide open during the balancing. Balancing cocks and valves shall be set. If this results in excessive total flow, this shall be corrected by partial closing of pump discharge valves during further adjusting and balancing. Settings of cocks, valves, etc. shall be permanently marked so that they can be restored if disturbed at any time.

C. After completion of the testing, adjusting and balancing of the water systems, provide electronic files (e.g. PDFs, etc.) of the complete test report showing the minimum following information which shall be submitted to the Engineer for review:

1. Systems inspection narrative on equipment and installation for conformance with design
2. Systems Readiness Report
3. TAB report covering flow balance and adjustments, performance tests, [vibration tests and sound tests]. Required information:
   a. Identification of each piece of apparatus, manufacturer, size, model, rows, etc.
   b. Flow as indicated on the Drawings for each piece of apparatus and corresponding pressure drop
   c. Temperatures, pressures and corresponding water flow at each coil after each complete system has been balanced and adjusted
   d. Head, gpm, bhp, volts, amps for each pump specified
   e. Suction and discharge pressures at each pump and corresponding water flow after each complete system has been balanced and adjusted
4. Narrative of uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.

Commented [DS2]: See previous notes. You will delete this most of the time UNLESS you provide specific criteria that the systems and equipment must meet.

3.04 MARKING OF SETTINGS AND TEST PORTS

A. Following the approval of the final TAB Report, the setting of all HVAC adjustment devices including valves, splitters and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time. Style and colors used for markings shall be coordinated with the General Contractor.

B. The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leaks and maintain integrity of vapor barrier.

END OF SECTION

SECTION 23 07 00
HVAC INSULATION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. All work specified herein shall be accomplished in accordance with the applicable requirements of Section 23 00 00 - HVAC General.

B. The insulation shall be installed in a neat and workmanlike manner by trained personnel regularly engaged in the installation of insulation and approved by the insulation manufacturer. Insulation, adhesives, coverings and coatings shall be applied in strict accordance with its respective manufacturer's recommendations. Installer has been in business for no less than 5 years and has completed at least 10 installations of similar size projects.

C. The contractor shall verify that test and inspection of the work to be insulated have been completed and approved before the insulation is applied.

D. All insulation must meet applicable codes for Flame Spread and Smoke Developed ratings when tested in accordance with ASTM 84 and UL 723.

E. VOC Content: Submit adhesive and sealants product information or MSDS showing VOC content information for all applicable products specified under this section. All applicable products in this section must meet low VOC content as specified by LEED Specification Section 01 81 16: Facility Environmental Requirements. All work performed under this specification shall be accomplished in accordance with the requirements and provisions of the following sections:

1.02 WORK INCLUDED

A. The work done under this section shall include all labor, materials, accessories, services and equipment necessary to furnish and install all insulation, complete, as indicated on the Drawings and as specified herein.

1.03 QUALITY ASSURANCE

A. Materials shall be the standard products of manufacturers regularly engaged in the production of insulation products. Insulation materials shall be products that have been in use in commercial buildings for at least 2 years prior to bid opening.

B. Surface Burning Characteristics:

1. Insulation shall have a composite insulation, jacket, binders, and adhesive Flame-Spread rating of 25 or less and a Smoke-Developed rating of 50 or less and shall be so listed by UL.
2. Insulation and related materials shall have surface burning characteristics determined by test performed on identical products per ASTM E 84, NFPA 255, and UL 723, mounted and installed as per ASTM E 2231.
3. Adhesives, mastics, tapes, and other accessories shall have the same component ratings.
4. Materials shall be labeled indicating compliance with the above requirements.
5. All testing shall be performed by a testing and inspecting agency acceptable to authorities having jurisdiction. Insulation, jacket materials, adhesives, mastics,

tapes and cement material containers shall be labeled with appropriate markings of applicable testing and inspecting agency.

1.04 RELATED WORK

A. Where pipes and ducts pass through fire walls, fire partitions, above grade floors, and fire rated chase walls, the penetration shall be protected and sealed with fire-stopping materials as specified in Section 23 00 00 - HVAC General.

B. Adequate provisions shall be made to protect the premises, equipment, and the work of other trades against droppings, adhesives and coatings used in the installation.

C. Where indicated, painting of insulation jackets shall be as specified in Section 09 91 00 - Painting.

D. Refer to Section 23 23 00 Refrigerant Piping, Insulation and Accessories for refrigerant piping insulation.

1.05 SUBMITTALS

A. Submit product information for insulation materials to the Architect in accordance with Division 1 and Section 23 00 00 - HVAC General.

B. Submit shop drawings and data to prove complete compliance with these specifications on products and methods of installation. Include materials used, thickness for each application, flame and smoke ratings, thermal conductivity, permeance, density for each product, and jackets (both factory and field applied). Indicate methods of applications.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide materials which are the standard products of manufacturers regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to purchase. Insulation shall be CFC and HCFC free.

B. Provide insulation that meets or exceed the requirements of ASHRAE 90.1.

C. Insulation exterior shall be cleanable, grease resistant, non-flaking and non-peeling. Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either wet or dry state.

2.02 PIPE INSULATION FOR STEAM AND WATER PIPING

A. Materials as specified in this section shall be manufactured by Armstrong, Johns-Manville, Knauf, Pittsburgh-Corning, CertainTeed, Pabco, Dow Chemical, Owens Corning or approved equal.

B. Insulation thicknesses shall be as shown in the following table:

Minimum Pipe Insulation	Insulation Thickness for Pipe Sizes

Piping System Types	Fluid Operating Temperature Range		Mean Rating Temp.	Less than 1 in.	1 to less than 1-1/2 in.	1-1/2 to less than 4 in.	4 to less than 8 in.	8 in. and Larger
	°C	°F	°F	In.	In.	In.	In.	In.
(Cooling Systems)								
Chilled Water*, Geothermal Heat Pump Loop, Condensate	4.4-15.6	40-60	75	0.5	1.0	1.0	1.0	1.5
* For chilled water piping located in attics and other unconditioned spaces (excluding return air plenums), increase the pipe insulation thickness by 1/2" for pipe sizes up through 8". Insulation for piping 10" and larger shall be 2-1/2" thick.								

C. Unless noted otherwise, the abovementioned piping systems inside the building shall be insulated with a 5 lb/ft^3 (nominal) density sectional fiberglass insulation with a thermal conductivity (k factor) not to exceed 0.23BTU·in/hr·ft^2·°F (0.033 W/m K), when tested in accordance with ASTM C 335 at 75 °F (24 °C). The jacket shall be fire retardant with a suitable vapor barrier. All joints and seams shall be sealed vapor tight. All joints and seams shall be lapped in place to form a continuous vapor barrier covering. All seams shall then be covered with “All Service Jacket” (ASJ) 3" wide tape. The tape shall match the jacket. The tape shall be squeegeed in place to provide complete adhesion of the tape to the jacket and to provide a continuous vapor barrier covering. Exterior water piping shall be heat traced (Refer to Section 23 21 13 - PIPING AND ACCESSORIES).

D. Piping installed outdoors shall be insulated with cellular glass insulation, Pittsburgh-Corning “Foamglas” or approved equal. Insulation thickness required to prevent condensation shall be determined by the manufacturer for worse case ambient conditions.

1. Install with all service jacket and in accordance with manufacturer’s recommendations.
2. Where heat tracing is specified, oversize insulation to allow space for heat tape.

E. Equipment shall be insulated in the same manner as specified for the associated piping. Suitable provisions shall be made for breaking flanges as may be required for maintenance. Hot water pumps do not get insulated unless specifically called for. The following equipment, but not limited to, requires insulation: expansion tanks, air separators, chemical treatment “shot type” feeders, storage tanks, etc.

F. Provide high density preformed pipe insulation inserts at all pipe hangers. Inserts shall be equal to Foamglas by Pittsburgh Corning or calcium silicate. Provide ribbed hanger saddles by Centerline, Buckaroos, Inc. or approved equal.

G. All exposed insulated piping in mechanical rooms below 10'-0" AFF shall be protected by a corrugated aluminum jacket with bands 3'-0" on center.

H. “Circuit setter” type balancing valves shall be insulated with polyisocyanurate or extruded polystyrene block insulation with matching PVC cover. Insulation shall by easily removable for service. Valve insulation shall be as manufactured by Extol or approved equal.

I. Provide insulating tape over all piping specialties to prevent condensation such as drain valves, drain plugs, combination temperature/pressure test plugs, etc.

2.03 BLANKET TYPE INSULATION (DUCTWRAP)

A. Description:

1. Flexible, limited combustible, blanket type insulation composed of mineral or inorganic glass fibers bonded together with a thermosetting resin, meeting ASTM C 553, Type 1 and ASTM C 1290.
2. Vapor retarder jacket: Provide one of the following types of vapor retarder jackets:
   a. Foil-scrim-kraft (FSK), foil reinforced kraft (FRK), or polypropylene-scrim-kraft (PSK) with a 2" (50mm) (min.) stapling and taping flange on one edge.
   b. Conforming to ASTM C 1136 Type II.
3. Surface Temperature Application Limits: Insulation shall be rated for use on surfaces operating at temperatures up to 250°F.
4. Ratings:

Insulation Type:	**Type 1:**	**Type 2:**
Minimum R-Value, out of package*: hr•ft²•°F/Btu (m²•°C/W) at 75°F (24°C) mean temperature	R-7.4 (1.30)	R-10.3 (1.81)
Minimum R-Value, installed: hr•ft²•°F/Btu (m²•°C/W) at 75°F (24°C) mean temperature	R-6.0 (1.06)	R-8.0 (1.46)
Minimum Density: lb/ft³ (kg/m³)	1.0 (16)	0.75 (12)
Thickness: Inches (mm)	2 (51)	3 (76)
Maximum Labeled K-value at 75°F (24°C) mean temperature: Btu.•in/hr.•ft²•°F (W/m.•°C)	0.27 (0.039)	0.29 (0.042)

*Value may vary by manufacturer; minimum installed value must be met

B. Insulate the following with Type 1 blanket insulation:

1. All galvanized steel ductwork containing heated and/or cooled supply air, except:
   a. Exposed ductwork in finished conditioned spaces.
   b. Ductwork indicated to be internally lined or insulated with external insulation.
2. Concealed surfaces of ceiling diffusers exposed to non-return air plenums.
3. Return air ductwork exposed to attics or non-return air plenums.
4. Relief air ductwork and plenums from the exterior to 18” past the relief air damper assembly.
5. Return air, toilet exhaust, and general exhaust ductwork exhausting conditioned air and routed through interior spaces that are ventilated with outside air or exposed to outside air conditions.
6. Concealed outside air ductwork located within indirectly conditioned spaces (e.g. indoor soffits, furr-downs, vertical chases, etc.).
7. Ductwork and plenums located inside of the building (i.e. located within the exterior boundary or skin of the building thermal envelope) when containing or flowing, makeup air, garage ventilation intake or exhaust air ducts and plenums, when not indicated to be insulated with rigid fiberglass insulation. This applies to ducts and plenums whether exposed or concealed within chases when located on the interior side of the exterior skin of heated or cooled space.

C. Insulate the following with Type 2 blanket insulation:

1. Ductwork and plenums located outside of the exterior boundary or skin of the building thermal envelope when containing or flowing heated and/or cooled air when not indicated to be insulated with rigid fiberglass insulation.
2. Supply air ductwork located in unconditioned attic spaces and in indoor spaces that are ventilated with outside air or exposed to outside air conditions.
3. Concealed surfaces of ceiling diffusers exposed to attics.

D. Subject to compliance with requirements, insulation shall be manufactured by: CertainTeed, Johns Manville, Knauf, Owens Corning, or approved equal.

2.04 DUCT LINER

A. Refer to Section 23 31 00 – Ductwork and Accessories for duct liner requirements.

2.05 EXTERIOR SUPPLY AND RETURN AIR DUCTWORK

A. Exterior supply and return air ductwork shall be constructed of galvanized sheet metal lined with 2" thick 3 lb/ft^3 duct liner board (R-2 min); Johns-Manville Linacoustic R-300. All ductwork seams shall be externally sealed watertight with a 30-year silicone caulk and coated with a rust preventive coating over the entire duct surface.

1. As an alternative to insulated sheet metal, an outdoor duct system as manufactured by Thermaduct, LLC may be used. The system shall incorporate duct and fittings having an installed minimum R-value of 12. The system shall utilize non-fibrous closed cell Kingspan KoolDuct fortified inner liner compliant to UL (C-UL) 181, Standard for Safety Listed, Class 1 system and SMACNA Class 1 leakage, or less. Submit product data and layout drawings during the submittal phase.
2. As an alternative to internal insulation, exterior insulation may be Class B foil faced polyisocyanurate foam insulation with weather resistant white flexible cladding; Alumaguard Lite White by Polyguard. Install in accordance with manufacturer's installation instructions.
3. As an alternative to internal insulation, exterior insulation may be physically crosslinked closed cell polyolefin foam insulation with factory applied heavy duty multilayer composite foil facing with a UV and weather durable coating; Thermobreak No-Clad insulation by Sekisui Voltek. Install in accordance with manufacturer's installation instructions.

2.06 DUCTWORK WITHIN MECHANICAL ROOMS

A. Ducts within mechanical rooms shall be insulated with 1½" thick, 3 lb/ft^3 rigid fiberglass board with an R factor of not less than 6 (K = 0.23 at 75 degrees F mean temperature) with reinforced foil vapor barrier. Insulation shall be secured to ductwork with stick pins and speed washers. All joints and stick pin terminations shall be sealed with 3" wide strips of vapor barrier material and applied to form a continuous vapor seal.

B. Apply 1" x 1" x 30 mils thick white PVC corner angles in accordance with ASTM D 1784, Class 16354-C at all insulation board corners.

2.07 SINGLE WALL BOILER BREECHING AND DIESEL EXHAUST

A. Single wall boiler breeching and diesel exhaust within the building shall be externally insulated with 2" thick calcium silicate block securely held in place with wire or metal bands.

1. As an alternate to field insulated single wall breeching, a factory fabricated insulated double wall pressure stack system may be used. Refer to Section 23 31 00 Ductwork and Accessories for additional information.

2.08 EXTERIOR WEATHER PROTECTION

A. Piping and/or breeching exposed to the weather and designated to be insulated shall be insulated in the same way it is insulated within the building for concealed areas. It shall then be weatherproofed with corrugated aluminum jacketing. It shall have 3/16" corrugations and shall be 0.016" thick with a factory attached moisture barrier continuously laminated across the full width of the jacketing. All pipe fittings, valves and specialties exposed to the weather shall be insulated and weatherproofed with aluminum jacketing. Childers Universe-E11 Jacs of the same metal as the jacketing shall be used. Jacketing shall have a 2" lap at all joints. Longitudinal laps shall be on the underneath side of horizontal runs and slightly offset from one another. The outside of the longitudinal lap shall also have a 1" hem turned under. All laps shall be made with weatherproof mastic. Wrap the jacketing tightly and smoothly and secure with aluminum or stainless steel bands. Bands shall not be more than 12" on center and a strap shall be placed at the circumferential laps. The lap shall have adequate mastic to make a tight joint. Excess mastic shall be removed from the outside to provide a neat and professional appearance.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Shop drawing submittals shall include a complete package of materials and methods intended for use as described in this section.

B. All work shall be in strict accordance with applicable codes, ordinances and the manufacturer’s recommendations.

C. All work shall be performed in a professional workmanlike manner and standard trade practice. It shall be smooth in appearance and suitable for finish painting.

D. All exterior piping shall be installed with a corrugated aluminum jacket with bands 3'-0" on center.

E. Provide insulating tape over all piping specialties to prevent condensation such as drain valves, drain plugs, combination temperature/pressure test plugs, etc.

F. Fiberglass pipe insulation shall be applied to clean (free of rust) dry pipe prior to leak testing. Chilled and condenser water systems shall not be operated until the insulation is completely installed with a vapor barrier in place. Refer to Section 23 21 13 - Piping and Accessories for additional information.

END OF SECTION

SECTION 23 07 14
FIRE-RATED INSULATION SYSTEMS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. All work specified herein shall be accomplished in accordance with the applicable requirements of Section 23 00 00 - HVAC General.

B. The insulation shall be installed in a neat and workmanlike manner by experienced personnel regularly engaged in the installation of insulation and approved by the insulation manufacturer. Insulation, adhesives, coverings and coatings shall be applied in strict accordance with its respective manufacturer's recommendations. The installer shall have been in business for no less than 5 years and completed at least 10 installations of similar size projects.

C. The contractor shall verify that testing and inspection of the work to be insulated has been completed and approved before the insulation is applied.

D. All insulation must meet applicable codes for Flame Spread and Smoke Developed ratings when tested in accordance with ASTM 84 and UL 723.

1.02 WORK INCLUDED

A. The work done under this section shall include all labor, materials, accessories, services and equipment necessary to furnish and install all insulation, complete, as indicated on the Drawings and as specified herein.

B. Systems include:

1. Plenum wrap insulation to achieve a non-combustible rating for combustible materials in an air plenum.
2. Duct insulation to achieve zero clearance to combustibles and a 2-hour fire-resistive rated duct enclosure on commercial kitchen grease duct exhaust systems.

1.03 REFERENCES

A. The following published specifications, standards, tests, or recommended methods of trade, industry, or governmental organizations apply to single layer noncombustible fire rated plenum insulation:

1. UL 1887 - Visible Flame and Smoke Characteristics for Plastic Pipe.
2. ASTM E 84/UL/ULC 723 - Surface Burning Characteristics.
3. ASTM E 136 - Non-combustibility.

B. The following published specifications, standards, or tests apply to zero clearance two-layer fire rated systems of grease duct insulation:

1. NFPA 96
2. International Code Council Evaluation Service (ICCES)
3. ASTM E 2336 - Standard Test Methods for Fire Resistance Rated Grease Duct Enclosures
4. CAN/ULC-S144-09 Standard Method of Fire Resistance Test - Grease Duct Assemblies First Edition
5. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials

6. ASTM E 119 - Standard Test Methods for Fire Tests of Building Construction and Materials
7. ASTM E 136 - Standard Test Method for Noncombustiblity
8. ASTM E 518 - Standard Test for Durability
9. ASTM E 814 - Standard Test Method for Fire Tests of Through-Penetration Fire Stops

1.04 QUALITY ASSURANCE

A. Materials shall be the standard products of manufacturers regularly engaged in the production of insulation products. Insulation materials shall be products that have been in use in commercial buildings for at least 5-years prior to bid opening.

B. Fabricator Qualifications: Fabrication performed in quality-controlled manufacturing environment by experienced fabricators with references indicating multiple successful projects fabricating high temperature insulation blanket as required for this project.

C. Installer Qualifications: Installers experienced in performing work of this section who have specialized in installation of work similar to the scope required for this project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in original unopened packages, clearly marked with manufacturer's name, product designation, manufacturer's lot numbers and appropriate third-party classification listings.

B. Store in a covered dry environment.

C. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.06 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by the manufacturer for optimum results. Do not install products under environmental conditions outside of manufacturer's absolute limits.

1.07 SUBMITTALS

A. Submit product information for insulation materials to the Architect in accordance with Division 1 and Section 23 00 00 - HVAC General.

B. Submit shop drawings and data to prove complete compliance with these specifications on products and methods of installation. Include materials used, thickness for each application, flame and smoke ratings, thermal conductivity, permeance, density for each product, and jackets (both factory and field applied), if any. Indicate methods of application.

C. Submittal shall include storage and handling requirements and recommendations.

D. Submit certification and installation documentation showing system performance and code compliance.

1.08 MANUFACTURERS

A. Basis of design manufacturer: Unifrax I, LLC. Equal manufacturers provided they conform with the contract documents: 3M Fire Barrier and Morgan Thermal Ceramics Firemaster.

B. Manufacturers other than the basis of design manufacturer shall include a Compliance Review of the Specifications and Addenda (if applicable). The Compliance Review shall be a paragraph-by-paragraph review of the Specifications with the following designations marked in the margin of the original Specifications and any subsequent Addenda:

1. "C": Complies with no exceptions.
2. "D": Complies with deviations. For each and every deviation, provide a numbered footnote with reasons for the proposed deviation and how the intent of the Specification will be satisfied.
3. "E": Exception, does not comply. For each and every exception, provide a numbered footnote with reasons for non-compliance and possible alternatives.

PART 2 - PRODUCTS

2.01 PLENUM INSULATION FOR NONCOMBUSTIBLE FIRE RATED PLENUM

A. Product: FyreWrap 0.5 Plenum Insulation by Unifrax I, LLC, Tonawanda, NY:

1. Nominal 0.5 inches (12 mm) thick foil encapsulated blanket material at 8 lbs/ft^3 to provide a non-combustible rating.
2. An inorganic, flexible, non-asbestos, bio-soluble high temperature, foil encapsulated blanket material.
3. Blanket insulation shall maintain a 2012ºF (1100ºC) operating temperature
4. Blanket fiber materials shall be tested per EU regulatory requirements, Directive 97/69/EC for bio-solubility, and verified by an independent laboratory.
5. Performance: A lightweight, non-asbestos, bio-soluble, high temperature, inorganic, foil encapsulated insulation blanket. The plenum insulation system shall be tested and listed to provide a non-combustible rating for combustible items located in air plenums.
   a. Performance Requirements:
      1) Single Layer System of 1/2 inch (13 mm) thick material
      2) Meets UL 1887 test criteria for visible flame and smoke characteristics.
      3) Meets 25/50 Flame and Smoke Ratings per ASTM E 84.
      4) Insulation and combustible item shall be tested as an assembly.
      5) Tested and listed for PVC, CPVC, PB, PE, PP, PVDF and ABS.

2.02 DUCT INSULATION FOR ZERO CLEARANCE FIRE-RATED GREASE DUCTS

A. Product: FyreWrap Elite 1.5 Duct Insulation by Unifrax I, LLC, Tonawanda, NY:

1. Nominal 1.5 inch (38 mm) thick foil encapsulated blanket material at 6 lbs/ft^3 to provide 2-hour fire resistive enclosure assembly per ASTM E 2336.
2. A lightweight, flexible, inorganic, non-asbestos, bio-soluble, high temperature, foil encapsulated blanket wrap.
3. Flexible, fully encapsulated blanket material, two-layer system to provide 2-hour fire resistive enclosure assembly per ASTM E 2336 and CAN/ULC-S144-09.
4. Blanket insulation shall maintain a 2012ºF (1100ºC) operating temperature.
5. Blanket fiber materials shall be tested per EU regulatory requirements, Directive 97/69/EC for bio-solubility, and verified by an independent laboratory.
6. Provide field fabricated or prefabricated fire rated access doors (for cleanouts as required) to maintain 2-hour rating and required clearance.
7. Provide firestop sealants, tape, insulation pins, clips, banding and other components per manufacturer's installation instructions to provide fully functioning zero clearance to combustibles grease duct system.
8. Performance: Lightweight, non-asbestos, bio-soluble, high temperature,

inorganic, foil encapsulated insulation blanket. The blanket material shall be capable of performing at 2000ºF (1093ºC) matching the internal and external fire test temperature for grease ducts. The duct wrap system shall be a tested and listed system evaluated for reduced clearances to combustibles as an alternative to a grease duct, with a two-hour fire rated shaft enclosure. Testing shall be conducted at a nationally recognized testing laboratory.

a. Performance Requirements:
   1) Two-layer system of 1½ inch (38 mm) 6 lbs/ft^3 (96 kg/m3) material
   2) Zero clearance to combustibles across the entire surface of the blanket material per internal fire tests of ASTM E 2336
   3) 2-hour fire resistive enclosure assembly per ASTM E 119
   4) CAN/ULC-S144-09: Stability-2hr, Integrity-2hr, Insulation-2hr
   5) Firestop tested per ASTM E 814, 2 Hour F and T Ratings
   6) Meets 25/50 flame and smoke ratings per ASTM E 84

2.05 ACCESS DOORS

A. Access Door: Field fabricated 16-gauge steel

1. Threaded Rods: ¼ inch (6 mm) diameter
2. Gasket: ½ inch (13 mm) Unfaced FyreWrap or ceramic fiber blanket

B. Access Door: Ductmate Ultimate prefabricated 16-gauge steel

C. Access Door: Ductmate F2 prefabricated 16-gauge steel

PART 3 – EXECUTION

3.01 GENERAL

A. Shop drawing submittals shall include a complete package of materials and methods intended for use as described in this section. Include installation instructions, UL details, Material Data Safety Sheets, etc.

3.02 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.

B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.03 PREPARATION

A. Inspect and verify that all surfaces are smooth, dry, clean and free from dust, debris, or other loose materials. Surfaces shall be dry before the application of insulation materials.

B. Clean surfaces thoroughly prior to installation.

C. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.04 INSTALLATION

A. All work shall be in strict accordance with applicable codes, ordinances and the manufacturer’s installation instructions.

B. All work shall be performed in a professional workmanlike manner and standard trade practice. The finished work shall be smooth in appearance and suitable for finish painting.

3.05 FIELD QUALITY CONTROL

A. The manufacturer shall visit the project site to review the work and report in writing any deficiencies to the installing contractor. The report shall include recommendations for corrective action.

B. Schedule site visits to review the work during the preconstruction meeting.

3.06 PROTECTION OF THE WORK

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products prior to Substantial Completion.

END OF SECTION

SECTION 23 09 00.10

BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. All work specified herein shall be accomplished in accordance with the applicable requirements of Section 23 00 00 - HVAC General.

B. It is the intent of this specification to describe the basic architecture and performance requirements of the Building Automation System (BAS). The turn-key BAS shall include all software including operator software, programming tools, graphics editor, all other available software programs, modules, or plug-ins offered by the DDC manufacturers, hardware, Control Units, Distributed Controllers, Unitary Controllers, Local Area Networks (LANs), sensors, modems, wiring, connectors, control devices, actuators, installation and calibration, supervision, adjustments and fine tuning necessary for a complete and fully operational system. The BAS application program shall be written to communicate specifically utilizing BACnet protocols. Software shall include password protection, alarming, logging of historical data, full graphics including animation, full suite of field engineering tools including graphical programming and applications. All software including user interface, technician tools, programming tools, and graphic tools shall not require licensing subscriptions. If subscriptions are required, the BAS provider shall include 10 years of subscription services.

C. A distributed Direct Digital Control (DDC) system, complete with all software and hardware functions shall be provided and installed. System shall be completely based on ANSI/ASHRAE Standard 135-2008, BACnet. This system is to control all mechanical equipment, including all unitary equipment such as VAV boxes, heat pumps, fan-coils, AC units, etc. and all air handlers, boilers, chillers, and any other listed equipment using Native BACnet-compliant components.

D. All systems shall be complete true standalone OPEN systems.

E. The BAS must be an OPEN system. An open system is defined as a system that used industry standard protocols such as BACnet, Modbus, or LonWorks. The BAS shall provide the owner with all the tools necessary to make any modifications to the system without the requirement of a technician from the BAS provider.

F. Everything shall be reprogrammed through software without change of any hardware. The owner shall have all the tools necessary to reprogram without any additional costs.

G. The BAS shall have backward and forward compatibility.

H. All equipment, labor, tubing, etc. required to accomplish the control sequences outlined on the Drawings and in this Section, shall be furnished as part of the HVAC work.

I. All field-level controllers and end devices shall be provided and installed by the controls contractor under this specification section.

J. All other HVAC equipment purchased and installed as described in other sections of these specifications shall be coordinated with the requirements of this section to assure compatibility and function.

K. All electrical control wiring required as part of this work shall be furnished and installed as

part of the HVAC work and shall be installed in accordance with Division 26.

L. This section generally describes the desired operating sequence and characteristics of all HVAC systems provided and installed as part of Division 23 of these specifications. The preparation of the detailed control schematics necessary to accomplish the desired systems operation shall be included as part of the HVAC work. Electronic copies of these control schematics in PDF format shall be submitted and reviewed by the Engineer as part of the Submittal phase prior to the purchase or installation of any control equipment or other equipment that depends on these control schemes for proper operation.

M. Mount top of thermostats and sensors at 46" AFF unless noted otherwise. Provide clear locking guard assemblies for all public area thermostats. Coordinate thermostat locations with all trades. Coordinate final locations with the general contractor, interior designer, and the owner prior to installation. Locate adjacent to light switches where possible. Do not locate thermostats at the center or near center of a wall. Thermostats shall be mounted no closer than 8" from the corner or end of a wall or door. All thermostats shall be ADA compliant.

N. All major control equipment shall be located in suitable enclosures; NEMA 1 for indoor installations and NEMA 3R for outdoor installations.

1.02 CODES AND REFERENCES

A. Workmanship, materials, and equipment together with the resultant complete and operational DDC system shall be in compliance with the Authorities Having Jurisdiction (AHJ) for the project and the most restrictive of applicable local, state and federal codes and ordinances in cooperation with these plans and specifications. This contractor shall secure and pay for all applicable costs, fees, permits, and licenses. No additional costs shall be allowed for these items. At a minimum, the installation shall comply with the applicable sections of the current editions in effect thirty (30) days prior to receipt of bids of the following codes and standards:

1. ANSI/ASHRAE Standard 135 – BACnet-A Data Communication Protocol for Building Automation and Control Networks
2. Additional ASHRAE Standards
3. FCC-Part 15 Subparagraph J Class A Emissions Requirements
4. National Fire Protection Association – 70, 90A, 90B, 92
5. Underwriters Laboratories (UL) – UL-916 – Energy Management Systems (EMS)
6. Underwriters Laboratories (UL) – UL-864 – Standard for Control Units and Accessories for Fire Alarm Systems/UUKL Smoke Control System Equipment
7. IEEE802.11a/b/g/n
8. IEEE802.11n HT20 @ 2.4GHz
9. IEEE802.11n HT20/HT40 @ 5GHz

1.03 SPECIFICATION NOMENCLATURE

A. BAS: Building Automation System

B. BTL: BACnet Testing Laboratories

C. DDC: Direct Digital Control

D. I/O: Input/Output

E. LAN: Local Area Network

F. MS/″TP: Master Slave / Token Passing

G. O&M: Operation and Maintenance

H. OWS: Operator Workstation

I. NC: Normally Closed

J. NO: Normally Open

K. PC: Personal Computer

L. PID: Proportional plus Integral plus Derivative

M. RTD: Resistance Temperature Detector

N. SPDT: Single Pole Double Throw

O. WAN: Wide Area Network

P. WIFI: IEE802.11 a/b/g/n

1.04 MANUFACTURERS

A. Acceptable manufacturers/installers for automatic controls: Trane Concierge, Honeywell WEBs, Automated Logic WebCTRL.

B. Manufacturer shall meet the performance and material specifications of a product or component.

C. Available manufacturer listing does not grant permission of a manufacturer to deviate from this specification.

D. Installed systems must be OPEN as referenced in Section 1.01.E and 1.01.F. The owner shall have the ability to modify, service, or expand the system without the need of a technician from the BAS provider.

1.05 SYSTEM PERFORMANCE

A. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for web browser interface:

1. Configuration and Tuning Screens: Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
2. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
3. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
4. Alarm Response Time: An object that goes into alarm shall be annunciated at the workstation within 15 sec. Each workstation on the network shall receive alarms within five seconds of each other.

5. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
6. Performance: Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
7. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
   a. Water Temperature: Plus or minus 1°F.
   b. Water Flow: Plus or minus 5 percent of full scale.
   c. Water Pressure: Plus or minus 2 percent of full scale.
   d. Space Temperature: Plus or minus 1°F.
   e. Ducted Air Temperature: Plus or minus 1°F.
   f. Outside Air Temperature: Plus or minus 2°F.
   g. Dew Point Temperature: Plus or minus 3°F.
   h. Temperature Differential: Plus or minus 0.25°F.
   i. Relative Humidity: Plus or minus 2 percent
   j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
   k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
   l. Airflow (Terminal): Plus or minus 10 percent of full scale.
   m. Air Pressure (Space): Plus or minus 0.01-inch wg.
   n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
   o. Electrical: Plus or minus 5 percent of reading.

1.06 WORK INCLUDED

A. Furnish, install, program, and place into operation the BAS as specified herein and as shown on the drawings.

B. Furnish all input and output (I/O) control and accessory components as required to provide a complete workable system.

1. The control system shall also incorporate mechanical/electrical automatic temperature control devices, enclosures, interconnecting conduit, and cabling.
2. The BACnet® operating stack must be embedded directly in each individual DDC device at the media access controller level and in all operator interface and configuration applications. All hardware must be BTL listed.
3. All building controllers, application controllers, unitary controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135-2008, BACnet®.
4. Communication gateways, bridges, protocol translators or any other device that translates any proprietary communication protocol to BACnet® shall not be permitted as a part of the DDC system provided pursuant with this specification except as required to communicate to existing building systems or to systems installed under other sections. No gateways shall be used for communication to controllers installed under this section.

C. General: The control system shall consist of a high-speed, peer-to-peer network of ANSI/ASHRAE 135 native BACnet® DDC devices (DDC controllers and a web-based operator interface) for building mechanical and electrical systems. Depict each mechanical system and building floor plan by point-and-click graphics. Web pages shall be accessible through a conventional web browser. Operators shall be able to perform all normal operator functions through the web browser interface.

1. Equipment graphics shall be animated displaying all point data from the sequence of operations.

2. Equipment shall have the ability to be scheduled for normal, weekend, holiday, and events.
3. Remote alarm notification shall be via email and text messaging.

D. The Owner will provide IP addresses and any other network configuration information necessary to each control contractor for the purpose of configuring each Area Controller on the network. The controls contractor shall coordinate the IP address for each Area Controller. It shall be the responsibility of the control contractor to coordinate with the owner for network connectivity.

E. The system shall directly control HVAC equipment as specified in the Contract Documents. Each zone controller shall provide occupied and unoccupied modes of operation by individual zone. Furnish energy conservation features such as optimal start and stop, lighting control, night setback, request-based logic, and demand level adjustment of set points.

F. System shall use the BACnet® protocol for communication. Schedules, set points, trends, and alarms specified in the Sequences of Operation shall be BACnet® objects.

G. Design and provide all equipment cabinets, panels, data communication network cables needed, and all associated hardware.

H. Provide all interconnecting cables between supplied cabinets, application controllers, and input/output devices.

I. Provide complete manufacturer's specifications for all items that are supplied. Include vendor name of every item supplied.

J. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, startup, and commissioning.

K. Provide protective devices to prevent damage to the BAS as a result of lightning.

L. The BAS shall allow full user operation with a minimum of training. It shall have an English language display, with both user prompts and a "help" user tutorial.

M. The bidder shall perform sufficient site investigations to include all requirements described in the construction documents. Bids shall include, at Bidder's discretion, costs related to site verifications for renovation projects. No additional costs shall be allowed for such items.

N. Contractor shall have an obligation to participate in, cooperate with and support the Commissioning Agent process. Support includes, but is not limited to, tools, equipment, and personnel. Reference Division 23 Commissioning of HVAC. The Contractor shall conduct a coordination meeting with the BAS installer, commissioning agent, and design engineer prior to the submittals being prepared. The purpose of the meeting will be to qualify Sequences of Operation and determine what Cx procedures will be implemented.

O. Communications with Third Party Equipment: Control systems included with the products to be integrated with the work of this section shall be furnished with a network card (IP) for status and monitoring for BACnet® or Modbus over IP interface into the Direct Digital Control System described in this section (reference sequence of operations and points list for specifics). Those systems include Boilers, Chillers, CRAC units, Energy Recovery Units, Airflow Monitoring, Lighting, Power Monitoring, Switchgear, Fire Detection, Utility Sub-Meters, Variable Frequency Drives, and/or Variable Refrigerant Flow systems.

P. Prices shall be adhered to in all additional services and changes during project construction and throughout the warranty period.

Q. All controller hardware shall have a 2-year manufacturer's warranty. Warranty to include parts and labor. Warranty shall also include installation of all current software/firmware upgrades/patches available at the end of the warranty period.

R. Provide cost for service agreement along with details of service for three (3) years after the end of the warranty period. Contract agreement and cost should not be included in this project but should be provided separately to the Owner. A customer service plan shall be provided to the Owner and with a detailed description of agreement and rates. Service agreement shall include the following:

1. Discount on service labor rates
2. Guaranteed service response time of dial-in modem support within two (2) business hours, onsite service within six (6) business hours, and emergency repair service within two (2) hours when required at an additional cost.
3. Priority telephone assistance
4. Quarterly service for the following:
    a. Review of system operation
    b. Service maintenance for host computer workstation, controllers taps/modems, temperature and humidity calibration, power fail restart sequences, DDC controllers, and access controllers and door hardware.
5. Service summary reports to Owner Data base protection
6. Software upgrades

1.07 QUALITY ASSURANCE

A. The DDC system manufacturer shall be engaged full-time in the manufacture of equipment and devices of the scope, size and service required.

B. The DDC system manufacturer shall operate a Quality Management System formally certified to be in compliance with ISO 9001:2015.

C. The BAS shall provide the owner with all the tools necessary to make any modifications to the system without the requirement of a technician from the BAS provider.

D. Installer qualifications: Automatic control system manufacturer's officially authorized representative who is trained and approved for installation of system components required for this Project.

E. Installer shall have an established working relationship with the Control System Manufacturer for a period of 5 years or greater. If the distributorship has not had a duration of more than 5 years, the contractor will not be approved without written approval prior to bid date (no exceptions).

F. The DDC system Contractor shall assign project technicians and engineers who are officially trained and certified by the DDC System Manufacturer in the design, installation, programming and operation of the DDC System components.

G. The BAS installer shall have all tools, testing, and calibration equipment necessary to ensure reliability and accuracy of the system.

H. 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.

I. The DDC BACnet® network shall be based upon and installed according to the DDC System Manufacturer's standard integrated hardware and software product design and in accordance with the Manufacturer's installation and application documentation.

J. Comply with ASHRAE/ANSI 135 (Data Communication Protocol for Building Automation and Control Systems {BACnet}) for DDC system components.

K. Maximum reliability shall be achieved through extensive use of high-quality, pre-tested components. Each and every controller, sensor, and all other DDC components shall be individually tested by the manufacturer prior to shipment.

L. Provide all necessary BACnet-compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for every controller in the system, including unitary controllers.

M. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system. All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.

N. Engineer shall reserve all authority regarding approval, conditional approval, or rejection of systems not fully complying with these specifications.

1.08 SUBMITTALS

A. Product Data and Shop Drawings: The contractor shall provide shop drawings or other submittals on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent. es on suitable solid-state media (file format: .DWG, .DXF, .VSD, or comparable) and three 11" x 17" prints of each drawing. When manufacturer's cutsheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Submittals shall be provided within 12 weeks of contract award. Submittals shall include:

1. DDC System Hardware
   a. A complete bill of materials to be used indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
   b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:
      1) Direct digital controllers (controller panels)
      2) Transducers and transmitters
      3) Sensors (including accuracy data)
      4) Actuators
      5) Valves
      6) Relays and switches
      7) Control panels
      8) Power supplies
      9) Batteries

10) Operator interface equipment
11) Wiring

c. Wiring diagrams and layouts for each control panel. Show termination numbers.

a. Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.

b. Riser diagrams showing control network layout, communication protocol, and wire types.

c. Include list of control valves, Cv, pressure drops, spring ranges including actuator action (i.e., fail position, two-position, fail open/in place/close, etc.).

2. Central System Hardware and Software

a. A complete bill of material of equipment used indicating quantity, manufacturer, model number, and relevant technical.

b. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:

1) Central Processing Unit (CPU) or web server
2) Monitors
3) Keyboards
4) Power supplies
5) Battery backups
6) Interface equipment between CPU or server and control panels
7) Operating System software – web server
8) Color graphic software

B. Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring. Include equipment interlocks of affected systems and equipment, including chillers, pumps, exhaust fans, etc.
4. Control diagrams shall also indicate panels, gauges, control components, spring ranges, and set points.
5. Details of control panel faces, including controls, instruments, and labeling.
6. Written description of sequence of operation for each system.
7. Schedule of dampers including size, leakage, and flow characteristics including actuator action (i.e., fail position, two-position, fail open/in place/close, etc.).
8. Schedule of valves including flow characteristics.
9. DDC System Hardware:
   a. Wiring diagrams for control units with termination numbers.
   b. Schematic diagrams and floor plans for field sensors and control hardware.
   c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between Network Area Controller and control unit.
10. Control System Software:

a. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
b. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
c. List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.

11. Controlled Systems:
    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

D. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with Open Protocol native BACnet.

E. Project Record Documents: Submit electronic copies of record (as-built) documents upon completion of installation for approval prior to final completion. Submittal shall consist of:

1. Project Record Drawings. As-built versions of submittal shop drawings provided in Visio or ACAD format.

F. Operation and Maintenance (O&M) Manual. In addition to items specified in Division 01 Section “Operation and Maintenance Data,” include printed, electronic, or online help documentation of the following:

1. As-built versions of submittal product data.
2. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
3. Qualification data: for installer and manufacturer. Reference Section 1.07 on Quality Assurance.
4. Operator’s manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, override control, and changing setpoints and variables.
5. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
6. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
7. Documentation of programs created using custom programming language including setpoints. tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
8. Graphic files, programs, and database on optical media or electronic PDF.
9. List of recommended spare parts with part numbers and suppliers.
10. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

11. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
12. Licenses, guarantees, and warranty documents for equipment and systems.
13. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection period, cleaning methods and materials recommended, and calibration; time between tasks; and task descriptions.
14. Calibration records and list of setpoints.
15. Field quality-control test reports.

G. Online As-Builts – Contractor shall provide digital replications of as-builts that shall be accessible from equipment graphic locations for each piece of mechanical or electrical equipment controlled or monitored by the BAS.

H. Training Materials: The contractor shall provide training to owner personnel at the project site. Each student shall be provided with a dedicated computer workstation utilizing a simulated BAS software platform that is installed for this project. The owner shall not incur any additional cost for training classes as listed below for the first 3 years.

1. Provide training for a designated staff of Owner's representatives. Training shall be provided on site by a factory trained instructor and experienced in presenting material.
2. Provide course outline and materials for each class at least six weeks before first class. Training shall be furnished via instructor-led sessions. Engineer will modify course outlines and materials if necessary to meet Owner's needs. Engineer will review and approve course outlines and materials at least three weeks before first class.
3. Training shall be provided as follows:
   a. Eight Hours furnished before project is turned over to owner.
   b. Eight hours furnished with in three months of project turnover to owner.
   c. Sixteen hours to be used in minimum four blocks at owner's discretion within 12 months from project turnover to owner.

I. The following training courses shall be conducted for 4 individuals on 4 separate occasions each year for a 3-year period (12 classes total) following substantial completion:

1. Operator Overview - Consists of general system navigation, scheduling functions, setpoint modifications and parameter adjustments.
2. Advanced Topics Overview – How to manage users and access level users are to be granted; detailed analysis of trend setup/configuration, trend historian, alarm setup, alarm actions (email, printing, etc.), point renaming, and detailed analysis of equipment parameters.
3. Program/Logic Manipulation - Modify system programs as needed for additions and modifications.
4. Graphic Manipulation - Modify system graphics as needed for additions and modifications.
5. Hardware Troubleshooting - Operators shall be able to interact with this live system through the BAS utilized for this project. Class will provide students the ability to identify and repair common problems regularly encountered.
6. Software Troubleshooting - Operators shall be able to interact with this live system through the BAS utilized for this project. Class will provide students the ability to identify and repair common issues that can be utilized via software modifications.
7. HVAC System Training - Objective of this class is to provide basic HVAC system knowledge of systems on this project. This includes basic principle of the air side systems including VAV air systems, economizer control, dehumidification, demand

control ventilation, as well as, water side distribution systems such as pumping type (variable or constant), system type (primary/secondary or variable primary), and economizer control.

J. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a flash drive, complete with data files.
3. Device address list.
4. Software license required by and installed for any DDC workstations and control systems.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

1.10 COORDINATION

A. All equipment, components, parts, materials, etc. provided throughout the period of Work shall be fully compatible with all other equipment, etc. provided at any other time throughout the period of Work. Should updated versions of equipment be provided which are not fully compatible with earlier equipment provided, Contractor shall replace earlier equipment with later version at no cost to the Owner.

B. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans (i.e. Architectural and Interior Design) and room details before installation.

C. Coordinate compatibility of installed equipment with Division 26 Section “Network Lighting Controls”.

D. Coordinate compatibility of installed equipment with Division 28 Section “Fire Detection and Alarm”.

E. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

F. Coordinate equipment with Division 22 for gas meters, water meters, sump pump high level alarms, oil minder detection for elevator sumps, pump failures, diesel fuel tank monitoring, diesel fuel transfer pump monitoring, and any other plumbing equipment requiring monitoring to achieve compatibility of communication interfaces.

G. Coordinate equipment with Division 26 Section “Electrical Power Monitoring and Control” to achieve compatibility of communication interfaces.

H. Coordinate equipment with Division 26 Section “Panelboards” to achieve compatibility with starter coils and annunciation devices.

I. Coordinate equipment with Division 26 Section “Motor-Control Centers” to achieve compatibility with motor starters and annunciation devices.

1.11 WARRANTY

A. Warrant work as follows:

1. Warrant materials for specified control system and peripheral control devices free from defects for a period of two (2) years after final acceptance. Warrant all labor for a period of two (2) years after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. During the warranty period, the BAS contractor shall respond to calls for warranty service within eight (8) working hours. Emergency service shall be obtainable within four (4) hours of notification by the Owner. Emergency service shall be obtainable on a 24-hour basis, seven (7) days per week. Additionally, Contractor shall offer 24/7 after-hours support to include alarm monitoring and associated dispatch service.
2. The BAS contractor's office shall be within a 150-mile radius of the job site.
3. The BAS contractor shall obtain final approval from the owner on requirements for graphics before graphics are installed. This includes what points to display on each graphic, equipment tagging, and how graphics are organized.
4. The BAS contractor shall obtain final room number requirements from the owner prior to creating floor plan graphics.

B. The Owner shall grant to the Contractor, reasonable access to the BAS system during the warranty period including VPN access rights. The owner shall provide, at no cost to the contractor, a remotely accessible Ethernet connection during this period. Access shall have all features as if directly connected to the DDC system. Provide an engineering password for access to system and training as noted in the training section of this document. The contractor shall have remote access via Internet to the entire facility control system to provide service and diagnostic support.

C. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.

1.12 OWNERSHIP OF PROPRIETARY MATERIALS

A. Project-specific software and documentation shall become the Owner's property. This includes, but is not limited to: Application Programming Code, Database, Documentation, Graphics, and Record Drawings.

PART 2 - PRODUCTS

2.01 SUPPLIER QUALIFICATIONS

A. The Building Automation System (BAS) system integrator shall be a local or factory authorized office staffed with factory trained engineers and system representatives fully capable of providing instruction, routine maintenance, and emergency maintenance service on all system components. The BAS system integrator and installation team shall have a minimum of 10-years' experience in the design and installation of BASs similar in scope and size to that specified herein and shall be prepared to provide evidence of this history. The BAS system integrator shall have no less than three (3) similar projects which have BACnet-based building systems as specified herein installed by the authorized representative. These projects must be on-line and functional such that the Owners/Users representative can observe the system in full operation.

B. The contractor shall use only thoroughly trained and experienced workmen completely familiar with the items required and with the manufacturers recommended methods of installation. In all respects, the workmanship shall be of the highest grade, and all construction shall be done according to the best practice of the trade. Conduit shall be provided as required by Division 26, except that metal-clad (MC) armored cable shall not be allowed. Unless otherwise noted, conduit shall be concealed and installed square to the building lines. Any work not meeting these requirements shall be replaced or rebuilt without extra expense to the Owner.

C. As part of the routine and emergency maintenance service on system components during the installation, acceptance and warranty periods specified herein, the BAS system integrator shall have documented proof of resident factory trained maintenance/service personnel in all areas/scope of this system.

2.02 GENERAL

A. Only those products of particular importance to appearance or function are described in this Products section. Other items required for satisfactory systems operation but not herein described shall be furnished and installed to meet the intent and Operating Sequences herein described.

B. All materials and equipment used shall be standard components, of regular manufacture for this application. All systems and components shall have been thoroughly tested and proven in actual use.

2.03 MATERIALS

A. Provide new products the manufacturer is currently manufacturing and selling for use in new installations. New products shall be from a single manufacturer where possible with substitutions approved by the Engineer/Owner. Do not use this installation as a product test site unless explicitly approved in writing by the Owner. Spare parts shall be available for at least the duration of the warranty period as a minimum.

B. Installed devices shall be BTL listed.

2.04 GRAPHICAL USER INTERFACE COMPUTER HARDWARE (LAPTOP COMPUTER)

A. The computer hardware requirements are primarily controlled by the BAS provider and shall consist of an Intel Core i5 or i7 with provisions for an Ethernet connection and to connect a printer. The processing speed, RAM, and hard drive capacity shall be confirmed with the software manufacturer/provider and operating system.

B. Connection to the BAS network shall be via an Ethernet network interface card.

2.05 COMMUNICATION

A. Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet/MSTP (RS485) as defined by the BACnet standard.

B. Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using ANSI/ASHRAE Standard 135-2016 (BACnet®/ZigBee®)

C. The controls wireless network shall be capable of similar performance to a wired, equally quantified network by responding to controls requests within 10% timing comparison to provide a similar user experience for facility managers and occupants.

D. The controls wireless network shall be secured using Advanced Encryption Standard AES-128 (FIPS Pub 197) and HMAC (FIPS Pub 198). A Trust Center will create a randomly generated 128-bit network security key for each ZigBee network.

E. IEEE 802.15.4 radios to minimize risk of interference and maximize battery life, reliability, and range.

F. Indoor design range shall be a minimum of 200 feet (60 m); open range shall be 2,500 ft. (762 m) with less than 2% packet error rate to minimize the need for repeaters and optimize network reliability.

G. To maintain robust communication, self-healing, redundant mesh networking and two-way communications shall be used to optimize the wireless network reliability.

H. Wireless communication shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications.

I. Space/wall sensors shall be available with batteries with a typical life of 15 or more years to minimize maintenance costs or with power harvesting capabilities to minimize the need for batteries.

J. Certifications shall include FCC CFR47 - RADIO FREQUENCY DEVICES - Section 15.247 & Subpart EEach controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

K. Wireless Zone Sensors

To check for proper operation, wireless space temperature sensors shall include a signal strength on the space sensor display.

To allow local troubleshooting without specialized tools, error codes shall be displayed on the digital display. Error codes shall include: not associated, address to 000, improper software configuration, input voltage too high, or general sensor failure. Codes shall be indicated on inside of sensor back cover.

To support use by the physically impaired, the wireless space sensor shall be a minimum font size of 12 points, and the LCD model shall be readable in low light conditions.

L. Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via the internetwork. System shall automatically adjust for daylight saving and standard time.

M. System shall have the capability of being expandable to at least 1.5 times the required input and output objects with additional controllers, associated devices, and wiring. Confirm exact system requirements with the Owner prior to final pricing and installation.

N. System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.

1. System shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.
2. System shall support Web services write data request to each analog and

binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.

3. For read or write requests, the system shall require username and password authentication and shall support SSL (Secure Socket Layer) or equivalent data encryption.
4. System shall support discovery through a Web services connection or shall provide a tool available through the Operator Interface that will reveal the path/identifier needed to allow a third-party Web services device to read data from or write data to any object in the system which supports this service.
5. Direct access to trend data shall be provided in order to facilitate historical information stored by the system.

2.06 SOFTWARE LICENSE AGREEMENT

A. The BAS contractor shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software as defined by the manufacturer's license agreement but shall protect the manufacturer's rights to disclosure of trade secrets contained within such software.

B. The open license must contain the following statements:

1. accept.station.in="*"
2. accept.station.out="*"
3. accept.wb.in="*"
4. accept.wb.out="*"

C. Provide a printed copy of the license agreement as part of the submittal package.

2.07 OPERATOR INTERFACE

A. Touchscreen Display - The Manufacturer shall provide a 10" color touchscreen display that allows the building occupants to accomplish the following tasks:

B. Control the set points for multiple pieces of equipment with a single touch. Set point adjustment by the occupant shall be bound by editable limits. Occupant override of the system/equipment operating mode shall be possible with a single touch on the touchscreen display.

C. The touchscreen display shall provide occupant access to system schedule. Occupants shall have the ability to schedule events more than one year in advance. Exception schedules and holidays shall be shown clearly on the calendar, visible to the occupant on the touchscreen display.

D. The touchscreen display shall offer PIN control, which shall limit system control access to only those with proper login credentials.

E. The touchscreen display shall display the alerts that require service of the connected equipment.The system shall support an unlimited number of concurrent users.

F. The Web Mobile App - The manufacturer shall make available a mobile application that enables access to the control system. The mobile application shall support shall support the latest versions of both iOS and Android.

G. The mobile application shall allow the building occupants to accomplish the following tasks:

H. Control the set points for multiple pieces of equipment with a single touch.

I. Set point adjustment by the occupant shall be bound by editable limits.

J. Occupant override of the system/equipment operating mode shall be possible with a single touch.

K. Web UI - The manufacturer shall provide a web browser-based interface for the service provider.

L. The service provider interface shall support multiple web browsers and shall be plug in free (i.e. JAVA Runtime Environment (JRE), Adobe Flash).

M. On-Line Help and Training - The web browser interface shall provide a context sensitive, on line help system to assist the servicer in operation and configuration of the system.

N. The web browser interface shall include graphics pages for all equipment and system applications. These pages shall allow a servicer to obtain information relevant to the operation of the equipment and/or application.

O. Manufacturer shall provide the following interface capabilities: Animated equipment graphics for each piece of equipment, alarm indication for all equipment and system applications, historical data logs. Data logs shall be begin recording at system start up.

2.08 CONTROLLERS

A. General. Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), and Smart Actuators (SA) as required to achieve performance specified in paragraph 1.05 (System Performance).

B. Provide There shall be one or more independent, standalone microprocessor based System Controllers to manage the global strategies.

C. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.

D. Each System Controller shall be listed as a Building Controller (B-BC) by the BACnet Test Labs

E. All System Controllers shall have a real time clock.

F. All System Controllers shall be able to accept a BACnet time synchronization command for automatic time synchronization.

G. Remote Access / Network Security. Controls manufacturer shall provide secure remote access to the Building Automation System (BAS).

H. Secure remote access to the BAS shall be available anywhere, anytime, using a compatible client device (PC/tablet/phone).

I. Secure remote access to the BAS shall be maintained by controls manufacturer.

J. Secure remote access to the BAS shall not require additional software to be installed on the client device (i.e. VPN client).

K. Secure remote access to the BAS shall not require ANY inbound ports on a firewall to be "exposed" or "forwarded".

2.10 UNITARY APPLICATION CONTROLLERS MINI SPLIT SYSTEMS, EXHAUST FANS)

A. General - Provide one (1) Native BACnet application controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller via MS/TP or ArcNet LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for control of unit.

B. Application controllers shall include universal inputs that can accept 10K thermistors, 0–5 Vdc, 4–20 mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary and analog outputs on board.

C. All program sequences shall be stored on-board the application controller. No batteries shall be needed to retain the logic program. All program sequences shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely via Ethernet connection. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using programming tools as described in system programming section.

D. Application controller shall include support for intelligent room sensor. Display on intelligent room sensor shall be programmable at controller. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor.

2.11 TOUCH SCREEN COMMUNICATING THERMOSTAT

A. BACnet Conformance

1. Touch screen communicating thermostats shall be approved by the BTL as meeting the BACnet Application Specific Controller requirements.
2. Touch screen Communicating Thermostats shall, at a minimum, support MS/TP BACnet LAN types. They shall communicate directly through this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device.
3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types.
4. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

B. Touch screen Communicating Thermostat hardware shall:

1. Include a backlit touch screen for the user interface, buttons are not allowed.
2. Include Three (3) universal inputs with 12-bit resolution that can accept 3K and 10K Type II thermistors, 0-10 Vdc, 0–5 Vdc, 4-20mA, and dry contact signals. Inputs on controller may be either analog or digital.
3. Include built-in temperature sensor.
4. Include built-in humidity sensor.

5. Include Six (6) relay outputs on board.
6. Include Two (2) analog outputs with 12-bit resolution. Each auto-detecting for 0-10 Vdc or 4-20 mA control signals.
7. Meet the requirements of Listed Underwriters Laboratory for Open Energy Management Equipment (PAZX) under the UL Standard for Safety 916.
8. Meet the requirements for FCC Part 15, Class B.
9. Be powered by 24 Vac power.

C. Temperature Sensors

1. Type. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor. Sensor shall be vibration and corrosion resistant. Accuracy: +/- 0.5 F at calibration point. Minimum dead band of 5°F. Sensors shall be able to be calibrated at sensor or local controller terminal.
2. Duct Sensors. Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 5 ft in length per 10 SF of duct cross-section. Install such that the sensing element is in the main air stream.
3. Immersion Sensors. Provide immersion sensors with a separable 316 stainless steel well. Sensor, well, wellhead, and Greenfield fitting shall be supplied as a complete assembly. Well construction and pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities. Mount thermo-well and sensor in a ½" NFT saddle or threadolet to allow easy access for repair or replacement of the sensor.
4. Space Sensors. Space sensors shall have setpoint adjustment, override switch, display, and communication port as shown. Space sensor shall have manufacturer standard locking cover (color coordinated with Architect). Wireless space sensors communication shall be installed and tested in accordance with manufacturer's instructions.
5. Differential Sensors. Provide matched sensors for differential temperature measurement.
6. Outside Air Sensors. Watertight inlet fitting. Install away from exhaust or relief vents, not in an outside air intake, and in a location that is in the shade most of the day shielded from direct sunlight.
7. Room Security Sensors. Stainless-steel cover plate with insulated back and security screws.

D. Humidity Sensors

1. Duct and room sensors shall have a sensing range of 5%-95% RH, accurate to +/- 2%. Humidity sensors for use in zones shall be provided with integrated temperature sensing in order to eliminate the need to have two sensors on the wall. Sensor shall be able to be calibrated at sensor or local controller terminal.
2. Duct sensors shall have a sampling chamber.
3. Outdoor air humidity sensors shall have a sensing range of 20%-95% RH and shall be suitable for ambient conditions of 40°F-170°F.
4. Humidity sensors shall not drift more than 1% of full scale annually.
5. Room air humidity sensor shall have manufacturer standard locking cover (color coordinated with Architect), with concealed set-point adjustment and indication.
6. Output signal shall be either 0-10Vdc or 4-20mA.
7. Humidity transmitters shall be factory calibrated and require no field setting.

E. CO_2 Sensors

1. CO_2 sensors shall be space or duct mounted carbon dioxide sensors as required by the application. Space CO_2 sensors shall be mounted next to space

temperature sensors. The sensor shall have a range of 0-2000 ppm with an accuracy of ±5%. The response time for the sensor shall be less than one minute. The sensor shall be capable of providing an analog signal proportional to the CO_2 level sensed. The signal shall be either 0-10 Vdc or 4-20mA.

2.12 ENCLOSURES

A. NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.

B. All controllers, power supplies and relays shall be mounted in enclosures.

C. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment. Indoor enclosures shall be NEMA 12 when installed in other than a clean environment.

D. Enclosures shall have hinged, locking doors.

E. All direct digital controllers located indoors shall be installed in NEMA 1 enclosures. All direct digital controllers located outdoors shall be installed in NEMA 3R enclosures. Enclosures shall be of suitable size to accommodate all power supplies, relays and accessories required for the application. Each enclosure shall include a perforated subpanel for direct mounting of the enclosed devices. Include matched key locks for all enclosures provided.

2.13 AUTOMATIC SHUTDOWN OF RECIRCULATING AIR SYSTEMS

A. All fans supplying more than 2,000 cfm of air to any space shall be installed with a smoke detector in the return ductwork. Duct smoke detectors shall be installed in the return air path of air distribution systems utilizing a common supply and/or return air plenum with a combined design capacity greater than 2,000 CFM.

B. The smoke detector shall be wired to stop the fan upon detection of smoke and signal the building fire alarm control panel. The smoke detector shall be furnished by the Electrical Contractor, mounted in the duct by the HVAC Contractor, and wired by the Electrical Contractor. The smoke detector/shutdown relay shall be installed within 3 feet of the safety shut down controller.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Thoroughly examine project plans for control device and equipment location. Report discrepancies, conflicts, or omissions to Architect or Engineer before starting rough-in work.

C. Notify the Owner’s representative in writing of conditions detrimental to the proper and timely completion of the work.

D. Inspect site to verify that duct-, pipe-, and equipment-mounted devices can be installed as shown before proceeding with installation. Report discrepancies, conflicts, or omissions to the Engineer before starting rough-in work.

E. Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to the Architect. The Controls Contractor shall perform, at his expense, necessary changes in specified work caused by failure or neglect to report discrepancies.

3.02 OPERATION

A. BACnet Object List:

1. The following points as defined for each piece of equipment are designated as follows:
   a. Binary Out (BO) – Defined as any two-state output (start/stop) (enable/disable), etc.
   b. Binary In (BI) - Defined as any two-state input (alarm, status), etc.
   c. Analog In (AI) - Defined as any variable input (temperature) (position), etc.
   d. Analog Out (AO) - Defined as any electrical variable output. 0–20mA, 4–20mA and 0–10 Vdc are the only acceptable analog outputs. The driver for analog outputs must come from both hardware and software resident in the controllers. Transducers will not be acceptable under any circumstance.
2. Each and every point will be checked out by the Contractor and the Owner's Representative will inspect each point with the bidder prior to acceptance. Provide complete written documented inspections, test and checkout report. Calibrate all equipment.

3.03 INSTALLATION

A. Install software in control units to be accessible by the web server. Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Provide all miscellaneous devices, hardware, software, interconnections installation and programming required to ensure a complete operating system in accordance with the sequences of operation and any point schedules.

C. Provide a complete and operational temperature control and building automation system based on the following points and sequence of operation. The system shall be complete as to sequences and standard control practices. The determined point list, if provided, is the minimum amount of points that are to be provided. If additional points are required to meet the sequence of operation, they shall be provided.

D. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible. Route cable in a professional, neat and orderly manner. Cable bends shall not exceed the manufacturers' suggested bend radius. Enclosures and hardware or wiring shall not block or limit accessibility to service compartments of any other equipment. All wiring shall be in accordance with Division 26 requirements.

E. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture and high or low temperatures.

F. Termination practices

1. Strip back only as much cable jacket as required to terminate.
2. Preserve wire twists as closely as possible to point of termination (0.5" maximum) to keep signal impairment to a minimum.

3. Avoid twisting cable during installation.
4. No terminations or splices shall be installed in or above ceilings. Cable shall be continuous from one device termination to the next.
5. Electrical interlocks – All electrical interlocks shall be provided as specified. All electrical interlocks shall be made by means of motor starters or shall be accomplished by separate relays. No motor power lead shall be utilized in an interlock circuit.

G. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for compatibility, performance, and reliability. All cabling shall be placed with regard to the environment, EMI/RFI (interference) and its effect on communication signal transmission.

H. Each cable run shall include a three-foot service loop with wire tie located in the ceiling above the control unit panel. This is to allow for future re-termination or repair.

I. Do not route any controls cable within two feet of any light fixture, HVAC unit service access area, electric panel, or any device containing a motor or transformer.

J. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the owner's representative prior to rough-in.

K. Cable installation and attachments

1. The support system shall provide a protective pathway to eliminate stress that could damage the cabling. The cable shall not be crushed, deformed, skinned, crimped, twisted, or formed into tight radius bends that could compromise the integrity of the cabling. Controls cables shall not be run loose on ceiling grid or ceiling tiles. Support shall be provided by mounting appropriate fasteners which may be loaded with multiple cables. Provided that the weight load is carried by the support rod or wire, the support assembly may attach to the ceiling grid for lateral stabilization. The required support wires for the ceiling grid or light fixtures shall not be utilized. Any fastener attached to the ceiling grid shall not interfere with inserting or removing ceiling tiles. All cabling and supports must be positioned at least 12 inches above the ceiling grid.
2. Controls cables shall be run in bundles above accessible ceilings and supported from building structure. Cabling shall be loosely bundled with wire wraps randomly spaced at 30 to 48 inches on center, wire wraps shall not be tight enough to deform cabling and shall not be used to support the cabling.
3. Do not mix different signal strength cables on the same J-Hook (i.e. fire alarm, 25-volt speaker cable). Multiple J-Hooks can be on the same attachment point up to the rated weight of the attachment device.
4. Controls cables shall be run in conduit stubs, where stubs are provided, from wall mounted devices to above accessible ceilings. Conduit shall be required only within walls and concealed spaces to provide access. Provide a plastic snap bushing or sleeve on the end of each conduit stub.
5. Conduit, duct or track shall be used for controls cable in exposed areas.
6. All conduit, ducts, track and raceways shall be supported from the structure at industry standard intervals for the size specified, utilizing proper anchoring devices and techniques for each type of cable used.
7. All penetrations through fire rated walls or floors shall feature a short length of metal conduit. The hole shall be neatly cut, not oversize or irregular. Seal the interior of the conduit sleeve around the cables and around the outside of the sleeve on each side of the penetration with fire-stop caulk or putty.

L. Verify location of thermostats, humidistats, and other exposed control sensors with the Drawings, especially Interior Design Drawings, and room details before installation. Install devices per ADA requirements.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

M. Install tamper-proof, lockable guards on space sensors in Entrances, Public Areas, and where indicated on the Drawings.

N. Install water differential pressure status switches with manifolds and shut off valves for isolation as required by the manufacturer for maintenance.

O. Installation of Sensors

1. Install sensors according to manufacturer's recommendations.
2. Mount sensors rigidly and adequately for the operating environment.
3. Install room temperature sensors on concealed junction boxes properly supported by wall framing. Mounting height shall be as noted on the drawings.
4. Duct temperature sensors shall mount in an electrical box (through a hole in the duct) and positioned to be easily accessible for repair or replacement. Sensor shall be insertion type with lock nut and mounting plate as a complete assembly. Utilize an averaging sensor for ductwork greater than 48 inches in any dimension, or where air temperature stratification can exist, such as a mixed air plenum. Mount using factory approved element holders.
5. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.
6. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.
7. Install low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 1 ft of sensing element for each 1 ft^2 of coil area. Provide additional switches as necessary to provide full protection of the air stream for larger duct areas where the sensing element may not provide full coverage. Install low-limit temperature switch on the discharge side of the first water coil or steam coil in the airstream.
8. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.
9. Install outdoor air temperature sensors on north wall at the designated location and with a sun shield.
10. Differential Air Static Pressure
    a. Supply and Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
    b. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.
    c. Piping to pressure transducer pressure ports shall contain a capped test port adjacent to transducer.
    d. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.
    e. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

11. Smoke detectors, freeze stats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

P. Flow Switch Installation

1. Use correct paddle for pipe diameter.
2. Adjust flow switch according to manufacturer's instructions.

Q. Air Flow Measuring Stations - the air flow passage of the station shall be the same size as the inside duct dimensions for insulated ductwork.

R. Actuators

1. General. Mount actuators and adapters according to manufacturer's recommendations.
2. Electric and Electronic Damper Actuators: Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation. Link actuators according to manufacturer's recommendations.
   a. For low-leakage dampers with seals, mount actuator with a minimum 5-degree travel available for damper seal tightening.
   b. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5 degrees open position, manually close the damper, then tighten linkage.
   c. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
   d. Provide necessary mounting hardware and linkages for actuator installation.
   e. Damper actuators mounted outdoors shall have outdoor rated enclosures.

S. Install automatic dampers according to Division 23 Section 23 31 00 “Ductwork and Accessories”.

T. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

U. Install labels and nameplates to identify control components according to Division 23 Section “HVAC General”.

V. Install hydronic instrument wells, valves, and other accessories according to Division 23 Sections 23 21 13 “Piping and Accessories”, 23 05 23 “Valves for HVAC Piping” and 23 21 16 “Hydronic Piping Specialties”.

W. Install refrigerant instrument wells, valves, and other accessories according to Division 23 Section 23 23 00 “Refrigerant Piping”.

X. Install duct mounted manual volume control dampers according to Division 23 Section 23 31 00 “Ductwork and Accessories”.

Y. Install electronic and fiber-optic cables according to Division 27 Section “Communications Horizontal Cabling”.

3.04 IDENTIFICATION OF HARDWARE AND WIRING

A. Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 2 inches of termination. All cables shall have a label on both ends utilizing a self-laminating, flexible vinyl film and non-smear nylon marking pens.

B. Permanently label or code each point of field terminal strips to show instrument or item served.

C. Label control panels with minimum ½" letters on laminated plastic nameplates.

D. Label each control component with a permanent label. Label plug-in components such that label remains stationary during component replacement.

E. Label valves with nameplates.

F. Manufacturer's nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

G. Label identifiers shall match record documents.

3.05 COORDINATION

A. Site

1. Assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will interfere with work of other trades. If installation without coordination causes interference with work of other trades, the Contractor shall correct conditions without extra charge.
2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Test and Balance

1. Provide the Test and Balance Contractor a single set of necessary tools to interface to control system for testing and balancing. Train the Test and Balance Contractor to use control system interface tools. The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
2. Provide a qualified technician to assist with testing and balancing the first 20 terminal units.
3. The Test and Balance Contractor shall return tools undamaged and in working condition at the completion of testing and balancing.

C. Life Safety

1. Duct smoke detectors required for air handler shutdown are provided and wired under Division 26.
2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23 and wired by Division 26.
3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 26.

D. Coordination with Other Controls. Integrate with and coordinate controls and control devices furnished or installed by others as follows:

1. Communication media and equipment shall be provided as specified in Division 27.
2. Each supplier of a controls product shall configure, program, start up, and test that product to meet the sequences of operation described, regardless of where within the contract documents those products are described.
3. Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
4. The Controls Contractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.

3.06 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Commissioning and start-up of the BAS system shall be performed by a factory-authorized service representative of the BAS Contractor or Manufacturer. Electrical subcontractors shall not perform this work.

C. Continually monitor field installation for code compliance and workmanship quality.

D. Control System Checkout and Testing - Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test each point through its full operating range to verify that safety and operating control set points are as required.
4. Startup Testing: Complete startup testing to verify operational control system before notifying Owner of system demonstration. Provide Owner with schedule for startup testing. Owner may have representative present during any or all startup testing.
    a. Calibrate and prepare for service each instrument, control, and accessory equipment.
    b. Verify that control wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.
    c. Enable control systems and verify each input device's calibration. Calibrate each device according to manufacturer's recommendations.
    d. Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
    e. Verify that analog output devices such as I/Ps and actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.
    f. Test wireless sensors in accordance with manufacturer’s instructions and fully document testing in startup log.
    g. Prepare a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.

h. Verify that system operates according to the sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.

i. Alarms and Interlocks.

1) Check each alarm with an appropriate signal at a value that will trip the alarm.

2) Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.

3) Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

E. DDC Verification

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are in correct direction.
8. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
9. Check DDC system as follows:
   a. Verify that DDC controller power supply is from emergency power supply, if applicable.
   b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
   c. Verify that spare I/O capacity has been provided.
   d. Verify that DDC controllers are protected from power supply surges.
   e. Verify that systems utilizing wireless communications fully comply with Paragraph 1.05.A – System Performance.

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

G. Relocate or reconfigure wireless communications devices as required to fully comply with Paragraph 1.05.A – System Performance. If additional communications devices are required (routers, switches, repeaters, etc.) these shall be provided, installed, and commissioned by the Controls Contractor at no additional cost.

H. Controls Contractor shall protect against and be liable for damage to work and to material caused by Contractor's work or employees.

I. Controls Contractor shall be responsible for work and equipment until inspected, tested, and accepted. Protect material not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

1. The General Contractor shall be responsible for wall sensors and control wiring/communication cabling damaged during construction.

J. The control system in its entirety shall be reviewed and tested by the Commissioning Agent (Cx). Specifically, the Mechanical and Controls Contractor shall create a testing matrix from the sequence of operation for each air handling system for the Cx to utilize and check off each mode after visually verifying each operation. The Cx shall submit the testing matrix to the Design Professional one (1) week prior to final inspection with all items checked and the Cx's signature of approval and date. The testing matrix shall be submitted to the Mechanical Engineer at 60% project completion for approval. Typical HVAC AHU Fire/Smoke Damper Control Matrix should include AHU fan status, supply damper status and return damper status for supply air detector activation and return air detector activation. Each status shall be verified and checked by the Cx. Typical HVAC Smoke Evacuation Mode Testing for AHU should include (if applicable); supply fan status, return fan status, relief damper status, return damper status, outside air fan status, outside air damper status, air handling units adjacent to zone status, air handling unit supply air fire/smoke damper status, return air fire/smoke damper status, interlocked exhaust fan status for area smoke detector activation, supply duct smoke detector activation, return duct smoke detector activation, outside air duct smoke detector activation and outside air/area smoke detector activation. Coordinate requirements with control drawings. Each status shall be verified and checked by the Cx.

3.07 PROGRAMMING

A. Point Naming. Name points as shown on the equipment points list provided with each sequence of operation.

B. Software Programming. Programming shall provide actions for each possible situation.

1. Application Programming. Provide application programming that adheres to sequences of operation as indicated on Drawings.
2. System Programming. Provide system programming necessary for system operation.

C. Operator Interface

1. Standard Graphics. Show on each equipment graphic input and output points and relevant calculated points. Point information on graphics shall dynamically update.
2. Install, initialize, start-up, and troubleshoot operator interface software and functions (including operating system software, operator interface database, and third-party software installation and integration required for successful operator interface operation).

3.08 ADJUSTING

A. Calibrating and Adjusting

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
   a. Check analog inputs at 0, 50, and 100 percent of span.
   b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
   c. Check digital inputs using jumper wire.

d. Check digital outputs using ohmmeter to test for contact making or breaking.
e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:
   a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
   b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
   a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
   b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
   a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
   b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures for review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Provide certificate stating that control system has been tested and adjusted for proper operation.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to the Project during other than normal occupancy hours for this purpose.

3.09 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls.

B. Provide at least two persons equipped with two-way communication. Demonstrate calibration and response of any input and output points requested by the Engineer and/or the Cx. Provide and operate test equipment required to prove proper system operation. Demonstrations shall be performed in the presence of the Engineer, Cx and owner simultaneously.

C. Demonstrate compliance with sequences of operation through each operational mode.

D. Demonstrate complete operation of operator interface.

E. Demonstrate: DDC Loop Response, Demand Limiting, Building Fire Alarm System Interface, and Trend Logs for each system.

F. Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

G. Acceptance

1. After tests described in this specification are performed to the satisfaction of the Engineer, Cx and Owner, the Engineer will accept the control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Engineer will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.
2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved as required in paragraph 1.08 (Submittals).

3.10 CLEANING

A. Each day clean up debris resulting from work. Remove packaging material as soon as its contents have been removed. Collect waste and place in designated location.

B. On completion of work in each area, clean-up work debris and equipment. Keep areas free from dust, dirt, and debris.

C. On completion of work, check equipment furnished under this section for paint damage. Repair damaged factory-finished paint to match adjacent areas. Replace deformed cabinets and enclosures with new material and repaint to match adjacent areas.

3.11 SEALING PENETRATIONS

A. All penetrations in walls, ceilings, and partitions required by controls work shall be sealed with an appropriate pliable sealant or fire caulking to make the penetration airtight and maintain the integrity of the fire rating. Penetrating items shall include, but not be limited to, conduit, cables, control wiring (especially for thermostats and sensors), hangers, mounting hardware, etc.

3.11 OPERATING SEQUENCE

A. All units and systems shall be controlled as described on the Drawings and as recommended by equipment manufacturers.

B. Coordinate with Owner in operating equipment to maximize comfort and economy.

C. Refer to the drawings for sequence of operation.

3.12 ADDITIONAL INSTRUCTIONS

A. Provide status and alarm points on the following equipment (if applicable) furnished and installed under other sections. Include furnishing and installing sensors, cabling and incorporating into graphic and alarm annunciation.

B. Make-up water for cooling towers, chilled water, hot water, tempered water systems to alarm and close valves if excessive flow is detected.

C. Domestic Water - Incoming meter, meter at cooling tower, domestic water pump status, surge tank level

D. Domestic Hot Water - Leaving water temperature, pump status

E. Fire Alarm - Alarm monitoring (full Fire Alarm integration), smoke dampers (damper position).

F. Electrical - Pre-trip alarms

G. Incoming Power - demand kilowatts, totalized kilowatts-hrs, loss of service, loss of phase

H. Generator - Status of generator

I. Elevator Pits - High water alarm

J. UPS System - Normal power, over/under voltage, battery power.

K. Lighting - Relays and contacts shown on electrical drawings, lighting blinking capability, override capability. Provide lighting contactors as scheduled on the electrical lighting drawings.

END OF SECTION

SECTION 23 23 00

REFRIGERANT PIPING, INSULATION AND ACCESSORIES

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. All work specified herein shall be accomplished in accordance with the applicable requirements of Section 23 00 00 - HVAC General.

B. Refrigerant piping shall meet the requirements of the Safety Standard for Refrigeration Systems (ANSI/ASHRAE Standard 15-Latest Edition) and the Code for Pressure Piping (ANSI/ASME Standard B31.5-Latest Edition: Refrigeration Piping and Heat Transfer Components).

C. Piping, valves, accessories, and insulation installed indoors shall have a flame-spread index of 25 or less, and smoke-developed index of 50 or less.

D. VOC Content: Submit adhesive and sealants product information or MSDS showing VOC content information for all applicable products specified under this section. All applicable products in this section must meet low VOC content as specified by LEED Specification Section 01 81 16: Facility Environmental Requirements. All work performed under this specification shall be accomplished in accordance with the requirements and provisions of the following sections:

1.02 WORK INCLUDED

A. The work under this section shall include all labor, materials, accessories, services, and equipment necessary to furnish and install all refrigerant piping, insulating systems, and accessories, complete, as indicated and specified herein.

B. Without limiting the generality thereof, the work in this section shall include the following items:

1. Direct expansion (DX) system piping (cooling only and heat pump)
2. Variable Refrigerant Flow/Variable Refrigerant Volume (VRF/VRV) system piping
3. Insulating the following systems:
    a. Refrigerant suction (low pressure gas) piping
    b. Refrigerant hot gas (discharge or high-pressure gas) piping
    c. Refrigerant liquid piping for VRF/VRV and Heat Pump systems
    d. Refrigerant liquid piping for ductless split systems

1.03 RELATED DOCUMENTS

A. Specification sections:

1. 23 81 28.12 Ductless Cooling Only Split Systems
2. 23 81 28.13 Ductless Split System Heat Pumps
3. 23 81 29 Variable Refrigerant Flow HVAC Systems

1.04 RELATED REFERENCES

A. Designation and Safety Classification of Refrigerants (ANSI/ASHRAE Standard 34-Latest Edition).

1.05 QUALITY ASSURANCE

A. Installer Qualification: Only trained and experienced installers skilled in refrigeration pipe installation, Copper-Tube, Pressure-Seal-Joint Fittings and brazing of copper tubing shall be used.

B. Piping, valves, and accessories shall be manufactured in the United States. Submit Certificate of Manufacture with shop drawings.

1.06 SUBMITTALS

A. Product Data: For each type of fitting, valve, and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, valve arrangements and locations, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

C. Piping materials including Certificate of Manufacture

D. Training certificates for installers of Copper-Tube, Pressure-Seal-Joint Fittings

E. Insulation products, adhesives, coatings, etc. including Material Safety Data Sheets

F. Field quality-control test reports

G. Operation and maintenance data

1.07 PRODUCT STORAGE AND HANDLING

A. Store piping, fittings, insulation, valves, and specialties in a clean and protected area.

B. Piping, tubes, and coils shall be stored with end caps in place to ensure that piping interior and exterior remain clean prior to installation.

PART 2 - PRODUCTS

2.01 REFRIGERANT PIPING

A. Piping shall be:

1. Type “L” hard drawn seamless copper tube conforming to ASTM B88, or
2. Type “ACR” (Air Conditioning and Refrigeration) service copper tubing conforming to ASTM B280.
   a. Straight Lengths: ASTM B 75, UNS C12200, H55 Temper (Light Drawn), ACR Bending Quality; Cleaned, Eddy Current Tested, and Plugged per ASTM B 280.

b. Coiled: ASTM B 280, UNS C12200, O60 Temper (Soft Annealed), ACR, cleaned and capped. Coils shall be dehydrated, purged with Nitrogen, and tightly capped to insure cleanliness. Piping shall be engineered and constructed to support R-410A to 700 psi @ 250°F.

1) Acceptable manufacturers:
   a) Streamline/Mueller
   b) Reftekk, Inc.
   c) Linesets, Inc.
   d) ACR Green Proshield by Select Manufacturing, Inc.
   e) JMF Company

B. Joints shall be brazed. Brazing filler metals shall comply with AWS A5.8.

C. Alternate piping/fitting connection system:

1. Copper-Tube, Pressure-Seal-Joint Fittings:
   a. Copper Press Fittings: Refrigerant Grade Copper (UNS C12200 min. 99.9% pure copper for body) for use with Type ACR, Hard Drawn Type K, and L, and Soft Annealed Type K, and L tubing compatible with ASTM Standards noted above.
      1) Continuous operating temperature: Minus 40°F to Plus 250°F (minus 40°C to plus 121°C).
      2) Maximum Rated Operating and Abnormal Pressure: 700 psi (48 bar/4800 kPa).
      3) Burst Pressure: >3X Maximum Operating and Abnormal Pressure: >2100psi/ >144 bar/ >14400 kPa).
      4) Vacuum Pressure Capability: 200 Microns.
      5) Leak Tightness: Helium ≤ $7.5x10^{-7}$ $Pa.m^3/s$ at +20°C and 10 bar.
   b. O-Rings: Factory installed Hydrogenated Nitrile Butadiene Rubber (HNBR) or material compatible with specific refrigerant used.
      1) Temperature Range: Minus 40°F to Plus 284°F (minus 40°C to plus 140°C). Temperature ratings may vary slightly.
   c. Warranty: 10-year manufacturer's warranty for defects in material and workmanship.
2. Tools: Manufacturer's approved jaw(s) and tool: Approved jaws display two circular 360 deg (400 g) press bands with circular groove on either side, along with a manufacturer's witness mark embossed on the bands.
   a. Maximum Allowable Working Pressure: In accordance with UL 207: 700 psig (48 bar).
   b. Minimum Allowable Burst Pressure: In accordance with UL 207: 2100 psig (145 bar).
3. Basis-0f-Design Product: Subject to compliance with the requirements herein, RLS, LLC, Rapid Locking System Press Fittings.
   a. Acceptable alternate press fitting products:
      1) Mueller/Streamline ACR Copper Press Fittings
      2) ZoomLock MAX by Parker Hannifin, Sporlan Division

2.02 VALVES, FITTINGS AND SPECIALTIES

A. Fittings shall be wrought copper conforming to ASME/ANSI Standard B16.

B. Valves, filter-driers, and other accessories shall be suitable for refrigerant service.

C. Field Swaged Brazing Cups: MSS-SP-73, ASME B 16.50

D. Field Bends (all angles): ASME B31.5

E. Full Port Refrigeration Service Valves:
1. Body: Forged brass uni-body style with brass cap including key end to remove core
2. Schrader service valve with cap
3. Core: Removable ball-type check valve with stainless-steel spring
4. Seat: Polytetrafluoroethylene
5. End Connections: Socket ends
6. Working Pressure Rating: 700 psig (factory tested)
7. Maximum Operating Temperature 300°F
8. Valves must be specifically rated for R-410A
9. Approved manufacturers: Diamondback, Parker, RLS, Mueller/Streamline

2.03 INSULATION

A. Refrigerant piping shall be insulated as follows:

1. Refrigerant Piping Installed Outdoors: shall be insulated with flexible elastomeric tubing insulation with factory applied UV resistant durable protective jacket; Armaflex Shield™ continuous coil pipe insulation as manufactured by Armacell, LLC or alternates listed below, when the product is available in the required pipe size and insulation wall thickness (k-factor: 0.25 hr•ft²•°F/Btu (0.036 m²•°C/W) at 75°F (24°C) mean temperature). Polyethylene (PE) insulation is not acceptable. No field applied protective coating or finish shall be used with this insulation. Longitudinal and butt joints shall be sealed per manufacturer's installation instructions.
   a. Acceptable alternate elastomeric product:
      1) K-Flex USA; K-Flex Titan™ (k-factor: 0.23 hr•ft²•°F/Btu (0.035 m²•°C/W) at 75°F (24°C) mean temperature).
      2) Mueller Streamline Duraguard UV (k-factor: 0.242 hr•ft²•°F/Btu (0.035 m²•°C/W) at 75°F (24°C) mean temperature).
2. Refrigerant Piping Installed Indoors: shall be insulated with flexible elastomeric tubing insulation; AP/Armaflex Black LapSeal™ pipe insulation as manufactured by Armacell, LLC or alternates listed below (k-factor: 0.245-0.28 hr•ft²•°F/Btu (0.035 m²•°C/W) at 75°F (24°C) mean temperature). Polyethylene (PE) insulation is not acceptable. All joints and seams shall be sealed weathertight with Armaflex Black LapSeal™ Tape. Black LapSeal™ Tape shall also be used to secure the thermostat cable to the pipe insulation prior to applying the finish coat. The finish coat for this flexible elastomeric insulation when installed outdoors shall be two coats of a water-based latex paint designed for use over all forms of flexible elastomeric insulation. Finish coat shall provide a protective finish suitable to both indoor and outdoor applications, formulated for cold weather flexibility to resist cracking and weather-resistant to ultraviolet (UV) and ozone. Coating shall be Armaflex WB finish or equivalent product compatible with the insulation.
   a. Acceptable alternate products:
      1) Aeroflex, USA, Inc.; Aerocell-SSPT™ (k-factor: 0.245 hr•ft²•°F/Btu (0.035 m²•°C/W) at 75°F (24°C) mean temperature) with Protape and two coats of field applied Aerocel Aerocoat. (Aerocel Aerocoat required for outdoor installation only).
      2) K-Flex USA, LLC., K-Flex Insul-Lock DS (k-factor: 0.245 hr•ft²•°F/Btu (0.035 m²•°C/W) at 75°F (24°C) mean temperature) (indoor use only).
      3) Mueller Streamline elastomeric insulation (k-factor: 0.245 hr•ft²•°F/Btu (0.035 m²•°C/W) at 75°F (24°C) mean temperature) (indoor use only).

3. Fittings, valves, and specialties shall be insulated with factory formed sectional units of the materials listed above.
4. Insulation that is outdoors and not directly exposed to sunlight (i.e., piping is enclosed in a prefabricated duct system) does not require the UV protective coating.
5. Insulating systems above are to be considered as a minimum. Air conditioning system manufacturer's recommendations take precedence over the insulation materials listed above. Submit air conditioning manufacturer's installation instructions and insulation product data for review and approval.

B. Insulation thickness shall be as follows:

ALL CODE VERSIONS

1. VRF/VRV Heat Pump and Heat Recovery Systems - Insulate all piping:
(Note that some ductless split systems and multi-split systems may operate at these temperatures. Verify operating temperatures with the manufacturer)

VRF/VRV Refrigerant Piping Systems											
REFRIGERANT CONDITION or PHASE	REFRIGERANT TEMPERATURE RANGE (°F)	INSULATION MEAN RATING TEMPERATURE (°F)	ACR TUBING OUTSIDE DIAMETER								
			1/4"	3/8"	1/2"	5/8"	3/4"	7/8"	1-1/8"	1-3/8"	1-5/8"
			INSULATION THICKNESS REQUIRED (INCHES)								
HIGH PRESS VAPOR	141-200	125	1-1/2"	1-1/2"	1-1/2"	1-1/2"	1-1/2"	1-1/2"	1-1/2"	1-1/2"	2"
LIQUID	105-140	100	1"	1"	1"	1"	1"	1"	1"	1"	1-1/2"
LOW PRESSURE VAPOR	40-60	75	1/2"	1/2"	1/2"	1/2"	1/2"	1/2"	1/2"	1/2"	1"
	BELOW 40	50	1"	1"	1"	1"	1"	1"	1-1/2"	1-1/2"	1-1/2"
NOTE: FOR PIPING SMALLER THAN 1-1/2 INCHES AND LOCATED IN PARTITIONS WITHIN CONDITIONED SPACES, REDUCTION OF THESE THICKNESSES BY 1 INCH SHALL BE PERMITTED, BUT NOT TO THICKNESSES BELOW 1 INCH.											

ASHRAE 90.1-2010, 2013, 2016, and 2019

1. Traditional Cooling Only Split Systems (TXV located at indoor unit) – Insulate suction piping only:
   a. All pipe sizes 1/2" insulation
2. Traditional Heat Pump Split Systems (TXV located at indoor unit) – Insulate suction piping only:
   a. <1-1/2" pipe 1" insulation
   b. 1-1/2"<4" pipe 1-1/2" insulation
3. Mini-Split Cooling Only (TXV located at outdoor unit) – Insulate all piping – 1/2" insulation
4. Mini-Split Heat Pump (TXV located at outdoor unit) – Insulate all piping – 1/2" insulation

PART 3 - EXECUTION

3.01 GENERAL

A. Refrigerant piping shall be supported as shown on the Drawings and as required at intervals not over 8'-0" O.C. and at all turns and offsets. Hangers and pipe clamps shall be copper plated tubing hangers of adequate size to fit around tubing and insulation as required. Saddles shall be used under insulated tubing to protect insulation. Piping routed more than 6 (six) lineal feet on the roof shall be supported by B-Line “Dura-Blok” rooftop supports or approved equal.

B. Pressure testing of piping systems shall be in accordance with standard industry practice for the refrigerant used.

C. Refrigerant piping shall be clean and free of outside contaminants at all times. Prior to start-up of any equipment or insulation installation, all piping shall be cleaned, tested, dehydrated and charged as recommended by the refrigerant compressor manufacturer.

1. Procedure: Joints and connections in refrigerant piping shall not be installed in partitions or walls or where inaccessible for testing, inspection and rework. Make provisions to prevent contact of dissimilar metals. During construction, cap all tubing to prevent moisture from entering. Keep in dry location.
2. Leak testing and recharging: Upon completion of installation of air conditioning equipment, test all refrigerant piping, components and accessories, including quick-connect refrigerant connectors for evaporator and condensing unit; test with a halide torch; prove tight by Contractor to assure a leak-tight refrigerant system. If leaks are detected at the time of installation or during warranty period, remove entire refrigerant charge from system, correct leaks, and retest system. After system is found to be leak free, evacuation shall be accomplished by use of a reliable gauge and a vacuum pump capable of pulling vacuum of at least one mm Hg absolute. Accomplish system evacuation in strict accordance with equipment manufacturer’s printed instruction. System leak testing, evacuation, dehydration and charging with refrigerant shall comply with standard industry practice and local codes and ordinances.

D. Refrigerant piping shall be run continuously, without joints, where possible. All joints in refrigerant piping shall be made accessible. Joints shall not be permitted in concrete slabs or below grade.

E. Refrigerant circuit access ports located outdoors shall be fitted with locking-type tamper-resistant caps or shall be otherwise secured to prevent unauthorized access.

F. All piping shall be run true to grade and shall be arranged to make the best possible appearance. Except where otherwise required by conditions of installation, all piping shall be symmetrical and parallel with lines of buildings or structure in which it is installed. All piping shall be run concealed except in mechanical room and where indicated otherwise.

G. All piping and equipment shall be supported and guided. Anchors shall be provided to absorb or transmit thrust and eliminate vibration or pulsation. Hangers or supports shall be provided near each change of direction. Supports shall be so located or shall be of such type as not to unduly restrict the movement of the pipe due to lateral or longitudinal expansion.

3.02 PIPING APPLICATIONS

A. Suction (low pressure gas), Hot Gas (high pressure gas) and Liquid Lines 7/8" OD and Smaller for Conventional Air-Conditioning, Heat Pump, and Heat Recovery Applications: Copper, Type ACR, O60 (soft annealed)-temper tubing and field bent fittings with brazed joints.

B. Suction (low pressure gas), Hot Gas (high pressure gas), and Liquid Lines 2-1/8" OD and smaller for Conventional Air-Conditioning, Heat Pump, and Heat Recovery Applications: Straight Lengths, Copper, Type ACR Type L, H55 (light drawn)-temper tubing and field bent fittings with brazed joints.

3.03 VALVE AND SPECIALTY APPLICATIONS

A. Install service valves as specified or as required to isolate system components.

3.04 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; route and size piping based on manufacturer's recommended line lengths and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15 (latest version).

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas. Concealed locations shall be free of pipe joints.

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

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

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

G. Install piping free of sags and bends.

H. Field bend changes in direction.

I. Select system components with pressure rating equal to or greater than maximum allowable working pressure.

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Provide jacketed insulation in locations where exposed to mechanical injury.

M. When brazing, remove solenoid-valve coils and sight glasses; also, remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

N. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

O. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 00 00 HVAC General.

P. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 00 00 HVAC General.

Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 00 00 HVAC General.

R. Provide proper compensation for pipe/tube expansion and contraction per equipment manufacturers recommendations.

3.05 PIPE JOINT CONSTRUCTION

A. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube".

1. Use Type BcuP-5 (15% Ag, 80% Cu, 5% P), copper-phosphorus alloy pre-formed brazing rings for joining copper swage fittings and copper socket fittings with copper pipe. Do NOT use flux.
2. Use Type Bag-5 (45% Ag), cadmium-free silver alloy for joining copper with bronze or steel. Use manufacturers recommended flux.

B. Field Swaged Brazing Cups: Fabricate brazing cup on one tubing end for each coupling. Only O60 (soft annealed) and H55 (light drawn) may be swaged. Do NOT swage H58 (drawn general purpose). Use swaging tool designed to provide a minimum of 0.0015" brazing gap and a maximum of 0.005" brazing gap. Brazing cup depth for each tube size shall be as follows:

1/4"	3/8"	1/2"	5/8"	3/4"	7/8"	1-1/8"	1-3/8"	1-5/8"	2-1/8"
0.250"	0.280"	0.310"	0.390"	0.420"	0.460"	0.510"	0.560"	0.600"	0.700"

C. Field Bends: Fabricate field bends with a center-line bend radius greater than or equal to 4 times the nominal OD of the pipe or tube. Tube shall be bent with a tubing bender sized for ACR OD tube sizes and shall not cause cracks or wrinkles in the tube or pipe. Do NOT use a conduit bender for bending ACR copper. The difference between maximum and minimum diameters for pipe bends should not exceed 8% of the nominal outside diameter of the pipe. Only O60 soft annealed-temper and H55 light drawn-temper shall be field bent. Do NOT field bend H58 drawn general purpose-temper copper tube.

D. Brazing and joining procedure:

1. Tube ends shall be cut with a clean sharp tubing cutter.
2. Deburr the I.D. of the cut tube end with a clean deburring tool.
3. Visually inspect the interior of each tube for obstructions and debris before assembly. Protect the joint from contamination before brazing.
4. Method of pre-cleaning: Non-shedding abrasive pads (Scotch Bright) to remove all oxides in the brazing area followed by wiping with a clean lint-free white cloth. Do not groove the surfaces while cleaning.
5. Purge all tubing with oil free nitrogen while brazing and until cool to the touch. Use an oxygen analyzer to verify the absence of oxygen prior to brazing. The oxygen content shall be less than 1% before start of brazing.

6. Use a neutral to slightly reducing flame using oxy/acetylene or oxy/propane.
7. Use the proper torch tip based on tube size as recommended by the torch manufacturer. Use of Turbo-Torch or Rosebud is permitted.
8. Post Brazing Cleaning: Exterior of all completed joints shall be washed with a water-soaked rag or sponge, followed by brushing with a stainless-steel hand wire brush to remove any residue for inspection.

C. Copper-Tube, Pressure-Seal-Joint Fittings:

1. Install fittings in strict accordance with manufacturer's installation instructions.
2. Installers shall be trained and certified by the manufacturer.
3. Test piping system according to manufacturer's recommendations and prepare a test report to be turned over to the Owner for their records.

3.06 HANGERS AND SUPPORTS

A. Piping hangers and supports must accommodate expansion and contraction, vibration, dead load of piping and its contents, and seismic-bracing requirements.

B. Install the following pipe attachments or combination thereof:

1. Adjustable steel clevis hangers for individual horizontal runs.
2. Channel strut or angle iron trapeze for multiple horizontal runs
3. Galvanized steel saddle with attachment screw for channel strut applications
4. Rigid high compressive strength foam insulating pipe support at all clamps and support points.
5. Rigid high compressive strength foam pipe support at all riser clamps.
6. Do NOT attach hangers directly to pipe or tube.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. Up to 3/4" OD: Maximum span, 60 inches; minimum rod size, 3/8 inch.
2. Greater than 3/4" thru 1" OD: Maximum span, 72 inches; minimum rod size, 3/8 inch.
3. Greater than 1" thru 2-1/8" OD: Maximum span, 96 inches; minimum rod size, 3/8 inch.

D. Support multi-floor vertical runs every 10 feet and at least at each floor with riser clamps.

3.07 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test as follows or as recommended by the equipment manufacturer's installation instructions:
   a. Line Test Pressure for Refrigerant R-410A:
      1) Suction (low pressure gas) Lines: 550 psig, or per equipment manufacturers recommendation.
      2) Hot-Gas (high pressure gas) and Liquid Lines: 550 psig, or per equipment manufacturers recommendation.
3. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.

a. Fill system with 95/5 nitrogen/hydrogen to the required test pressure.
b. System shall maintain test pressure at the manifold gage throughout duration of test.
c. Test all joints and fittings with hydrogen leak detector, at test pressure.
d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.08 SYSTEM CHARGING

A. Charge system using the following procedures and per equipment manufacturer's installation instructions.

1. Evacuate (triple evacuation procedure) entire refrigerant system with a vacuum pump to obtain a steady state vacuum of less than 500 micrometers. If vacuum holds for 12 hours, system is ready for charging. Do NOT evacuate the system through a charging manifold. Use only suction rated hoses and core removal tools.
2. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
3. Charge system as recommended by equipment manufacturer.

3.09 OWNER REVIEW OF MAINTENANCE REQUIREMENTS

A. Review manufacturer's maintenance instructions with the owner's representative to make them aware of any reoccurring maintenance requirements such as recoating piping insulation, lubricating service valves, etc.

END OF SECTION

SECTION 23 31 00

DUCTWORK AND ACCESSORIES

PART 1 - GENERAL

1.01 DESCRIPTION

A. All work in this section shall be subject to the provisions of Section 23 00 00 - HVAC General.

B. Furnish and install all material, labor, accessories, etc. shown on the drawings and as specified herein to completely install all ductwork systems.

C. Ductwork systems shall be classified as follows:

1. Static pressure class +2 in. wg - from constant volume air handling unit, and terminal unit to supply diffusers; all return, outside air and exhaust ductwork;

D. Refer to PART 3 – EXECUTION for duct sealing requirements.

E. Ductwork shall be constructed according to the latest edition of SMACNA ductwork construction standards applicable to the type of ductwork, system pressures described above, and the system material construction.

F. Duct sizes shown on the drawings are nominal inside clear.

1.01 RELATED DOCUMENTS

A. Specification sections:

1. 23 31 00 Fire Resistive Ductwork and Accessories
2. 23 35 33 Listed Kitchen Ventilation System Exhaust Ducts
3. 23 37 00 Louvers, Grilles, Registers and Diffusers
4. 23 51 00 Gas Vents, Flues, and Stacks

1.02 QUALITY ASSURANCE

A. Fire, smoke, combination fire/smoke and radiation dampers shall be installed and maintained in accordance with:

1. Manufacturer’s installation instructions
2. UL approved installation instructions and supplemental instructions
3. UL Damper Marking and Application Guide, latest edition
4. NFPA Standard 90A (latest edition)
5. SMACNA’s Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems (latest edition)

B. Control (balancing and shut-off) dampers shall be certified in accordance with:

1. AMCA Standard 500-D, Laboratory Methods of Testing Dampers for Rating
2. AMCA Publication 511, Certified Ratings Program – Product Rating Manual for Air Control Devices

C. Ductwork in food service establishments shall be in accordance with SMACNA’s Food Grade Ductwork and Sheet Metal Guidelines.

1.03 SUBMITTALS

A. Product Data:

1. Duct materials:
   a. Fiberglass ductboard
   b. Outdoor duct systems
   c. Flexible duct connectors
   d. Flexible ductwork
2. Dampers and accessories
3. Remote damper operators
4. Access doors
5. Flexible duct connectors
6. Duct liner
7. Sealants, mastics, adhesives and coatings

B. For all fire dampers, combination fire and smoke dampers, and smoke dampers, submit UL approved installation instructions for each specific application.

PART 2 - PRODUCTS

2.01 DUCTWORK

A. Ductwork shall be constructed of galvanized steel sheets of the thickness listed in the SMACNA manuals for the pressures referenced above,

B. Single-Wall Rectangular Ducts and Fittings:

1. General Fabrication Requirements: Comply with SMACNA's “HVAC Duct Construction Standards - Metal and Flexible” based on indicated static-pressure class unless otherwise indicated.
2. Transverse Joints: Select joint types and fabricate per SMACNA's “HVAC Duct Construction Standards - Metal and Flexible,” “Transverse (Girth) Joints,” for static pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's “HVAC Duct Construction Standards - Metal and Flexible.”
   a. Alternate Product: Subject to compliance with requirements, provide Ductmate Industries, Inc.; 25/35/45 Rectangular Flange System or comparable product by one of the following:
      1) Nexus PDQ; a division of Shilco Holdings, Inc.
      2) Ward Industries, Inc; a division of Hart & Cooley, Inc.
      3) Prior Approved Equal
   b. Slide-on Flanges:
      1) Description: Roll-formed, add on, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
      2) Material: galvanized steel.
      3) Gauge and Shape: For duct constructed using prefabricated systems, refer to the manufacturer's guidelines for sheet gauge, intermediate reinforcement size and spacing, and proper joint reinforcement.
      4) Manufacturers of prefabricated systems must provide duct construction and reinforcement guidelines along with independent testing for leakage, deflection, and seismic performance.

5) Independent leakage testing must be provided for systems operating at pressures of 10 in. wg (or greater) positive or negative.
6) Manufacturer's prefabricated systems printed assembly and installation procedures must be adhered to at all times.
7) Manufacturer's procedures must include fastener and cleat spacing along with details for all system variations including break-away and roofing connections.
8) All manufactured system components must be clearly embossed with manufacturer's name or markings. Substitution of manufacturer's system components is not permitted.

c. Formed flanges will be accepted on ductwork 42 inches wide or less and subjected to 2 in. wg static positive pressure or less.
1) Formed on Flanges: Construct as T-25 A/B flanges, of which construction guidelines are given in Figure 2-1 of the 2005 SMACNA "HVAC Duct Constructions Standards, Metal and Flexible." No other construction standards pertaining to formed on flanges will be accepted.
2) Formed on flanges must include the use of corners, securely crimped in place, bolts, cleat, and gasket

3. Longitudinal Seams: Select seam types and fabricate per SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Longitudinal Seams – Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."
4. Snap-lock longitudinal duct seams are not allowed in public spaces unless secured with sheet metal fastening screws as recommended by SMACNA.
5. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate per SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Single-Wall Round and Flat-Oval Ducts and Fittings

1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) Linx Industries
2) McGill AirFlow, LLC
3) SEMCO, LLC
4) Sheet Metal Connectors, Inc.
5) Spiral Manufacturing Co., Inc.
6) Prior Approved Equal
2. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
3. Transverse Joints: Select joint types and fabricate per SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

a. Transverse Joints in Ducts Larger Than 50 Inches in Diameter: Flanged.
   1) Unexposed Duct 3 inches to 30 inches in diameter: Round duct connects with a one-piece interior slip coupling at least two gages heavier than duct wall, beaded at center and fastened to duct with screws. Seal joint with an approved sealant applied continuously around both ends of coupler prior to assembling and after fastening.
   2) All Exposed Duct and Unexposed Duct 30 inches to 72 inches in diameter: Three-piece, gasket flanged-joint consisting of two internal flanges, with integral mastic sealant, and one external closure ring, for connecting the internal flanges and securing the closed cell neoprene gasketing in place.
      a) Basis-of-Design Product: Subject to compliance with requirements, provide Ductmate Industries, Inc.; Spiralmate or similar comparable product by one of the following:
         (1) Prior Approved Equal
   3) Ducts larger than 72 inches in diameter: Use companion angle flanged joints as defined in Figure 3-1 for the 2005 SMACNA Manual “HVAC Duct Construction Standards, Metal and Flexible” Third Edition. Refer to manual for proper sizing and construction details.
   4) Dust Collection Systems and Exposed Duct 3 inches to 14 inches in diameter: Use a one-piece, polyethylene lined gasket connector with integrated bolt for the closure system.
      a) Basis-of-Design Product: Subject to compliance with requirements, provide Ductmate Industries, Inc.; Quicksleeve or comparable product by one of the following:
         (1) Prior Approved Equal

4. Longitudinal Seams: Select seam types and fabricate per SMACNA's “HVAC Duct Construction Standards - Metal and Flexible,” Figure 3-2, “Round Duct Longitudinal Seams,” for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's “HVAC Duct Construction Standards - Metal and Flexible.”
   a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
   b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
5. Tees and Laterals: Select types and fabricate per SMACNA's “HVAC Duct Construction Standards - Metal and Flexible,” Figure 3-5, “90 Degree Tees and Laterals,” and Figure 3-6, “Conical Tees,” for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's “HVAC Duct Construction Standards - Metal and Flexible.”

D. Double-Wall Round and Flat-Oval Ducts and Fittings

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Linx Industries
   b. McGill AirFlow, LLC
   c. SEMCO, LLC
   d. Sheet Metal Connectors, Inc.

2. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
3. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
    a. Transverse Joints: Select joint types and fabricate per SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
        1) Transverse Joints in Ducts Larger Than 50 inches in Diameter: Flanged.
            a) All Exposed Duct and Unexposed Duct 30 inches to 72 inches in diameter: Three-piece, gasket flanged-joint consisting of two internal flanges, with integral mastic sealant, and one external closure ring for connecting the internal flanges and securing the closed cell neoprene gasketing in place.
            b) Basis-of-Design Product: Subject to compliance with requirements, provide Ductmate Industries, Inc.; Spiralmate or comparable product by one of the following:
                (1) Prior Approved Equal
    b. Longitudinal Seams: Select seam types and fabricate per SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
        1) Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
        2) Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
    c. Tees and Laterals: Select types and fabricate per SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
4. Inner Duct: Minimum 0.028-inch (24 gauge) perforated galvanized sheet steel having 3/32-inch diameter perforations, with an overall open area of 23 percent.
5. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard".
    a. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x ºF at 75ºF mean temperature.
    b. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
    c. Coat insulation with antimicrobial coating.
    d. Cover insulation with polyester film complying with UL 181, Class 1.
6. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
    a. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x ºF at 75ºF mean temperature.

E. When detailed, round and oval ductwork shall be supported using galvanized wire rope cable and locking cable terminations. The locking cable terminations shall have an Ultimate Breaking Strength (U.B.S.) of at least 5 times the published Working Load Limit (W.L.L.). Wire ropes and locking cable terminations shall be sized, spaced, and furnished by the manufacturer. Submit layout drawings and product data during the submittal phase. Wire rope and locking cable terminations shall be Dynatite Suspension System as manufactured by Duro Dyne Corporation or Cable Shark as manufactured by Ductmate.

F. Rectangular sheet metal duct elbows shall be smooth radius type without turning vanes or square (or mitered) type with turning vanes. Sharp throat elbows (ASHRAE Fitting No. CR3-2) shall not be permitted. Round sheet metal duct elbows shall be smooth radius type without turning vanes, gored type or mitered type with turning vanes.

G. Unless otherwise indicated, elbows shall have a centerline radius of not less than 1½ times the width of the duct. Where space limitations necessitate use of short radius or square elbows, provide turning vanes.

H. Fiberglass duct board shall be UL 181 listed as a Class 1 Rigid Air Duct with a thermal conductivity not to exceed 0.23 at 75°F per ASTM C 518. Thickness shall be as indicated on the drawings or as required by the energy code in effect. Fiberglass duct board shall be Johns Manville Super Duct RC, Knauf Atmosphere Air Duct Board, Owens Corning QuietR Duct Board or Certainteed Ultra*Duct Black Duct Board.

1. Tapes and mastics used to seal fibrous glass ductwork shall be listed and labeled in accordance with UL 181A and shall be marked “181A-P” for pressure-sensitive tape, “181A-M” for mastic or “181A-H” for heat-sensitive tape.

I. Exhaust ductwork shall be galvanized sheet metal (G 90 minimum) constructed to SMACNA standards and shall not be insulated unless noted otherwise.

J. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

K. Exterior supply and return air ductwork shall be constructed of galvanized sheet metal (G 90 minimum) lined with 2" thick 3 lb/ft^3 duct liner board (R-8 min. [R-12 min. in Climate Zones 5 through 8]); Johns-Manville Linacoustic R-300. All seams shall be externally sealed watertight with a 30-year silicone caulk and coated with a rust preventive coating over the entire duct surface. Rust preventative coating shall be “Rust Destroyer” by Advanced Protective Products, Inc., or approved equal. As an alternative to insulated sheet metal, an outdoor duct system as manufactured by Thermaduct, LLC may be used. The system shall incorporate duct and fittings having an installed minimum R-value of 8 [R-12 min. in Climate Zones 5 through 8]. The system shall utilize non-fibrous closed cell Kingspan KoolDuct fortified inner liner compliant to UL (C-UL) 181, Standard for Safety Listed, Class 1 system and SMACNA Class 1 leakage, or less. Submit product data and layout drawings during the submittal phase. Crown or slope ductwork at ¼" per foot transversely to prevent standing water on top of ductwork. For projects located within 2 miles of the seacoast, flanges and hardware shall be aluminum (alloy 3003 - H14 temper per ASTM B209).

L. Ductwork connecting kitchen exhaust hoods to exhaust fans shall be constructed of 16-gauge black steel with welded seams. All grease exhaust ductwork shall be constructed and installed according to requirements of local code authorities and NFPA 96 (latest edition) requirements. Slope duct down towards the hood at ¼" per linear foot up to 75 horizontal linear feet and at 1" per linear foot greater than 75 horizontal linear feet or per local code requirements. Access doors shall be provided as described below.

1. Alternate grease duct construction: factory-built grease duct system incorporating an integral fire-rated enclosure listed and labeled in accordance with UL 2221. The grease duct enclosure assembly and through-penetration firestop system shall be installed in accordance with the listing and manufacturer's installation instructions. Refer to Section 23 35 33 Listed Kitchen Ventilation System Exhaust Ducts for additional requirements.

M. Kitchen hood exhaust ductwork shall be insulated per NFPA 96 (latest edition) and local code requirements (Re: Section 23 07 14 Fire Rated Insulation Systems). Kitchen hood supply ductwork shall be insulated per specifications for HVAC supply ductwork.

N. Dishwasher exhaust ductwork above the ceiling shall be either 18-gauge stainless steel (2D finish) or 16-gauge aluminum. All seams and joints shall be welded liquid tight.

O. Dishwasher exhaust risers and trim collars below the ceiling shall be 18-gauge, type 304 stainless steel finished in a 180-grit polished finish.

P. All dishwasher exhaust ductwork shall slope down toward the dishwasher connections at ¼" per linear foot and be constructed with no pockets which will trap condensation.

Q. Support roof mounted ductwork at 6 feet (max.) on center with Mifab Series DSA duct support system. UV resistant rubber bases shall be placed on roofing walk pad material. Coordinate with general contractor and roofing installer. Manufacturer shall submit layout drawings and product information during the submittal phase.

2.02 FLEXIBLE DUCTWORK

A. Flexible ducts shall be listed and labeled as UL Standard 181 Class 1 air duct. Air connectors are not allowed.

B. Flexible ductwork shall comply with the following:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems"
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems"
3. SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated.
4. Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1".
5. ASTM E 96/E 96M, "Test Methods for Water Vapor Transmission of Materials."

C. Flexible ductwork shall be installed between main supply ducts and diffusers. Length shall be a maximum of 8'-0" long, except in residential applications, where the length shall be as indicated.

Commented [JRH1]: If the project is governed by the 2015 UMC, flex duct length is limited to 5'.

D. Flexible ductwork shall be Thermaflex M-KE R-6 (R value = 6.0 minimum or as required by local energy code) flexible air duct or equal by Quietflex, Flexmaster, Atco, JP Lamborn, or Royal Metal Products. Provide R-8 when located outside the thermal envelope.

E. Flexible ductwork size shall be the same size as the diffuser neck it serves, unless indicated otherwise.

F. Take-offs for sheet metal ductwork shall be made using a conical spin-in type fitting with manual balancing damper.

Commented [JRH2]: Edit out if project will only use fiberglass duct board

G. Flexible duct connections to ceiling diffusers shall be installed without kinks or sags to provide unrestricted airflow. Provide Flex Flow Elbow supports by Thermaflex or FlexRIGHT elbow support by Build Right Products.

H. Tapes and mastics used to seal metallic and flexible air ducts shall comply with UL 181B and shall be marked “181B-FX” for pressure-sensitive tape or “181B-M” for mastic.

I. Mechanical fasteners for use with flexible nonmetallic air ducts shall comply with ul 181b and shall be marked “181B-C”.

2.03 LIFE SAFETY DAMPERS

A. General

1. Fire, smoke, combination fire/smoke and radiation dampers shall have the installation approved by the Authority Having Jurisdiction (AHJ) where field modifications are necessary as part of the manufacturer’s supplemental instructions.
2. Modifications must be made per the manufacturer’s installation instructions.
3. Some modifications fall under UL approval, some need AHJ approval.
4. Contact the manufacturer for guidance on modifications. The manufacturer will point out approved modifications and modifications needing AHJ approval. Manufacturers can also help explain the impact of modifications to the AHJ.
5. All dampers are recommended to be cycled after any modification.

6. UL Life Safety Damper actuators shall be factory installed and cycle-tested prior to shipment. Field mounting or substitutions of a damaged actuator is not covered under the UL certification and thus replacement shall be completed in accordance with the damper manufacturer’s field service program.

2.04 FIRE DAMPERS

A. Fire dampers shall be installed at all locations where ductwork or supply or return air openings penetrate any floor, wall or partition with a fire rating.

B. All fire dampers shall be of the “Dynamic” type as classified in UL Standard 555.

C. Fire dampers shall have a rating compatible with the floor, wall or partition, shall be tested to UL Standard 555 and be labeled for the intended installation (horizontal or vertical).

D. Fire Resistance Rating: 1½ hours unless noted otherwise indicated on drawings for 3 hours.

E. Closure device: Each fire damper shall be equipped with a factory installed heat responsive device (fusible link) rated to close the damper when temperature at the damper reaches: 165°F .

F. Airflow Closure Rating:

1. Dynamic fire dampers shall be selected for the velocity and pressure rating of the intended installation. Refer to the plans and schedules for airflow rates (CFM) and pressures (in. wg).
2. Dampers shall have a minimum velocity rating of 2000 fpm at a pressure rating of 4 in. wg.
3. Dampers in systems operating above 2000 fpm or 4 in. wg shall be selected for a velocity rating of 4000 fpm at a pressure rating of 6 in. wg.

G. Types:

1. Curtain: for use in systems up to 4000 fpm velocity; Style B or C with the blade stack out of the airstream (Style A with the blade stack in the airstream may be used behind registers and grilles or where space conditions do not permit the use of a Style B damper).
   a. Construction:
      1) Frame: Galvanized steel (in gauges required by manufacturer's UL listing).
      2) Blade design: interlocking galvanized steel
      3) Sleeves: Damper shall be supplied as a single assembly with a factory sleeve.
      4) Retaining Angles: Damper shall be supplied with factory retaining angles sized to provide installation overlap in accordance with the manufacturer's UL listing.
      5) Duct Transition Connection: breakaway type
      6) In corrosive and seacoast applications, damper assembly shall be constructed of Type 316 stainless-steel.
2. Round: for use in systems up to 2000 fpm velocity.
   a. Construction:
      1) Frame: Galvanized steel (in gauges required by manufacturer's UL listing).
      2) Blade design: single galvanized steel blade (in gauge required by manufacturer's UL listing).
      3) Retainer plate(s): supplied with damper.
      4) Sleeves: Length as required per wall thickness.
      5) Duct Transition Connection: breakaway type.
      6) In corrosive and seacoast applications, damper assembly shall be constructed of Type 316 stainless-steel.

H. All dampers shall be installed in strict accordance with the manufacturer's UL approved installation details.

I. Where fire dampers are required in a fibrous glass ductboard system, provide sheet metal sleeve per manufacturer's UL installation instructions. Verify gage of sleeve and attachment angle with governing code authorities. Installation shall also conform to SMACNA Figure 5-9 "Fibrous Glass Duct Installation".

2.05 CEILING RADIATION DAMPERS

A. A listed ceiling radiation damper shall be installed at all locations where ductwork or register, diffuser, grille, etc. penetrates the ceiling membrane of a fire-resistance-rated floor/ceiling or roof/ceiling assembly. Ceiling radiation dampers shall have a rating compatible with the floor/ceiling or roof/ceiling assembly and shall be tested to UL Standard 555C.

B. Fire Resistance Rating: 1 hour (minimum).

C. Closure device: Each ceiling radiation damper shall be equipped with a factory installed heat responsive device (fusible link) rated to close the damper when temperature at the damper reaches: 165°F

D. Construction:

1. Dampers shall be factory-built curtain or butterfly type. They shall conform to the requirements of NFPA Standard 90A and be UL Labeled for the required assembly rating.
2. All dampers shall be installed in strict accordance with the manufacturer's UL approved installation instructions.
3. Provide steel sleeves, mounting angles and steel duct drops of design and length where required to permit mounting within the opening.
4. Provide thermal blanket where required by the manufacturer's UL installation instructions.
5. Where ceiling radiation dampers are shown on the drawings, and if fiberglass ductwork is used, dampers shall be installed with a sheet metal collar or housing or shall be listed for use with fiberglass ductwork.

2.06 COMBINATION FIRE AND SMOKE DAMPERS

A. Fire/smoke dampers shall be installed at all locations where ductwork or supply or return air openings penetrate any floor, wall or partition with a fire and smoke rating, or where otherwise shown on the drawings.

B. Fire/smoke dampers shall be provided with actuators capable of closing the damper on activation of area smoke detectors, the fire alarm system and/or the Firefighter's Smoke Control Panel and shall be normally closed. Actuators shall be compatible with the activating smoke detectors or fire alarm system (coordinate with other trades).

C. Unless otherwise indicated, smoke detectors integral to the combination fire/smoke damper shall be furnished and installed by the fire alarm contractor (coordinate with other trades).

D. All combination fire/smoke dampers shall be of the "Dynamic" type as classified in UL Standards 555 and 555S.

E. Fire/smoke dampers shall have a rating compatible with the floor, wall or partition, shall be tested to UL Standards 555 and 555S and be labeled for the intended installation (horizontal or vertical).

F. Fire Resistance Rating: 1½ hours unless noted otherwise on drawings for 3 hours.

G. Leakage Rating: Class 1 (maximum of 8 cfm/ft^2 at 4 in. wg) unless noted otherwise.

H. Elevated Temperature Rating: 250°F (121°C) for 30 minutes. For smoke control systems provide provide dampers rated for 350°F (177°C) for 30 minutes.

I. Airflow Closure Rating:

1. Dynamic fire/smoke dampers shall be selected for the velocity and pressure rating of the intended installation. Refer to the plans and schedules for airflow rates (CFM) and pressures (in. wg).
2. Dampers shall have a minimum velocity rating of 2000 fpm at a pressure rating of 4 in. wg.

J. Types:

1. Round: for use in systems up to 3000 fpm velocity.
   a. Construction:
      1) Frame: Galvanized steel (in gauges required by manufacturer's UL listing).

2) Blade design: single galvanized steel blade (in gauge required by manufacturer's UL listing).
3) Retainer plate(s): supplied with damper.
4) Sleeves: Length as required per wall thickness.
5) Duct Transition Connection: breakaway type.
6) In corrosive and seacoast applications, damper assembly shall be constructed of Type 316 stainless-steel.

2. Multi-blade:
   a. Up to 2000 fpm velocity: Triple Vee-groove type blade.
   b. 2000-4000 fpm velocity: Fabricated double skin airfoil type blade.
   c. Construction:
      1) Frame: Galvanized steel with mitered and interlocking corners (in gauges required by manufacturer's UL listing).
      2) Blade design: Galvanized steel (in gauges required by manufacturer's UL listing) strengthened by three longitudinal Vee grooves running the entire length of each blade as required by manufacturer's UL listing.
      3) Blade Stops: Each blade stop (at top and bottom of damper frame) shall occupy the minimum of the damper opening required by manufacturer's UL listing area to allow for maximum free area and to minimize pressure loss across the damper.
      4) Seals:
         a) Blade Edge: Blade seals shall be extruded silicone rubber permanently bonded to the appropriate blade edges.
         b) Jamb: Flexible stainless-steel compression type.
      5) Linkage: Concealed in jamb.
      6) Axles: Minimum ½" diameter plated steel.
      7) Bearings: Axle bearings shall be sintered bronze sleeve type or stainless steel rotating in polished extruded holes in the damper frame.
      8) Sleeves: Damper shall be supplied as a single assembly with a factory sleeve.
      9) Retaining Angles: Damper shall be supplied with factory retaining angles sized to provide installation overlap in accordance with the manufacturer's UL listing.
      10) Duct Transition Connection: breakaway type
      11) In corrosive and seacoast applications, damper assembly shall be constructed of Type 316 stainless-steel.

K. Heat Responsive Device: Electric, controlled closure, quick detect heat-actuated device designed to prevent damage to ductwork and other HVAC system components. The device shall be a reusable/resettable link (RRL) with a temperature setting of 165°F (74°C).

L. Photoelectric [ionization] Type Smoke Detector (if indicated on the drawings): rated for air velocities from 300 to 4000 fpm; UL268A listed, factory mounted internally on the damper sleeve

M. Damper Motors: Two-position meeting the following:

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, efficiency requirements and the following:
   a. Motor Sizes: Minimum size as required by manufacturer's UL listing
   b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

c. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40°F (minus 40°C).
d. Electrical Connection: 115 V, single phase, 60 Hz.

N. Momentary Test Switch (for use in combination fire and smoke dampers that are not part of a smoke management system): factory mounted and wired assembly for testing and cycling the damper during start-up and maintenance. Power wiring to test switch and actuator shall be per manufacturer's installation instructions.

O. Combination Fire and Smoke Dampers shall have a single point wiring per UL requirements (except where two signals are required as with the Temperature Limited Override specified above).

2.07 CORRIDOR COMBINATION FIRE AND SMOKE DAMPERS

A. Corridor fire/smoke dampers shall be installed at all locations where ductwork or supply or return air openings penetrate any tunnel corridor ceiling with a fire and smoke rating, or where otherwise shown on the drawings.

B. Corridor fire/smoke dampers shall be provided with actuators capable of closing the damper on activation of area smoke detectors, the fire alarm system and/or the Firefighter's Smoke Control Panel and shall be normally closed. Actuators shall be compatible with the activating smoke detectors or fire alarm system (coordinate with other trades).

C. Unless otherwise indicated, smoke detectors integral to the corridor fire/smoke damper shall be furnished and installed by the fire alarm contractor (coordinate with other trades).

D. All corridor fire/smoke dampers shall be of the "Dynamic" type as classified in UL Standards 555 and 555S.

E. Corridor fire/smoke dampers shall be tested to UL Standards 555 and 555S and be labeled for the intended installation.

F. Maximum pressure drop: 0.10 in. wg; provide ductwork transitions as required so as not to exceed maximum pressure drop.

G. Fire Resistance Rating: 1 hour.

H. Leakage Rating: Class 1 (maximum of 8 cfm/ft^2 at 4 in. wg) unless noted otherwise.

I. Elevated Temperature Rating: 250°F (121°C) for 30 minutes. For smoke control systems provide provide dampers rated for 350°F (177°C) for 30 minutes.

J. Airflow Closure Rating:

1. Dynamic fire/smoke dampers shall be selected for the velocity and pressure rating of the intended installation. Refer to the plans and schedules for airflow rates (CFM) and pressures (in. wg).
2. Dampers shall have a minimum velocity rating of 2000 fpm at a pressure rating of 4 in. wg.

K. Types:

1. Round: for use in systems up to 3000 fpm velocity.
   a. Construction:
      1) Frame: Galvanized steel (in gauges required by manufacturer's UL listing).
      2) Blade design: single galvanized steel blade (in gauge required by manufacturer's UL listing).
      3) Retainer plate(s): supplied with damper.
      4) Sleeves: Length as required per wall thickness.
      5) Duct Transition Connection: breakaway type.
      6) In corrosive and seacoast applications, damper assembly shall be constructed of Type 316 stainless-steel.
2. Multi-blade:
   a. Up to 2000 fpm velocity: Triple vee-groove type blade.
   b. 2000-4000 fpm velocity: Fabricated double skin airfoil type blade.
   c. Construction:
      1) Frame: Galvanized steel with mitered and interlocking corners (in gauges required by manufacturer's UL listing).
      2) Blade design: 16 ga. galvanized steel strengthened by three longitudinal 1" deep Vee grooves running the entire length of each blade. Each blade shall be symmetrical relative to its axle pivot point, presenting identical performance characteristics with air flowing in either direction through the damper. Provide symmetrical blades of varying size as required to completely fill the damper opening.
      3) Blade Stops: Each blade stop (at top and bottom of damper frame) shall occupy no more than ½" of the damper opening area to allow for maximum free area and to minimize pressure loss across the damper.
      4) Seals:
         a) Blade Edge: Blade seals shall be extruded silicone rubber permanently bonded to the appropriate blade edges.
         b) Jamb: Flexible stainless-steel compression type.
      5) Linkage: Concealed in jamb.
      6) Axles: Minimum ½" diameter plated steel.
      7) Bearings: Axle bearings shall be sintered bronze sleeve type rotating in polished extruded holes in the damper frame.
      8) Sleeves: Damper shall be supplied as a single assembly with a factory sleeve.
      9) Retaining Angles: Damper shall be supplied with factory retaining angles sized to provide installation overlap in accordance with the manufacturer's UL listing.
      10) Duct Transition Connection: breakaway type
      11) In corrosive and seacoast applications, damper assembly shall be constructed of Type 316 stainless-steel.

L. Heat Responsive Device: Electric, controlled closure, quick detect heat-actuated device designed to prevent damage to ductwork and other HVAC system components. The device shall be a reusable/resettable link (RRL) with a temperature setting of 165°F (74°C).

M. Photoelectric [ionization] Type Smoke Detector (if indicated on the drawings): rated for air velocities from 300 to 4000 fpm; UL268A listed, factory mounted internally on the damper sleeve.

N. Damper Motors: Two-position meeting the following:

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, efficiency requirements and the following:
   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so the driven load will not require motor to operate in service factor range above 1.0.
   b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
   c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
   d. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
   e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40°F (minus 40°C).
   f. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
   g. Electrical Connection: 115 V, single phase, 60 Hz.
2. Momentary Test Switch (for use in combination fire and smoke dampers that are not part of a smoke management system): factory mounted and wired assembly for testing and cycling the damper during start-up and maintenance. Power wiring to test switch and actuator shall be per manufacturer's installation instructions.

O. Corridor Combination Fire and Smoke Dampers shall have a single point wiring per UL requirements (except where two signals are required as with the Temperature Limited Override specified above).

2.08 SMOKE DAMPERS

A. Smoke dampers shall be installed at all locations where ductwork or supply or return air openings penetrate any floor, wall or partition with a smoke rating, or where otherwise shown on the drawings, except where such ductwork or openings are part of an engineered smoke removal system.

B. Smoke dampers shall be provided with factory installed actuators capable of closing the damper on activation of area smoke detectors, the fire alarm system and/or the Firefighter's Smoke Control Panel and shall be normally closed. Actuators shall be compatible with the activating smoke detectors or fire alarm system (coordinate with other trades).

1. For stair and elevator hoist-way pressurization fans, provide a Class 1, normally open smoke damper at the fan inlet for use as a control damper; Ruskin Model SD60, Pottorff Model SD-151, or equal.

C. Unless otherwise indicated, smoke detectors integral to the smoke damper shall be furnished and installed by the fire alarm contractor (coordinate with other trades).

D. All smoke dampers shall be tested and certified in accordance with UL Standard 555S.

E. Leakage Rating: Class 1 (maximum of 8 cfm/ft^2 at 4 in. wg) unless noted otherwise.

F. Elevated Temperature Rating: 350°F (177°C) for 30 minutes.

Commented [JH3]: [Designer note:
250°F is typically acceptable for smoke control systems.
350°F is specified to provide the maximum level of safety.
250°F may be considered as a VE alternative if absolutely necessary.]

G. Airflow Closure Rating:

1. Dynamic smoke dampers shall be selected for the velocity and pressure rating of the intended installation. Refer to the plans and schedules for airflow rates (CFM) and pressures (in. wg).
2. Dampers shall have a minimum velocity rating of 2000 fpm at a pressure rating of 4 in. wg.
3. Dampers in systems operating above 2000 fpm or 4 in. wg shall be selected for a velocity rating of 4000 fpm at a pressure rating of 6 in. wg.

H. Types:

1. Round: for use in systems up to 3000 fpm velocity.
   a. Construction:
      1) Frame: Galvanized steel (in gauges required by manufacturer's UL listing).
      2) Blade design: single double skin galvanized steel blade (in gauge required by manufacturer's UL listing).
      3) Retainer plate(s): supplied with damper.
      4) Sleeves: Length as required per wall thickness.
      5) Duct Transition Connection: breakaway type.
      6) In corrosive and seacoast applications, damper assembly shall be constructed of Type 316 stainless-steel.
2. Multi-blade:
   a. Up to 2000 fpm velocity: Triple Vee-groove type blade.
   b. 2000-4000 fpm velocity: Fabricated double skin airfoil type blade.
   c. Construction:
      1) Frame: Galvanized steel with mitered and interlocking corners (in gauges required by manufacturer's UL listing).
      2) Blade design: Galvanized steel strengthened longitudinal Vee grooves running the entire length of each blade.
      3) Blade Stops: Each blade stop (at top and bottom of damper frame) shall occupy the minimum damper opening area required by manufacturer's UL listing to allow for maximum free area and to minimize pressure loss across the damper.
      4) Seals:
         a) Blade Edge: Blade seals shall be extruded silicone rubber permanently bonded to the appropriate blade edges.
         b) Jamb: Flexible stainless-steel compression type.
      5) Linkage: Concealed in jamb.
      6) Axles: Minimum ½" diameter plated steel.
      7) Bearings: Axle bearings shall be sintered bronze sleeve type or stainless steel rotating in polished extruded holes in the damper frame.
      8) Sleeves: Damper shall be supplied as a single assembly with a factory sleeve.
      9) Retaining Angles: Damper shall be supplied with factory retaining angles sized to provide installation overlap in accordance with the manufacturer's UL listing where required.
      10) Duct Transition Connection: breakaway type
      11) In corrosive and seacoast applications, damper assembly shall be constructed of Type 316 stainless-steel.

Commented [JRH4]: [Designer note: Extruded aluminum (6063-T5) airfoil blades may be specified for extremely low pressure drop and acoustically sensitive applications, but are more costly]

I. Photoelectric [ionization] Type Smoke Detector (if indicated on the drawings): rated for air velocities from 300 to 4000 fpm; UL268A listed, factory mounted internally on the damper sleeve.

J. Damper Motors: Two-position meeting the following:

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, efficiency requirements and the following:
   a. Motor Sizes: Minimum size as required by manufacturer's UL listing.
   b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
   c. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40°F (minus 40°C).
   d. Electrical Connection: 115 V, single phase, 60 Hz.
2. Momentary Test Switch (for use in smoke dampers that are not part of a smoke management system): factory mounted and wired assembly for testing and cycling the damper during start-up and maintenance. Power wiring to test switch and actuator shall be per manufacturer's installation instructions.

K. Accessories for active smoke management systems:

1. Open Closed Indicator (OCI): factory mounted and tested with two switches, one set to close when the damper blades are at their open position, and the other set to close when the damper blades are at their closed position. This will be wired to the Fire Fighter's Smoke Control Station to indicate true damper position.
2. Test Switch and Indicator Panel: 5" x 5" control panel with toggle switch, red LED (replaceable) indicator light to indicate closed damper position and a green LED (replaceable) indicator light to indicate open damper position.
3. Power wiring to OCI, test switch and actuator shall be per manufacturer's installation instructions.

L. Smoke Dampers shall have a single point wiring per UL requirements.

2.09 CONTROL DAMPERS

A. Automatic control dampers shall be installed as shown on the drawings and shall be controlled as described in the 23 09 00 - Automatic Controls section of these specifications.

B. Unless indicated otherwise, dampers shall be of the opposed blade type constructed of minimum 18-gauge galvanized steel and shall have rigidly constructed blades less than 6" wide and shall have duct mounting flanges.

C. Dampers shall be the low leakage type with replaceable blade and jamb seals. Maximum pressure drop for dampers operating in systems exceeding 2000 fpm shall be 0.10 in. wg.

D. Outside air supply and exhaust openings shall be provided with a Class 1 motorized damper with a maximum leakage rate of 4 cfm/ft^2 (20.3 L/s · m^2) at 1.0 in. wg (249 Pa) when tested in accordance with AMCA 500D.

1. Gravity (non-motorized) dampers having a maximum leakage rate of 20 cfm/ft^2 (101.6 L/s · m^2) at 1.0 in. wg (249 Pa) when tested in accordance with AMCA 500D may be used in any one of the following conditions:
   a. In buildings for exhaust and relief dampers.
   b. In buildings of less than three stories in height above grade.
   c. For ventilation air intakes and exhaust and relief dampers in buildings of any height in Climate Zones 1, 2 and 3.

d. Where the design outdoor air intake or exhaust capacity does not exceed 300 cfm (141 L/s).

Gravity (non-motorized) dampers for ventilation air intakes shall be protected from direct exposure to wind.

2. Dampers smaller than 24 inches (610 mm) in either dimension shall be permitted to have a leakage rate of 40 cfm/ft2 (203.2 L/s · m2) at 1.0 in. wg (249 Pa) when tested in accordance with AMCA 500D.

2.10 CONSTANT AIRFLOW REGULATORS

A. Type: Project shall use a modulating passive pressure independent control orifice that automatically regulates supply, return or exhaust airflows in duct systems to constant levels. The orifice shall respond to duct pressure without the use of electric or pneumatic controls or sensors. The product shall be available for new construction or retrofit applications and eliminates the need for on-site testing, adjusting and balancing (TAB).

B. Quality Assurance:

1. Regulators shall be listed under UL 2043 – Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces
2. Ceiling radiation dampers provided from the factory shall be listed under UL 555C – Standard for Ceiling Dampers and Ceiling Air Diffusers
3. Manufacturer shall have been engaged in the production of this type of equipment for a minimum of ten (10) years.

C. Construction:

1. Frame and Blade shall be made of ABS plastic meeting the requirements of UL 94 V-0 flammability standard.
2. Damper: Aero-wing (aerofoil type)
3. Outer Seal: Flex-type ring seal gasket
4. Temperature range: -25°F to 140°F
5. Static pressure operating range: Low Pressure from 0.10 to 0.42 in. wg, Standard Pressure from 0.2 to 0.8 in. wg, High Pressure from 0.6 to 2.4 in. wg.
6. Airflow adjustment: Factory calibrated. Contact the manufacturer for any field adjustments.

D. Available accessories:

1. Quick-connect rings for square ducts
2. Rectangular to round adapters
3. Grille mount box
4. Fire damper
5. Boot with ceiling radiation damper (UL 555C listed for floor/ceiling or roof/ceiling 3-hour fire resistance assemblies)

E. Available sizes: 4", 5", 6", 8", and 10"

F. Manufacturer Basis of Design: American Aldes Model CAR

G. Warranty: Five (5) years from date of shipment
H. Equal products by: Greenheck, Pottorff

2.11 REMOTE DAMPER OPERATORS

A. Cable operated type:

1. Manufacturers: Subject to compliance with all requirements: Pottorff, Ventfabrics, Inc., Duro Dyne or Young Regulator Company.
2. Description: Cable system designed for remote manual damper adjustment.
3. Cable: Stainless steel with flexible steel casing or steel with synthetic casing.
4. Control: Concealed regulator kit with steel locking rack and pinion gear with hex head adjustment or damper control is via push-pull lever action.
5. Linear slot diffuser: Pottorff Models RCS-10 (rectangular) or RCS-10R (round) or Young Regulator Model 270-275ML plenum mounted cable controller with 5020CC (round) or 830AC (rectangular) balancing damper.

B. Install in strict conformance with manufacturer's installation instructions.

2.12 FLEXIBLE DUCT CONNECTORS

A. Install flexible duct connectors at connections of sheet metal duct to motor driven equipment, in ductwork crossing building expansion joints, or otherwise noted. Install per manufacturer's instructions, and support sheet metal ductwork so that no weight is supported by the flexible duct connector.

B. Basis-of-Design Product unless noted otherwise below: Subject to compliance with requirements, provide Ductmate Industries, Inc.; PROflex or comparable product by one of the following:
1. Duro Dyne Inc.
2. Ventfabrics, Inc
3. Prior Approved Equal

C. Materials: Flame-retardant or noncombustible fabrics compliant with NFPA 701.

D. Coatings and Adhesives: Comply with UL 181, Class 1 and have a maximum flame spread/smoke developed rating of 25/50.

E. Metal-Edged Connectors: Factory fabricated with a fabric strip 5¾-inches wide attached to two strips of 2¾-inch wide, 0.028-inch thick, galvanized sheet steel. Provide metal compatible with connected ducts.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200ºF.

G. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250ºF.

H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of ¼-inch movement at start and stop.

I. For systems operating at +4 in. wg, provide a molded rubber duct expansion joint. Construction shall consist of an elastomer tube and cover, reinforced with a woven fabric capable of accommodating duct system movement and vibration. Expansion joints shall be Flexicraft Industries, Rubber Duct Expansion Joint Model.

2.13 ACCESS DOORS

A. Hinged, gasketed and latched Access Doors (AD) and/or panels shall be installed at each fire and smoke damper, each duct mounted smoke detector, each valve, at each duct mounted balancing damper or any other mechanical equipment or device that requires accessibility. Doors and panels shall be sized (minimum 18" x 18", duct size allowing), and located to optimize access to dampers, detectors, and other equipment for service and replacement. Access Panels (AP) in walls, ceilings or other surfaces shall be coordinated with architectural finishes and selected by the architect.

B. Access doors shall be designed for five times the pressure of the duct in which it is mounted.

C. Access doors for fire dampers, combination fire/smoke dampers and smoke dampers in medium pressure (+4 in.wg and higher) duct systems shall be the implosion type designed to prevent excessive negative pressure downstream resulting in collapsed ductwork. At the contractor's option, the access door may be an integral feature of the damper assembly.

D. Access doors for grease exhaust ducts shall be in accordance with NFPA 96 (latest edition). Vertical grease ducts shall have an access door at each floor level in an inconspicuous location.

E. Access doors for fire dampers, combination fire/smoke dampers and smoke dampers shall be permanently identified by a die-cut label with ½" high red block letters on a white background. Label shall read FIRE DAMPER, COMBINATION FIRE/SMOKE DAMPER or SMOKE DAMPER.

F. Duct-Mounted Access Doors: Fabricate access panels per SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct".

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ductmate Industries, Inc.; Access Doors or comparable product by one of the following:
   a. American Warming and Ventilating; a division of Mestek, Inc.
   b. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
   c. Prior Approved Equal
2. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision Panel:
1) Observation type doors shall be sandwich type provided at all fire and smoke dampers, humidifiers, in-duct smoke detectors, and UVC emitters.
2) Minimum 12"x12" with 8"x8" viewport, insulated or non-insulated.
3) For ducts smaller than 12-inches, 10"x6" shall be used with a 4"x 2-5/8" viewport with a single pane of safety glass.
d. Hinges and Latches: 1"x1" butt or piano hinge with cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

3. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
4. Number of Hinges and Locks:
a. Access Doors Less Than 12 inches Square: No hinges and two sash locks.
b. Access Doors up to 18 inches Square: Continuous hinge and two sash locks.
c. Access Doors up to 24 by 48 inches: Continuous hinge and two compression latches.
d. Access Doors Larger Than 24 by 48 inches: Continuous hinge and two compression latches.

G. Pressure Relief Access Door:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. American Warming and Ventilating; a division of Mestek, Inc.
b. Cesco Products; a division of Mestek, Inc.
c. Elgen Manufacturing
d. Flexmaster U.S.A., Inc.
e. Greenheck Fan Corporation
f. McGill AirFlow LLC
g. Nailor Industries Inc.
h. Pottorf
i. Ventfabrics, Inc.
j. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
k. Prior Approved Equal
2. Door and Frame Material: Galvanized sheet steel.
3. Door: Single or Double wall with insulation fill, as required, with metal thickness applicable for duct pressure class.
4. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
5. Factory set at 3.0- to 8.0-in. wg.
6. Doors close when pressures are within set-point range.
7. Hinge: Continuous piano
8. Latches: Cam
9. Seal: Neoprene or foam rubber
10. Insulation Fill: 1" thick, fibrous-glass or polystyrene-foam board.

Commented [JRH5]: 10-inch wg available if required. Edit accordingly.

H. Duct Access Panel Assemblies:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ductmate Industries, Inc.; Ultimate Door or comparable product by one of the following:
a. Flame Gard, Inc.

b. Prior Approved Equal

2. UL 1978 listed by an NRTL
3. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.
4. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.
5. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000ºF.
6. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.14 DUCT LINER

A. Also refer to Section 23 07 00 - HVAC Insulation.

B. Supply air ductwork a minimum of 15 linear feet downstream and return air ductwork a minimum of 15 linear feet upstream of low-pressure air handling equipment and terminal units shall be internally lined with 1½" thick acoustical duct liner/insulation (minimum R-6 or greater where required by code), Johns Manville Linacoustic RC or approved equal.

1. Duct liner shall be securely fastened to ductwork with stick pins, speed washers and adhesive.
2. Leading edges of liner shall have a sheet metal nosing.
3. Exposed edges and butt joints shall be “buttered” with duct sealer.
4. Duct liner shall be interrupted at all fire, smoke, combination fire/smoke and radiation dampers.
5. Duct liner shall be interrupted not less than 6" upstream and 6" downstream of electric-resistance and fuel-burning heaters in a duct system.

C. Supply air ductwork a minimum of 50 linear feet (or as indicated) downstream of static pressure class +4 in. wg air handling equipment shall be internally lined with 1½" thick acoustical duct liner/insulation, (minimum R-6 or greater where required by code) Johns Manville Linacoustic RC or approved equal. Return air ductwork shall be lined as described in 2.13.B above or as indicated.

D. Return air ductwork, sound boots and transfer ducts shall have 1" thick liner, Johns Manville Linacoustic RC or approved equal.

1. Refer to Section 23 07 00 - HVAC INSULATION for return air ductwork requiring external insulation.

E. Indoor exposed rectangular sheet metal supply and return air ductwork shall be lined with 1" thick duct liner (minimum R-4 or greater where required by code) Johns Manville Linacoustic RC or equal.

Commented [JRH6]: This note is intended to apply where exposed ductwork is installed in areas subject to condensation (e.g. entryways, retails spaces with a high volume of traffic, etc.). Use discretion and, if in doubt, leave this note in as is.

F. Indoor exposed round, spiral or flat oval ductwork shall be lined with 1" thick fiberglass duct liner/insulation (minimum R-4 or greater where required by code) Johns Manville Spiracoustic Plus or approved equal.

G. Subject to compliance with requirements, duct liner products shall be manufactured by: CertainTeed, Johns Manville, Knauf, Owens Corning, or approved equal.

PART 3 – EXECUTION

3.01 INSTALLATION

A. All ductwork shall be installed in accordance with applicable SMACNA Standards according to the pressure class described in PART 1 - GENERAL.

B. Seal, inspect and test ductwork prior to insulating or concealing. Seal all ductwork and plenums to meet the following SMACNA duct seal class:

1. Class A: Seal all transverse joint, longitudinal seams, and duct wall penetrations.
   a. Pressure-sensitive tape shall not be used as the primary sealant, unless it has been certified to comply with UL 181A or UL 181B by an independent testing laboratory and the tape is used in accordance with that certification.
   b. All connections shall be sealed, including but not limited to spin-in fittings, taps, other branch connections, access doors, and duct connections to equipment.
   c. Sealing that would void product listings is not required.
   d. Spiral lock seams need not be sealed.
2. Tapes, sealants and mastics used to seal metallic and flexible air ducts and flexible air connectors shall comply with UL 181B and shall be marked “181B-FX” for pressure-sensitive tape or “181B-M” for mastic/sealant.
3. Mechanical fasteners for use with flexible nonmetallic air ducts shall comply with UL 181B and shall be marked “181B-C”.

C. Seal the annular space around all duct, grilles, registers, diffusers, etc. penetrations through walls, floors, and ceilings airtight with an approved material. Refer to the Architectural documents for approved materials.

D. Sheet metal and flexible ductwork shall be supported as recommended by SMACNA Standards from structural members. Zip ties are not an acceptable method for suspending ductwork. Ductwork shall not be allowed to rest on ceilings, light fixtures or structural members. Ductwork supported from joists shall be supported from the top chord of all joists.

E. All ductwork accessories shall be installed in strict accordance with manufacturer’s recommendations.

F. Ductwork that is designed to operate at static pressures in excess of 3 in. wg and all ductwork located outdoors shall be leak-tested in accordance with SMACNA Standards. Representative sections totaling no less than 25% of the total installed duct area for the designated pressure class shall be tested. All sections shall be selected by the building owner or the designated representative of the building owner. Positive pressure leakage testing is acceptable for negative pressure ductwork. The maximum permitted duct leakage shall be:

$$L_{max} = C_L P^{0.65}$$

where

L_{max} = maximum permitted leakage, cfm per100 ft^2 of duct surface area
C_L = 4, duct leakage class, cfm per100 ft^2 of duct surface area per inch of $water^{0.65}$
P = test pressure, which shall be equal to the design duct pressure class rating, in. of water

All ductwork seams shall be sealed with mastic to provide a system that is within the recommended SMACNA leakage limits. As an alternate, water-based spray-on hardcast products may be used provided they meet or exceed the project requirements.

The ductwork test report shall be submitted in electronic (PDF) format to the Engineer prior to the Contractor’s request for final payment.

G. All ductwork shall be cleaned inside and out prior to system start up and shall be left in a neat and orderly manner.

H. Duct sizes shown on drawings are inside clear dimensions.

I. Unless otherwise approved, ducts shall be true to dimensions indicated, straight and smooth on the inside with neatly finished joints, securely anchored to the building in an approved manner, and installed to be completely free from vibration under all conditions of operation. Exact routing of ductwork will be dependent on location of framing members. Route ductwork to avoid cutting framing members.

J. Brace ducts not more than 60 inches on center.

K. Make slip joints in the direction of air flow.

L. Offset ducts around obstructions where possible. Where duct must encompass obstruction, area of duct shall remain constant.

M. Duct tapers shall not exceed 1:4 ratio and transformations 30 degrees between air flow and diverging or converging air flow.

N. Provide access doors for access to all equipment, dampers and motors concealed by sheet metal.

O. Where applicable, provide seismic bracing and restraints for ductwork per ASCE/SEI 7, latest edition and the latest edition of the SMACNA Seismic Restraint Manual. Also, refer to Section 23 05 48 Noise and Vibration Control.

3.02 BALANCING DAMPERS

A. Install manual volume dampers where indicated on the drawings and where required to properly balance the air distribution system.

B. Provide an opposed blade damper behind the face of each supply register which shall be adjustable through the face of the register with a screwdriver.

C. Provide an opposed blade damper behind the face of return air registers, where indicated, which shall be adjustable through the face of the register with a screwdriver.

D. Provide a butterfly damper in the neck of each ceiling diffuser unless noted otherwise.

END OF SECTION

SECTION 23 34 00

UNITARY EXHAUST AND SUPPLY FANS AND VENTILATORS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Refer to specification section 23 00 00 - HVAC General, all of which applies to work described in this section as if written in full herein. Special attention should be given to Section 2.02 ELECTRICAL WORK for specifics on motor and drive requirements.

B. Furnish and install all unitary exhaust and supply fans and ventilators of the size, type, capacity and characteristics as shown on the equipment schedules and herein described.

C. Base fan-performance ratings on actual project site altitude.

D. Acceptable manufacturers include only those whose products have been in satisfactory use in similar service for not less than five (5) years.

E. Electrical Standards: Provide electrical motors and products which have been listed and labeled by Underwriters Laboratories Inc. and comply with NEMA Standards.

F. Certification, Fan Performance: Fans shall be certified to bear the AMCA label for air and sound performance.

PART 2 - PRODUCTS

2.01 CENTRIFUGAL AND AXIAL FANS AND VENTILATORS

A. All units shall be rigidly constructed of materials suitable for the intended service and shall be installed with all accessories listed on the Drawings.

B. All roof mounted units shall be installed on factory supplied 14-inch high (minimum) insulated roof curbs of the proper type, size and construction for proper mounting. Curbs shall account for all roof slopes and pitches so that the unit is installed level. Units shall be anchored to curbs by a minimum of two lag screws of adequate size on each side. Curbs shall be constructed of galvanized steel, except when the project is located within 5 miles of a sea coast they shall be of aluminum construction.

C. Outdoor fans shall be completely weatherproof for outdoor installation and shall contain internal vibration isolation to assure smooth and quiet performance.

D. Fan wheels and blades shall be constructed of aluminum and shall be statically and dynamically balanced at the factory.

2.02 CEILING-CENTRIFUGAL AND CABINET FANS

A. Units shall be direct-drive type with back-draft damper, acoustically insulated cabinets and speed controller.

2.03 EXHAUST FANS SERVING KITCHEN HOODS

A. Grease handling exhaust fans shall carry a UL 762 Listing and shall be provided with all accessories/features required to meet that listing.

B. Grease exhaust fans shall discharge a minimum of 42" above the finished roof.

2.04 EXHAUST FANS SERVING DISHWASHERS

A. Dishwasher exhaust fans shall be all aluminum construction.

PART 3 - EXECUTION

3.01 GENERAL

A. All units shall be installed in accordance with manufacturer’s recommendations and as shown on the Drawings.

B. Ceiling-centrifugal and cabinet fans shall be supported from structural members and shall not rest on the ceiling, on lights or on structural members.

C. Units shall be interlocked and controlled as indicated on the Drawings.

D. Ceiling-mounted units shall be installed with ceiling grilles flush with the ceiling.

E. Curb-mounted fans shall be secured to the roof curb with lag screws in each hole in the fan curb cap.

F. Electrical connection to the fan motor shall be made through the roof opening inside the roof curb.

G. Replace fan and motor pulleys as required to achieve design airflow.

END OF SECTION

SECTION 23 37 00

LOUVERS, GRILLES, REGISTERS AND DIFFUSERS

PART 1 - GENERAL

1.01 DESCRIPTION

A. All work in this section shall be subject to the provisions of Section 23 00 00 - HVAC General.

B. Furnish and install all louvers, grilles, registers and diffusers of the size, type, capacity, and characteristics as shown on the equipment schedules and specified herein.

C. Equipment schedules and specifications are intended to establish a minimum level of quality and workmanship for the project. When other than the basis of design equipment is proposed, the Contractor shall be responsible for all costs associated with engineering and construction modifications necessary in his or any other trade that may be required to satisfy the Contract Documents.

D. Refer to the drawings for basis of design manufacturer and acceptable alternates.

PART 2 - PRODUCTS

2.01 LOUVERS

A. Louver components (heads, jambs, sills, blades, etc.) shall be factory assembled by the manufacturer into a complete unit. Louver sizes too large for shipping shall be built-up from factory assembled louver sections to provide the overall sizes required.

B. Louver design shall incorporate structural supports required to withstand a wind load of 20 lbs./square foot.

C. All louver performance data submitted for approval shall bear the AMCA Certified Ratings Seal for Air Performance and Water Penetration.

D. All louvers shall have a factory applied finish coating as scheduled with the color selection made by the Architect at the time of shop drawing approval. Color charts shall be submitted with louver shop drawings.

E. Screens:

1. General: Provide a screen at each exterior louver.
2. Frames: Same kind and form of metal as indicated for louver to which screens are attached.
3. Screening material:
   a. Bird Screen: Aluminum, ¼" by ¼" square mesh wire; 0.047" thick

2.02 SEVERE DUTY LOUVERS

A. In hurricane prone regions (as defined by the International Building Code) and where scheduled, louvers shall be the severe duty type to protect intake and exhaust openings from wind-driven rain and wind-borne debris.

B. Severe duty louvers shall be AMCA certified in accordance with AMCA 540/550, Enhanced Level E, for water, air and wind-driven rain.

C. Structural Performance: Severe duty louvers shall withstand the effects of gravity loads, wind loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver blade rattle or flutter, or permanent damage to fasteners and anchors.

1. Wind-Load: 150 lbs./sq. ft. (7.182 kPa) maximum pressure acting inward or outward

D. Florida Product Approved louvers are acceptable for use in Florida's High Velocity Hurricane Zone if a Miami-Dade Notice of Acceptance in not required.

2.03 GRILLES, REGISTERS AND DIFFUSERS

A. Units shall be of the type, size, and construction as scheduled or indicated.
B. Unless otherwise noted or indicated, all air devices shall be supplied with a factory finish of manufacturer's standard white.

C. Grilles, registers and diffusers shall be ordered with borders compatible with the ceiling system type in which they are installed. Refer to architectural drawings for type of ceiling and/or suspension system.

D. Aluminum air devices shall be used for all areas subject to excessive moisture or humidity (e.g. showers, pools, bathrooms, etc.).

PART 3 - EXECUTION

3.01 LOUVERS

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

B. The louver installation shall be made weatherproof by caulking and sealing at the frame and flanges in accordance with the manufacturer's recommendations.

C. Combination louver/dampers shall be installed with the required actuators and linkage mechanisms and shall be field adjusted for full opening/closure stroke. Louvers shall be interlocked as scheduled or indicated.

3.02 GRILLES, REGISTERS AND DIFFUSERS

A. All air devices located in ceiling tiles shall be centered or shall be on quarter points of 2 ft. x 2 ft. tiles.

B. Where a line of sight allows the ductwork, wall, or ceiling structure to be seen behind any units, such ductwork, wall or ceiling structure shall be painted with nonflammable flat black paint to minimize visibility.

C. All air devices not installed on T-bar ceiling grids shall be securely fastened to adjacent structures.

D. Where air distribution devices are installed in inaccessible ceilings, provide the spin-in fitting without a volume damper. Provide an opposed blade damper in the neck of the air distribution device with access to the damper control through or at the face of the device.

END OF SECTION

SECTION 23 38 00

KITCHEN VENTILATION EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Furnish and install a self-compensating ventilation canopy over the cooking battery complete with makeup and exhaust fans with curbs, grease filters, dry chemical fire suppression system, vapor-proof lights and controls.

PART 2 - PRODUCTS

2.01 KITCHEN HOOD VENTILATION AND EXHAUST SYSTEM

A. Description: Hood over food cooking equipment shall provide for both air supply and air exhaust. Supply air provided through blower with filters directly from outside. Exhaust air pulled through “grease” extractor filters and discharged vertically above the roof. Canopy shall be constructed with a totally welded inner exhaust canopy and a complete outer canopy providing an air plenum between the exhaust and supply canopies on the top and front. Canopy ends shall be double thickness 18-gauge material as specified. Canopy shall be of the short circuit design. Refer to the Drawings for model, size and capacities.

B. Features of Range Hood:

1. Stainless steel construction with matching soffit above to ceiling. Outside surface shall be finished white epoxy enamel.
2. “Grease” extractor filters shall be stainless steel, UL Labeled, 20" x 20" x 2" size, self-draining.
3. Removable grease gutters under filters, pitched to drain to a removable metal collection container.
4. Makeup air slots shall be adjustable. Hood shall have been tested and rated by Underwriters Laboratories Inc. for a proven exhaust rate of 250 cfm L/F over high heat (600 degrees F+) cooking equipment with a supply air ratio of 84%, as listed by UL for the high heat test.
5. Built in vapor proof hood interior lights, one per each 3 feet of length, pre-wired to switch.
6. Pre-wired control panels with stainless steel exposed surface containing operating pilot lights and switches.
7. Hood size to completely cover the cooking equipment plus an overhang of 12" minimum on all sides.
8. Hood to be UL classified.

C. Features of Duct Package:

1. Exhaust duct shall be all welded construction per NFPA 96.
2. Exhaust and supply ducts shall be of the concentric arrangement and UL Labeled number MH10644 so that the exterior duct can be installed to within 1" of combustible materials. Duct to include slip joint connections as approved by UL for vertical duct, with horizontal duct to include flanges for field welding.
3. Parallel duct arrangement is acceptable providing the Contractor satisfies the clearance requirements of NFPA 96 and the local fire marshal.

D. Features of Roof-Mounted Assembly:

1. Supply air fan package constructed of aluminized steel including intake section with air filters and birdscreen, support legs and factory enamel finish.
2. Top discharge exhaust fan with plug in connection for master electric panel, furnished for field installation of factory furnished economizer section. No birdscreens or backdraft dampers. The fan shall be UL Labeled for grease contaminated air. Provide low silhouette curb as drawn.
3. Master electric pre-wired control panel, factory mounted and wired with main power source connection, control circuit terminal strip, magnetic motor contactors, manual motor overload switch, contactors, relays, transformers, circuit breakers, fuses and fused disconnect.
4. Factory wiring in conduit conforming to NFPA Standard 70 and designed to withstand effects of heat, vapor and grease on the equipment. Wiring shall include low voltage (24 volt) control wiring in conduit to opening in top of canopy, connecting wiring harness and conduit to master electric control panel.
5. A complete kitchen hood fire extinguishing system shall be provided under this item.
6. Approval: The “Seal of Approval” of the NATIONAL SANITATION FOUNDATION TESTING LABORATORY (NFS) shall appear on the Ventilation System.
7. Code: The system construction shall be in accordance with NFPA Standard 96, “Vapor Removal from Commercial Cooking Equipment,” and the Southern Building Code Congress.
8. Manufacturers: Duo-Aire, Greenheck, Cambridge-XL.

2.02 EXHAUST CANOPY FIRE PROTECTION SYSTEM

A. The fire suppression protection system should be of the stored pressure, wet chemical pre-engineered fixed nozzle type manufactured by Wells Fargo Pyro Technologies, Inc. A carbon dioxide cartridge is designed in compliance with Military Specification “MIL-C-601G,” and shall be used as the pneumatic releasing device for the system. The cartridge shall be an integral part of the control head assembly. The wet chemical storage cylinder shall be D.O.T. rated for stored pressure of 175 psig, and a pressure gauge shall be provided on the cylinder valve for visual inspection. The system shall be capable of automatic and manual actuation. Automatic actuation shall be provided by an appropriate number of thermal detectors mounted in series on a stainless steel wire input line to the control head. Manual actuation shall be provided by turning a handle on the primary head and/or by an optional remote pull station with a dedicated stainless steel input line to the control head.

B. The system shall have been tested to the UL Standard for Fire Extinguishing Systems for Protection of Restaurant Cooking Areas, UL 300, and listed by Underwriters Laboratories Inc. It shall be installed in accordance with the National Fire Protection Association Standard No. 17A Wet Chemical Extinguisher Systems, and No. 96 Standard for the Installation of Equipment for the Removal of Smoke and Grease Laden Vapors from Commercial Cooking Equipment, and comply with all local and/or state codes and standards.

C. Provide pressure activated electric shutoff switch and remote manually operated shutoff switch to all gas and electric cooking equipment located under hood and to exhaust and makeup fans shutoff switch.

D. All piping shall be schedule 40 hot-dipped galvanized steel. Fittings shall be banded pattern, extra heavy galvanized malleable iron threaded with a 2,000 psi WOG rating.

2.03 SUPPLY AND EXHAUST DUCT

A. Furnish and install supply and exhaust ductwork in accordance with the latest edition of NFPA 96 and all applicable local codes.

B. Exhaust ductwork shall be constructed of black steel minimum of 16-gauge thickness. All seams, joints, and penetrations shall have a continuous external weld except where the exhaust duct is connected to the exhaust canopy collar. Connection to the exhaust canopy collar shall be constructed in accordance with NFPA 96.

2.04 ROOFTOP MAKEUP AIR FAN

A. Provide air supply utility set of the single inlet, single width type. Fan housing shall be constructed of heavy gauge galvanized steel with weatherproof coating. Fan shall be provided with weather housing.

B. Fan wheel shall be aluminum, backwards inclined non-overloading. Fan shall be complete with adjustable belt drives, motor and disconnect switch.

C. Provide fan with filter hood for use with 2" thick cleanable filters complete with hood support frame, roof curb adapter for use in the downblast arrangement, backdraft damper and birdscreen.

2.05 ROOFTOP CENTRIFUGAL UPBLAST EXHAUST

A. Provide UL Listed upblast centrifugal fan of aluminum construction complete with non-sparking centrifugal fan wheel.

B. Fan shall come complete with motor and adjustable belt drive, disconnect switch, birdscreen, grease trough, and hinged base (for cleaning).

C. Fan and installation shall comply with NFPA 96.

D. Motor, bearings, and drive shall be isolated from exhaust air. Motor shall be cooled by clean outside air.

PART 3 - EXECUTION - Not Used

END OF SECTION

SECTION 23 74 00

SINGLE PACKAGE ROOFTOP AIR CONDITIONERS

PART 1 - GENERAL

1.01 DESCRIPTION

A. All work in this section shall be subject to the provisions of Section 23 00 00 - HVAC General.

B. Furnish and install factory assembled, piped and wired single package rooftop air conditioners of the type, operational characteristics and capacity as shown and scheduled and as specified herein. All rooftop units shall be by the same manufacturer. The manufacturer shall have available factory trained service engineers and an inventory of replacement parts within a 100-mile radius of the job site.

C. Refer to the drawings for basis of design manufacturer and acceptable alternates.

D. Compressor shall be warranted against parts failure for five (5) years.

E. Submit catalog cuts, certified performance data, and dimensional data.

PART 2 - PRODUCTS

2.01 EQUIPMENT AND MATERIALS

A. Unit shall be designed specifically for outdoor installation with all exterior surfaces of phosphatized, zinc-coated steel with primer and baked enamel finish. All components, including accessories shall be contained within the unit.

B. Access to internal components shall be by removable gasketed access panels with quick release latches and lifting handles.

C. Unit shall have factory installed lifting lugs capable of accepting standard lifting slings and spreader bars to facilitate hoisting.

D. Electrical power connections shall be to a single point.

E. Unit shall be insulated with a minimum of ½" thick, 1½ lb./ft^3 density fiberglass insulation. Insulation shall have a microbial resistant neoprene coating.

F. Unit shall be designed for curb mounting and mate with a full perimeter roof curb for a complete weather tight seal. Curb shall be a minimum of 14" high and manufactured of 12-gauge zinc-coated steel and be supplied by the unit manufacturer with a wood nailer strip and full perimeter gasket. Unit sides shall overhang the curb to form a protective drip lip. Supply and return ducts shall connect to the curb prior to placement of the unit. The manufacturer shall furnish gasketing materials for a leak-tight seal between the unit and duct connections.

2.02 HEATING SECTION

A. Provide aluminized steel or stainless steel slotted port gas burners and stainless steel heat exchanger as scheduled. Warranty on heat exchanger shall be 10 years.

B. Controls shall include redundant gas valve and intermittent pilot with electric spark ignition.

2.03 COMPRESSOR

A. Fully hermetic scroll or rotary compressor(s) shall be provided with capacity reduction of a minimum of 50% on units 7½ tons and larger.

B. A crankcase heater shall be provided and wired to be active continuously.

C. The compressor shall be provided with spring isolators and flexible discharge line and hot gas muffler.

D. Motor shall be specifically designed for operation within a refrigerant atmosphere. Inlet screens shall be provided. Motor shall be capable of starting and continuously operating at ambient temperatures as high as 120ºF. Motor shall have overload protection and internal thermostats.

E. Compressor motor shall be capable of withstanding voltage fluctuations of plus or minus 10% of name plate voltage.

2.04 REFRIGERATION CIRCUIT

A. The unit shall be certified as complying with AHRI Standard 210/240 or 340/360 and bear the AHRI seal.

B. The evaporator coil shall consist of 3/8" O.D. copper tubes mechanically bonded to aluminum plate fins and be pressure and leak tested at 425 psig. Condenser fans shall be statically and dynamically balanced. Fan motors shall be UL Listed for outdoor use, have built-in thermal overload protection and permanently lubricated bearings. Condensing section shall be designed for a maximum of 130ºF condensing temperature with ambient air at 95ºF. Coil shall be circuited for sub-cooling.

C. Unit shall incorporate an insulated and sealed IAQ drain pan with threaded drain connections at each end of the unit. The Contractor shall install P-traps. Overflow protection shall be provided via a float switch wired to shut the unit off if liquid is detected.

D. Refrigeration controls shall include as a minimum, high and low pressure control, compressor winding thermostat and overload, lockout circuit re-settable at the unit thermostat, contactors for condenser/evaporator fans and compressor, and 24 volt control power transformer.

E. Unit shall ship with an operating charge of refrigerant of R-454B.

2.05 EVAPORATOR FANS

A. Evaporator fan shall be direct driven or belt driven forward curved type with an adjustable sheave and motor sized to meet the air flow and static pressure as scheduled.

B. Fans assembly shall be isolated from the unit on rubber-in-shear or spring type isolators.

C. Motor shall have thermal overload protection and motor and fan bearings shall be permanently lubricated.

D. Fan wheel shall be protected from corrosion with a painted finish.

2.06 FILTERS

A. Two (2) sets of 2" low velocity filters shall be provided with the unit. Filters shall be MERV 8, pleated, disposable type equal to Farr 30/30 or as scheduled.

B. Only one size filter per unit is allowed.

C. During construction, the initial set of filters will be installed along with temporary media consisting of two plys of polyester fibers; 1¼" (32mm) thick with a non-migrating tackified surface having a MERV 8 rating.

1. For non-ducted (plenum return) systems, use roll filter media over each inlet duct.
2. For ducted systems, use precut pads with holding frames installed at each return air register or grille.

2.07 ACCESSORIES TO BE PROVIDED

A. Accessories noted below may or may not be required for equipment scheduled. Refer to the equipment schedules on the drawings for specific accessory requirements.

B. Non-fused disconnect switch.

C. GFI convenience outlet.

D. Anti-cycling timer to provide 5-minute delay between compressor shut-down and restart.

E. Roof curb. Coordinate with the roof system used so that a minimum of 8" of the curb is above the finished roof for flashing purposes. The top of the curb shall be level and the slope of the roof shall be compensated for by the curb.

F. Enthalpy controlled economizer cycle with minimum position rheostat including dampers with modulating controllers and spring return operators.

G. Demand controlled ventilation - A CO_2 sensor shall also be provided. The CO_2 sensor shall be wired to the rooftop unit economizer such that on a CO_2 level rise the outside air damper shall modulate until the CO_2 level returns below setpoint which shall return the outside air damper back to normal operation. The CO_2 sensor manufacturer shall be the same as the rooftop unit manufacturer.

H. DDC system communicating controller.

I. Hail Guards.

J. Phase Monitor (3 phase units only)

PART 3 - EXECUTION

3.01 EQUIPMENT

A. Unit shall be shipped with a full refrigerant charge.

B. Unit shall be run tested at factory before shipping.

3.02 INSTALLATION

A. Unit shall be installed level within manufacturer's recommendations.

B. The second set of filters shall be installed after the unit has been cleaned and testing and balancing has been completed.

END OF SECTION

SECTION 23 82 39.19

ELECTRIC WALL HEATERS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. All work specified herein shall be accomplished in accordance with the applicable requirements of Section 23 00 00 - HVAC General.

1.02 WORK INCLUDED

A. Receipt, unloading, handling, proper storage and protection from damage of all materials.

B. Layout and coordination of work with other trades.

C. The work under this section shall include all labor, materials, accessories, services, and equipment necessary to furnish and install wall heaters complete as indicated on the Drawings and as specified herein.

PART 2 - PRODUCTS

2.01 WALL HEATERS

A. Unit shall be completely factory assembled, wired, tested and shipped as a single assembly; capacity shall be as indicated on the Drawings.

B. Unit heaters shall be constructed in accordance with provisions of the National Electrical Code and shall be UL or ETL tested and listed to UL Standard 2021 – UL Standard for Safety Fixed and Location-Dedicated Electric Room Heaters.

C. Front grille shall be 16-gauge steel or aluminum finished in baked enamel or anodized with downflow discharge louvers.

D. Element shall consist of helically coiled nickel chromium alloy resistance wire enclosed in corrosion resistant sheaths.

E. Controls shall include fan delay switch, built-in thermostat, automatic reset thermal overload switch and a non-fused disconnect power switch.

F. Unit shall be designed to either recess into the wall or for surface mounting as scheduled, and shall include all mounting accessories.

G. Unit shall be Raywall, QMark, Markel, Berko, Indeeco or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All units shall be installed in strict accordance with the manufacturer’s recommendations.

END OF SECTION

SECTION 23 82 39

ELECTRIC UNIT HEATERS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. All work specified herein shall be accomplished in accordance with the applicable requirements of Section 23 00 00 - HVAC General.

1.02 WORK INCLUDED

A. Receipt, unloading, handling, proper storage, and protection from damage of all materials.

B. Layout and coordination of work with other trades.

C. The work under this section shall include all labor, materials, accessories, services, and equipment necessary to furnish and install electric unit heaters complete as indicated on the Drawings and as specified herein.

D. Refer to the drawings for approved manufacturers.

1.03 QUALITY ASSURANCE

A. Electric heaters shall be constructed in accordance with provisions of the National Electrical Code and shall be UL or ETL tested and listed to UL Standard 2021 – UL Standard for Safety Fixed and Location-Dedicated Electric Room Heaters.

PART 2 - PRODUCTS

2.01 UNIT HEATERS

A. Unit shall be of the horizontal or vertical discharge fan-forced propeller type.

B. Casing shall be constructed of heavy gauge die-formed, furniture grade steel, phosphate coated and finished in baked enamel.

C. The heating element shall be aluminum-finned with a copper clad steel sheath.

D. Fan shall be direct drive propeller type designed specifically for unit heater applications.

E. The motor shall be totally enclosed, thermally protected, continuous duty type selected to match airflow requirements.

F. Unit shall be provided with the manufacturer’s standard mounting bracket for either ceiling or wall mounting as required.

G. Unit shall be equipped with individually adjustable horizontal discharge louvers.

H. Wiring shall be designed for a single source power connection with elements, motor and control circuits subdivided and fused to conform to the latest National Electrical Code, OSHA, and Underwriters Laboratories Inc. standards. All three phase heaters shall have balanced phases. A factory wired non-fused disconnect switch shall be provided. Control circuit voltage shall not exceed 120 volts.

I. Unit heater shall be equipped with an automatic reset linear thermal cut-out, a fan delay switch, and control circuit transformer.

J. Thermostat shall be unit mounted or wall mounted as shown on the Drawings.

2.02 CEILING HEATERS

A. Unit shall be of the vertical discharge fan-forced type.

B. Housing shall be constructed of heavy gauge steel with a baked-on powder coat finish.

C. The grille shall be constructed of 18-gauge powder coated steel.

D. The heating element shall be the block-finned type with parallel steel fins.

E. Fan shall be the direct drive propeller or vane axial type.

F. The motor shall be totally enclosed, thermally protected, continuous duty type selected to match airflow requirements.

G. Unit shall be provided with the manufacturer's standard mounting hardware for ceiling mounting.

H. Wiring shall be designed for a single source power connection with elements, motor and control circuits subdivided and fused to conform to the latest National Electrical Code, OSHA, and Underwriters Laboratories standards. A factory wired non-fused disconnect switch shall be provided. Control circuit voltage shall not exceed 120 volts.

I. Ceiling heater shall be equipped with a manual reset thermal limit (integral thermostat) or automatic reset thermal limit (remote wall mounted thermostat), a fan delay switch, and control circuit transformer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All units shall be installed in strict accordance with the manufacturer's installation instructions.

B. In areas where heaters are used for freeze protection, thermostat setpoint shall be adjusted to 40^{o}F.

END OF SECTION