

DIVISION 23: HEATING, VENTILATING, AND AIR-CONDITIONING

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SECTION 23 0501 – COMMON HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Furnish labor, materials, and equipment necessary for completion of work as described in Contract Documents.
- B. It is the intent of these specifications that the systems specified herein are to be complete and operational before being turned over to the owner. During the bidding process, the contractor is to ask questions or call to the engineer's attention any items that are not shown or may be required to make the system complete and operational. Once the project is bid and the contractor has accepted the contract, it is his responsibility to furnish and install all equipment and parts necessary to provide a complete and operational system without additional cost to the owner.
- C. Furnish and install fire stopping materials to seal penetrations through fire rated structures and draft stops.
- D. Includes But Not Limited To:
 - 1. General procedures and requirements for HVAC.
- E. Related Sections:
 - 1. Section 23 0593: Testing, Adjusting, and Balancing for HVAC.

1.3 SUBMITTALS

- A. Substitutions: By specific designation and description, standards are established for specialties and equipment. Other makes of specialties and equipment of equal quality will be considered provided such proposed substitutions are submitted to the Architect for his approval, complete with specification data showing how it meets the specifications, at least 5 working days prior to bid opening. A list of approved substitutions will be published as an addendum.
 - 1. Submit a single copy of Manufacturer's catalog data including Manufacturer's complete specification for each proposed substitution.
 - 2. The Architect or Engineer is to be the sole judge as to the quality of any material offered as an equal.
- B. Product Data, Shop Drawings: Within 30 days after award of contract, submit 10 sets of Manufacturer's catalog data for each manufactured item.
 - 1. Literature shall include enough information to show complete compliance with Contract Document requirements.
 - 2. Mark literature to indicate specific item with applicable data underlined.
 - 3. Information shall include but not be limited to capacities, ratings, type of material used, guarantee, and such dimensions as are necessary to check space requirements.
 - 4. When accepted, submittal shall be an addition to Contract Documents and shall be in equal force. No variation shall be permitted.
 - 5. Even though the submittals have been accepted by the Engineer, it does not relieve the contractor from meeting all of the requirements of the plans and specifications and providing a complete and operational system.
- C. Drawings of Record: One complete sets of blue line mechanical drawings shall be provided for the purpose of showing a complete picture of the work as actually installed.
 - 1. These drawings shall serve as work progress report sheets. Contractor shall make notations neat and legible therein daily as the work proceeds.
 - 2. The drawings shall be kept at the job at a location designated by the Mechanical Engineer.
 - 3. At completion of the project these "as-built" drawings shall be signed by the Contractor, dated, and returned to the Architect.
- D. Operating Instructions and Service Manual: The Mechanical Contractor shall prepare 2 copies of an Operation and Maintenance Manual for all mechanical systems and equipment used in this project. Manuals shall be bound in hard-backed binders and the front cover and spine of each binder shall indicate the name and location of the project. Use plastic tab indexes for all sections. Provide a section for each different type of equipment item. The following items shall be included in the manual, together with any other pertinent data. This list is not complete and is to be used as a

guide.

1. Provide a master index at the beginning of the manual showing all items included.
 2. The first section of the manual shall contain:
 - a. Names, addresses, and telephone numbers of Architect, Mechanical Engineer, Electrical Engineer, General Contractor, Plumbing Contractor, Sheet Metal Contractor, and Temperature Control Contractor.
 - b. List of Suppliers which shall include a complete list of each piece of equipment used with the name, address, and telephone number of vendor.
 - c. General Description of Systems including –
 - 1) Location of all major equipment
 - 2) Description of the various mechanical systems
 - 3) Description of operation and control of the mechanical systems
 - 4) Suggested maintenance schedule
 - d. Copy of contractor's written warranty
 3. Provide a copy of approved submittal literature for each piece of equipment.
 4. Provide maintenance and operation literature published by the manufacturer for each piece of equipment which includes: oiling, lubrication and greasing data; belt sizes, types and lengths; wiring diagrams; step-by-step procedure to follow in putting each piece of mechanical equipment in operation.
 5. Include parts numbers of all replaceable items.
 6. Provide control diagram and operation sequence, along with labeling of control piping and instruments to match diagram.
 7. Include a valve chart indicating valve locations.
- E. Include air balance and/or water balance reports.

1.4 SUBMITTALS FOR COMMON HVAC REQUIREMENTS

- A. Samples: Sealer and gauze proposed for sealing ductwork.
- B. Quality Assurance / Control:
1. Manufacturer's installation manuals providing detailed instructions on assembly, joint sealing, and system pressure testing for leaks.
 2. Specification data on sealer and gauze proposed for sealing ductwork.
- C. Quality Assurance
1. Requirements: Construction details not specifically called out in Contract Documents shall conform to applicable requirements of SMACNA HVAC Duct Construction Standards.
 2. Pre-Installation Conference: Schedule conference immediately before installation of ductwork.

1.5 QUALITY ASSURANCE

- A. Requirements of Regulatory Agencies:
1. Perform work in accordance with applicable provisions of local and state Plumbing Code, Gas Ordinances, and adoptions thereof. Provide materials and labor necessary to comply with rules, regulations, and ordinances.
 2. In case of differences between building codes, state laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Promptly notify Architect in writing of such differences.
- B. Applicable Specifications: Referenced specifications, standards, and publications shall be of the issues in effect on date of Advertisement for Bid.
1. "Heating, Ventilating and Air Conditioning Guide" published by the American Society of Heating and Air Conditioning Engineers.
 2. "Engineering Standards" published by the Heating, Piping, and Air Conditioning Contractors National Association.
 3. "2009 International Building Code", "2009 International Mechanical Code", and "2009 International Fire Code" as published by the International Conference of Building Officials.
 4. 2009 Idaho Plumbing Code as published by the International Association of Plumbing and Mechanical Officials.
 5. "National Electrical Code" as published by the National Fire Protection Association.
 6. "2009 International Energy Conservation Code".
- C. Identification: Motor and equipment name plates as well as applicable UL and AGA labels shall be in place when Project is turned over to Owner.

1.6 INSPECTIONS AND PERMITS

- A. Pay for permits, fees, or charges for inspection or other services. Local and state codes and ordinances must be properly executed without expense to Owner and are considered as minimum requirements. Local and state codes and ordinances do not relieve the Contractor from work shown that exceeds minimum requirements.

1.7 ADDITIONAL WORK:

- A. Design is based on equipment as described in the drawing equipment schedule. Any change in foundation bases, electrical wiring, conduit connections, piping, controls and openings required by alternate equipment submitted and approved shall be paid for by this division. All work shall be in accordance with the requirements of the applicable sections.

PART 2 - PRODUCTS FOR COMMON HVAC REQUIREMENTS

- A. Finishes, Where Applicable: Colors as selected by Architect.
- B. Duct Hangers:
 - 1. One inch 25 mm by 18 ga 1.27 mm galvanized steel straps or steel rods as shown on Drawings, and spaced not more than 96 inches 2 400 mm apart. Do not use wire hangers.
 - 2. Attaching screws at trusses shall be 2 inch 50 mm No. 10 round head wood screws. Nails not allowed.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Site Inspection:
 - 1. Examine premises and understand the conditions which may affect performance of work of this Division before submitting proposals for this work.
 - 2. No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.
- B. Drawings:
 - 1. Mechanical drawings show general arrangement of piping, ductwork, equipment, etc, and do not attempt to show complete details of building construction which affect installation. This Contractor shall refer to architectural, structural, and electrical drawings for additional building detail which affect installation of his work.
 - a. Follow mechanical drawings as closely as actual building construction and work of other trades will permit.
 - b. No extra payments will be allowed where piping and/or ductwork must be offset to avoid other work or where minor changes are necessary to facilitate installation.
 - c. Everything shown on the mechanical drawings shall be the responsibility of Mechanical Contractor unless specifically noted otherwise.
 - 2. Consider architectural and structural drawings part of this work insofar as these drawings furnish information relating to design and construction of building. These drawings take precedence over mechanical drawings.
 - 3. Because of small scale of mechanical drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Investigate structural and finish conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions. Do not scale drawings for locations of equipment or piping. Refer to large scale dimensioned drawings for exact locations.
- C. Insure that items to be furnished fit space available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents.
 - 1. If approval is received to use other than specified items, responsibility for specified capacities and insuring that items to be furnished will fit space available lies with this Division.
 - 2. If non-specified equipment is used and it will not fit job site conditions, this Contractor assumes responsibility for replacement with items named in Contract Documents.

3.2 PREPARATION

- A. Cut carefully to minimize necessity for repairs to existing work. Do not cut beams, columns, or trusses.
 - 1. Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.
 - 2. Each Section of this Division shall bear expense of cutting, patching, repairing, and replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.

3. Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.

3.3 INSTALLATION

- A. Arrange pipes, ducts, and equipment to permit ready access to valves, unions, traps, starters, motors, control components, and to clear openings of doors and access panels.

3.4 STORAGE AND PROTECTION OF MATERIALS:

- A. Provide storage space for storage of materials and assume complete responsibility for losses due to any cause whatsoever. Storage shall not interfere with traffic conditions in any public thoroughfare.
- B. Protect completed work, work underway, and materials against loss or damage.
- C. Close pipe openings with caps or plugs during installation. Cover fixtures and equipment and protect against dirt, or injury caused by water, chemical, or mechanical accident.

3.5 EXCAVATION AND BACKFILL

- A. Perform necessary excavation of whatever substance encountered for proper laying of all pipes and underground ducts.
 1. Excavated materials not required for fill shall be removed from site as directed by Engineer.
 2. Excavation shall be carried low enough to allow a minimum coverage over underground piping of 5'-0" or to be below local frost level.
 3. Excess excavation below required level shall be backfilled at Contractor's expense with earth, sand, or gravel as directed by Engineer. Tamp ground thoroughly.
 4. Ground adjacent to all excavations shall be graded to prevent water running into excavated areas.
- B. Backfill pipe trenches and allow for settlement.
 1. Backfill shall be mechanically compacted to same density as surrounding undisturbed earth.
 2. Cinders shall not be used in backfilling where steel or iron pipe is used.
 3. No backfilling shall be done until installation has been approved by the Engineer.

3.6 COOPERATION

- A. Cooperate with other crafts in coordination of work. Promptly respond when notified that construction is ready for installation of work under Division 23000. Contractor will be held responsible for any delays which might be caused by his negligence or failure to cooperate with the other Contractors or crafts.

3.7 SUPERVISION

- A. Provide a competent superintendent in charge of the work at all times. Anyone found incompetent shall be removed at once and replaced by someone satisfactory, when requested by the Architect.

3.8 INSTALLATION CHECK:

- A. An experienced, competent, and authorized representative of the manufacturer or supplier of each item of equipment indicated in the equipment schedule shall visit the project to inspect, check, adjust if necessary, and approve the equipment installation. In each case, the equipment supplier's representative shall be present when the equipment is placed in operation. The equipment supplier's representative shall revisit the project as often as necessary until all trouble is corrected and the equipment installation and operation is satisfactory to the Engineer.
- B. Each equipment supplier's representative shall furnish to the Owner, through the Engineer, a written report certifying the following:
 1. Equipment has been properly installed and lubricated.
 2. Equipment is in accurate alignment.
 3. Equipment is free from any undue stress imposed by connecting piping or anchor bolts.
 4. Equipment has been operated under full load conditions.
 5. Equipment operated satisfactorily.
- C. All costs for this installation check shall be included in the prices quoted by equipment suppliers.

3.9 CLEANING EQUIPMENT AND PREMISES

- A. Properly lubricate equipment before Owner's acceptance.
- B. Clean exposed piping, ductwork, equipment, and fixtures. Repair damaged finishes and leave everything in working order.
- C. Remove stickers from fixtures and adjust flush valves.
- D. At date of Substantial Completion, air filters shall be new, clean, and approved by Owner's representative.
- E. Trap elements shall be removed during cleaning and flushing period. Replace trap elements and adjust after cleaning and flushing period.

3.10 TESTS

- A. No piping work, fixtures, or equipment shall be concealed or covered until they have been inspected and approved by the inspector. Notify inspector when the work is ready for inspection.
- B. All work shall be completely installed, tested as required by Contract Documents and the city and county ordinances and shall be leak-tight before the inspection is requested.
- C. Tests shall be repeated to the satisfaction of those making the inspections.
- D. Water piping shall be flushed out, tested at 100 psi and left under pressure of supply main or a minimum of 40 psi for the balance of the construction period.

3.11 WARRANTY

- A. Contractor shall guarantee work under Division 23 to be free from inherent defects for a period of one year from acceptance.
 - 1. Contractor shall repair, revise or replace any and all such leaks, failure or inoperativeness due to defective work, materials, or parts free of charge for a period of one year from final acceptance, provided such defect is not due to carelessness in operation or maintenance.
 - 2. In addition, the Contractor shall furnish all refrigeration emergency repairs, emergency service and all refrigerant required due to defective workmanship, materials, or parts for a period of one year from final acceptance at no cost to the Owner, provided such repairs, service and refrigerant are not caused by lack of proper operation and maintenance.
- B. In addition to warranty specified in General Conditions, heating, cooling, and plumbing systems are to be free from noise in operation that may develop from failure to construct system in accordance with Contract Documents.

3.12 SYSTEM START-UP, OWNER'S INSTRUCTIONS

- A. Off-Season Start-up
 - 1. If Substantial Completion inspection occurs during heating season, schedule spring start-up of cooling systems. If inspection occurs during cooling season, schedule autumn start-up for heating systems.
 - 2. Notify Owner 7 days minimum before scheduled start-up.
 - 3. Time will be allowed to completely service, test, check, and off-season start systems. During allowed time, train Owner's representatives in operation and maintenance of system.
 - 4. At end of off-season start-up, furnish Owner with letter confirming that above work has been satisfactorily completed.
- B. Owner's Instructions
 - 1. Instruct building maintenance personnel and Owner Representative in operation and maintenance of mechanical systems utilizing Operation & Maintenance Manual when so doing.
 - 2. Minimum instruction periods shall be as follows –
 - a. Mechanical - Four hours.
 - b. Temperature Control - Four hours.
 - c. Refrigeration - Two hours.
 - 3. Instruction periods shall occur after Substantial Completion inspection when systems are properly working and before final payment is made.
 - 4. None of these instructional periods shall overlap another.

3.13 PROTECTION

- A. Do not run heat pump, air handling units, fan coil units, or other pieces of equipment used for moving supply air without proper air filters installed properly in system.
- B. The mechanical systems are not designed to be used for temporary construction heat. If any equipment is to be started prior to testing and substantial completion, such equipment will be returned to new condition with full one year warranties, from date of substantial completion after any construction use. This includes, but is not necessarily limited to: Equipment, filters, ductwork, fixtures, etc.

3.14 COMMON HVAC REQUIREMENTS:

A. INSTALLATION

- 1. During installation, protect open ends of ducts by covering with plastic sheet tied in place to prevent entrance of debris and dirt.
- 2. Make necessary allowances and provisions in installation of sheet metal ducts for structural conditions of building. Revisions in layout and configuration may be allowed, with prior written approval of Architect. Maintain required airflows in suggesting revisions.
- 3. Hangers And Supports:
 - a. Install pair of hangers close to each transverse joint and elsewhere as required by spacing indicated in table on Drawings.
 - b. Install upper ends of hanger securely to floor or roof construction above by method shown on Drawings.
 - c. Attach strap hangers to ducts with cadmium-plated screws. Use of pop rivets or other means will not be accepted.
 - d. Where hangers are secured to forms before concrete slabs are poured, cut off flush all nails, strap ends, and other projections after forms are removed.
 - e. Secure vertical ducts passing through floors by extending bracing angles to rest firmly on floors without loose blocking or shimming. Support vertical ducts, which do not pass through floors, by using bands bolted to walls, columns, etc. Size, spacing, and method of attachment to vertical ducts shall be same as specified for hanger bands on horizontal ducts.

B. CLEANING

- 1. Clean interior of duct systems before final completion.

END OF SECTION 23 0501

SECTION 23 0548 – SEISMIC AND VIBRATION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 05 01 apply to this Section.

1.2 SUMMARY

- A. Furnish and install engineering, labor, material, and equipment necessary for a complete anchorage and seismic restraint system and vibration isolation system as described in Contract Documents.
 - 1. The system design and installation shall be based on Seismic Zone D of the International Building Code and other standards listed below.
 - 2. The work shall include all mechanical isolated and non- isolated equipment, ducts and piping systems which shall include:
 - a. Air handling units.
 - b. Utility and inline exhaust fans.
 - c. Ceiling and roof fans.
 - d. Air compressors.
 - e. Pumps.
 - f. Round ductwork 24" round and larger.
 - g. Rectangular ductwork 4 sq. ft. in cross-sectioned area and larger.
 - h. All piping 2-1/2" and larger except waste, vent and roof drainage piping.

1.3 REFERENCE STANDARDS

- A. International Building Code, Current Edition
- B. NFPA Bulletin 90A, Current Edition
- C. UL Standard 181
- D. Tri-Services Manual, Fagel Et Al
- E. MACNA Guidelines for Seismic Restraints of Mechanical Systems

1.4 SEISMIC REQUIREMENTS & QUALIFICATIONS

- A. The Mechanical Contractor shall be responsible for supplying and installing equipment, vibration isolators, flexible connections, rigid steel frames, anchors, inserts, hangers and attachments, supports, seismic snubbers and bracing to comply with the current code. All supports, hangers, bases, braces and anchorage for all non-isolated equipment, ductwork and piping shall be installed as detailed and specified in the contract documents. Specific requirements on equipment anchorage and restraints, locations and sizes shall be furnished to the contractor after shop drawings for mechanical equipment have been reviewed and approved. All supports, hangers, bases, anchorage and bracing for all isolated equipment shall be designed by a professional engineer employed by the restraint manufacturer, qualified with seismic experience in bracing for mechanical equipment. Shop drawings submitted for earthquake bracing and anchors shall bear the Engineer's signed professional seal.
- B. The Contractor shall require all equipment suppliers to furnish equipment that meets the seismic code, with bases designed to receive seismic bracing and/or anchorage. All isolated mechanical equipment bracing to be used in the project shall be designed from the Equipment Shop Drawings certified correct by the equipment manufacturer for Seismic Zone III with direct anchorage capability.

1.5 SUBMITTALS

- A. Submittal data prior to fabrication, shall include but not be limited to the following:
 - 1. Complete engineering calculations and shop drawings for all vibration and seismic requirements for all equipment to be isolated and restrained.
 - 2. The professional stamp of the engineer who is responsible for the design of the Vibration and Seismic Restraint System for isolated equipment.

3. Details for all the isolators and seismic bracing with snubbers proposed for items in this specification and on the drawings.
4. Details for steel frames, concrete inertia bases, and anchors to be used in conjunction with the isolation of the items in this specification and drawings.
5. Clearly outlined procedures for installing and adjusting the isolators, seismic bracing anchors and snubbers.
6. The proposed location of pipe and duct restraints.

PART 2 - PRODUCTS

2.1 RESTRAINT EQUIPMENT

- A. Manufacturer of restraint equipment for isolated equipment shall be the manufacturer of the vibration isolators furnished for the equipment. Design of restraints and anchors for isolated equipment shall also be by the manufacturer.
- B. Approved Manufacturers and Suppliers:
 1. Manufacturers and suppliers of restraint equipment and systems approved for use by the Contractor, for isolated and non-isolated systems, are Mason Industries. Inc., Korfund, Amber/Booth Company, Vibration Mountings & Control Co. or prior approved equal.

2.2 INERTIA PADS

- A. Reinforced concrete inertia bases, the steel members of which are designed and supplied by the isolator manufacturer. The concrete shall be poured into a welded steel frame, incorporating prelocated equipment anchor bolts, 1/2" diameter reinforcing bars on nominal 8" centers each way, and recessed isolator mounting brackets to reduce the mounting height of the equipment, but yet remain within the confines of the base. The thickness of the base shall be 6 inches, or as indicated on the drawings. Where inertia bases are used to mount pumps, the bases shall be wide enough to support piping elbows. Provide with 1 inch minimum deflection springs.
- B. Approved Manufacturers:
 1. Mason
 2. Peabody
 3. Vibration Mountings

PART 3 - EXECUTION

3.1 SEISMIC REQUIREMENTS

- A. All mechanical equipment, piping and ductwork shall be braced, snubbed or supported to withstand seismic disturbances and remain operational. Furnish all engineering, labor, materials and equipment to provide protection against seismic disturbances as specified herein.
- B. Isolated Equipment:
 1. All vibration isolated equipment shall be mounted on rigid steel frames or concrete bases as described in the vibration control specifications unless the equipment manufacturer certified direct attachment capability. Each spring mounted base shall have a minimum of four all-directional seismic snubbers that are double acting and located as close to the vibration isolators as possible to facilitate attachment both to the base and the structure. The snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials.
 2. Elastomeric material shall be replaceable and a minimum of 3/4" thick. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8" nor more than 1/4". Snubbers shall be installed with factory set clearances. Snubbers shall be equal to Mason Z-1011.
 3. A one "g" minimum vertical and lateral level shall be used in the design of all snubbers restraining isolated equipment.
- C. Piping:
 1. All isolated and non-isolated piping 2-1/2" I.D. and larger shall be protected in all planes by restraints to accommodate thermal movement as well as restrain seismic motion. Locations shall be as scheduled and shall include but not be limited to:
 - a. At all drops to equipment and at flexible connections.
 - b. At all 45° or greater changes in direction of pipe.
 - c. At horizontal runs of pipe, not to exceed 30 feet O.C. spacing.
 - d. Piping shall be restrained by a cable restraining system using a minimum of two cables at all restraint points.
 - e. Shop drawings shall be submitted with the locations of all restraints shown on a floor plan and noting the size and type of restraint to be used.

f. Gas piping shall have additional restraints as scheduled.

D. Non Isolated Equipment:

1. The restraint systems for all non isolated equipment shall be designed according to Table 23J, sec. 2312 of the Uniform Building Code with an importance factor of 1.5, a site factor $Z = 0.75$ and a $C_p = 0.3$. Horizontal force factor for elements of structures. In addition, the vertical forces restraint requirement shall be computed as 1/2 the value of the horizontal forces. All equipment not anchored directly to floors shall be restrained by cables as designed and furnished by the Restraint Manufacturer.

E. Ductwork:

1. All isolated and non isolated rectangular ductwork 4 sq. feet in cross-sectional area and larger and all isolated and not isolated round ductwork 24" round and larger shall be protected in all planes by restraints to accommodate thermal movement as well as restrain seismic motion. Locations shall be as determined by the Seismic Restraint Manufacturer and shall include but not be limited to:
 - a. All horizontal runs of ductwork, not to exceed 30 feet O.C. spacing.
 - b. At all 45° or greater changes in direction of ductwork.
 - c. At each end of duct runs and drops to equipment.
 - d. At each flexible connection.
 - e. Ducts shall be restrained by a cable restraining system using a minimum of two cables at all restraint points.
 - f. Shop drawings shall be submitted with the size and type of all restraints to be used. A floor plan shall be provided to show the locations of all restraints.

3.2 VIBRATION ISOLATION REQUIREMENTS

- A. All mechanical equipment 1 horsepower and over, unless otherwise noted, shall be isolated from the structure by means of resilient vibration and noise isolators designed and supplied by the manufacturer supplying seismic design and equipment. All piping and ductwork shall be isolated from the structure. Isolation equipment, hangers, connections, and other isolating devices shall be designed and installed to prevent transmission of vibration to the structure from the mechanical equipment or any associated piping and ductwork. All isolation systems shall be designed and installed to provide isolation efficiency of 98 percent.
- B. All spring supports shall be designed to have an additional travel of 50 percent between the design height and the solid height.
- C. All heating, hot water piping in the mechanical equipment room and piping three supports away from other mechanical equipment shall be isolated from the structure by means of vibration and noise isolators. Suspended piping shall be isolated with combination spring and fiberglass hangers in the supporting rods. Floor-mounted piping shall be supported directly on spring mounts.
- D. Vertical pipe risers shall be isolated from the structure by means of vibration and noise isolating expansion hangers. The hangers shall have a minimum rated deflection of four times the anticipated pipe movement and shall be enclosed in a housing for fail-safe equipment.
- E. Flexible members shall be incorporated in the piping adjacent to all reciprocating equipment.
- F. Flexible connections shall be incorporated in the ductwork adjacent to all air-moving units.

END OF SECTION 23 0548

SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install identification of equipment and piping as described in Contract Documents.
- B. Mechanical Contractor shall touch-up equipment where factory paint has been damaged. Repaint entire item where more than 20 percent of the surface is involved.
- C. Primary painting of walls, ceilings, ductwork, piping and plenums is covered in the general painting section of these Contract Documents.

PART 2 - PRODUCTS

2.1 PAINT

- A. Benjamin Moore Impervo or equivalent by Paint Manufacturer approved in Section 09 900.
- B. Use appropriate primer.

2.2 LABELS

- A. Black Formica with white reveal on engraving.

2.3 CODED BANDS

- A. Using colored bands and arrows to indicate supply and return, with colored reflective tape, color code all piping installed in this contract at not more than 20-foot intervals, at equipment, at walls, etc., in accordance with ANSI Standards.
- B. Approved Manufacturers:
 - 1. Seton
 - 2. Craftmark

2.4 PIPE IDENTIFICATION

- A. In addition to the colored bands, stencil with black paint in 1/2 inch high letters a symbol and directional arrow for all fluids handled or use Seaton coded and colored pipe markers and arrows to meet ANSI Standards.

2.5 EQUIPMENT IDENTIFICATION

- A. Provide an engraved plastic plate for each piece of equipment stating the name of the item, symbol number, area served, and capacity. Label all control components with plastic embossed mechanically attached labels. Sample:
 - 1. Supply Fan SF-1 - North Classrooms
 - 2. 10,000 CFM @ 2.5"

2.6 VALVE IDENTIFICATION

- A. Make a list of and tag all valves installed in this work.
 - 1. Valve tags shall be of brass, not less than 1"x2" size, hung with brass chains.
 - 2. Tag shall indicate plumbing or heating service.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Engraved Plates:
 - 1. Identify thermostats and control panels in mechanical rooms, furnaces, boilers and hot water heating specialties, duct furnaces, air handling units, electric duct heaters, and condensing units with following data engraved and fastened to equipment with screws –
 - a. Equipment mark noted on Drawings (i.e., SF-1)
 - b. Area served (i.e., North Classrooms)
 - c. Capacity (10,000 CFM @ 2.5)

- B. Stenciling:
 - 1. Locate identifying legends and directional arrows at following points on each piping system –
 - a. Adjacent to each item of equipment and special fitting.
 - b. At point of entry and exit where piping goes through wall.
 - c. On each riser and junction.
 - d. Every 50 feet on long continuous lines.
 - 2. Steam Pipe, Hot Water Heating, Chilled Water, Gas, & Valve Identification –
 - a. Identify specific pipe contents by stenciling pipe with written legend and placing of arrows to indicate direction of flow.

C. Painting:

- 1. Background Color - Provide by continuous painting of piping.

Symbol	Name	Color
NG	Natural Gas	Yellow
FS	Fire Sprinkler	Red
AIR	Air	Blue

- 2. Identification stenciling and flow arrows shall be following colors for proper contrast:

<u>Arrows & ID Stenciling</u>	<u>Color Shade of Pipe</u>
White	Red, Grays, & black
Black	Yellows, Oranges, Greens, & White

END OF SECTION 23 0553

SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Division 23 0501 - Common HVAC Requirements and Basic Mechanical Materials and Methods Sections apply to work of this section.

1.2 SUMMARY SCOPE

- A. This Section includes TAB to produce design objectives for the following:
 - 1. Air Systems.
 - a. Rooftop Units.
 - b. Exhaust fans.

1.3 SUBMITTALS

- A. Agency Data:
 - 1. Submit proof that the proposed testing, adjusting, and balancing agency meets the qualifications specified below. The firm or individuals performing the work herein specified may not be the installing firm.
- B. Engineer and Technicians Data:
 - 1. Submit proof that the Test and Balance Engineer assigned to supervise the procedures, and the technicians proposed to perform the procedures meet the qualifications specified below.
- C. Procedures and Agenda: Submit a synopsis of the testing, adjusting, and balancing procedures and agenda proposed to be used for this project.
- D. Sample Forms: Submit sample forms, if other than those standard forms prepared by the AABC or NEBB are proposed.
- E. Certified Reports: Submit testing, adjusting, and balancing reports bearing the seal and signature of the Test and Balance Engineer. The reports shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below.
 - 1. Draft Reports: Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on the approved forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.
 - 2. Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 4 complete sets of final reports.
 - 3. Report Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data. Divide the contents of the binder into the below listed divisions, separated by divider tabs:
 - a. General Information and Summary
 - b. Air Systems
 - c. Temperature Control System Verification.
- F. Report Contents: Provide the following minimum information, forms, and data:
 - 1. General information and Summary: Inside cover sheet to identify testing, adjusting, balancing agency, Contractor, Owner, Engineer, and Project. Include addresses and contact names and telephone numbers. Also include a certification sheet containing the seal and name, address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentation used for the procedures along with the instrument calibration sheet.
 - 2. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on the standard report forms prepared by the AABC or NEBB, for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form. The report shall contain the following information, and all other data resulting from the testing, adjusting, and balancing work:
 - a. All nameplate and specification data for all air handling equipment and motors.

- b. Actual metered running amperage for each phase of each motor on all pumps and air handling equipment.
 - c. Actual metered voltage at air handling equipment (phase-to-phase for all phases).
 - d. Fan RPM for each piece of air handling equipment.
 - e. Total actual CFM being handled by each piece of air handling equipment.
 - f. Actual CFM of systems by rooms.
3. Certify that all smoke and fire dampers operate properly and can be reset under actual system operating conditions.

G. Calibration Reports:

- 1. Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

1.4 CERTIFICATION

A. Agency Qualifications:

- 1. Employ the services of a certified testing, adjusting, and balancing agency meeting the qualifications specified below, to be the single source of responsibility to test, adjust, and balance the building mechanical systems identified above, to produce the design objectives. Services shall include checking installations for conformity to design, measurement, and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, recording and reporting the results, and operation of all systems to demonstrate satisfactory performance to the owner.
- 2. The testing, adjusting, and balancing agency certified by National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) in those testing and balancing disciplines required for this project, and having at least one person certified by NEBB or AABC as a Test and Balance supervisor, and a registered professional mechanical engineer, licensed in the state where the work will be performed.

B. Codes and Standard:

- 1. NEBB: "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
- 2. AABC: "National Standards for Total System Balance."
- 3. ASHRAE: ASHRAE Handbook, 1984 Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.

1.5 PROJECT CONDITIONS

- A. Systems Operation: Systems shall be fully operation and clean prior to beginning procedures.

1.6 SEQUENCING AND SCHEDULING

- A. Test, adjust, and balance the air systems before hydronic, steam, and refrigerant systems within +10% to -5% of contract requirements.
- B. The report shall be approved by the Engineer. Test and balance shall be performed prior to substantial completion.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 PRELIMINARY PROCEDURES FOR AIR SYSTEM BALANCING

- A. Before operating the system, perform these steps.
 - 1. Obtain design drawings and specifications and become thoroughly acquainted with the design intent.
 - 2. Obtain copies of approved shop drawings of all air handling equipment, outlets (supply, return, and exhaust) and temperature control diagrams.
 - 3. Compare design to installed equipment and field installations.
 - 4. Walk the system from the system air handling equipment to terminal units to determine variations of installation from design.
 - 5. Check filters for cleanliness and to determine if they are the type specified.
 - 6. Check dampers (both volume and fire) for correct and locked position. Check automatic operating and safety controls and devices to determine that they are properly connected, functioning, and at proper operating setpoint.
 - 7. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a cross-check with required fan volumes.
 - 8. Determine best locations in main and branch ductwork for most accurate duct traverses.
 - 9. Place outlet dampers in the full open position.

10. Prepare schematic diagrams of system "As-Built" ductwork and piping layouts to facilitate reporting.
11. Lubricate all motors and bearings.
12. Check fan belt tension.
13. Check fan rotation.

3.2 MEASUREMENTS

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

3.3 PERFORMING TESTING, ADJUSTING, AND BALANCING

- A. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards. Balancing of the air systems and hydronic systems shall be achieved by adjusting the automatic controls, balancing valves, dampers, air terminal devices, and the fan/motor drives within each system.
- B. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.
- C. Patch insulation, ductwork, and housings, using materials identical to those removed.
- D. Seal ducts and piping, and test for and repair leaks.
- E. Seal insulation to re-establish integrity of the vapor barrier.
- F. Adjust timing relays of environmental equipment motor reduced voltage starters to the optimum time period for the motor to come up to the maximum reduced voltage speed and then transition to the full voltage speed to prevent damage to motor, and to limit starting current spike to the lowest possible and practical.
- G. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
- H. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.4 RECORD AND REPORT DATA

- A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms.
- B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.
- C. Report shall be certified and stamped by a registered professional mechanical engineer employed by the agency and

licensed in the state where the work will be performed.

- D. Engineer is to provide a floor plan and test and balance contractor to include the plan in test and balance report and identify actual cfm on drawing or number the diffusers to match report.

3.5 DEMONSTRATION

- A. If requested, testing, adjusting, and balancing agency shall conduct any or all of the field tests in the presence of the engineer.
- B. Agency shall include a maximum of one (1) call back to the project within the one year warranty period to make additional adjustments if requested by the engineer.

END OF SECTION 23 0593

SECTION 23 0712 - DUCTWORK INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install insulation on air ducts outside building insulation envelope as described in Contract Documents.
- B. Furnish and install insulation on fresh air ducts and combustion air ducts within building insulation envelope as described in Contract Documents.
- C. Furnish and install insulation on other air ducts where indicated on Drawings.

PART 2 - PRODUCTS

2.1 INSULATION

- A. 1-1/2 inch thick fiberglass with aluminum foil scrim kraft facing and have a density of one lb/cu ft.
- B. Approved Manufacturers:
 - 1. Manville Microlite FSK
 - 2. CSG Type IV standard duct insulation
 - 3. Owens-Corning FRK
 - 4. Knauf (Duct Wrap FSK)

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct wrap in accordance with Manufacturer's recommendations.
- B. Do not compress insulation except in areas of structural interference.
- C. Completely seal joints.

END OF SECTION 23 0712

SECTION 23 0717 – ROUND SUPPLY DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install round supply duct insulation as described in Contract Documents.

1.3 QUALITY ASSURANCE

- A. Insulation shall be UL rated with FSK (foil-skrim-kraft) facing.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Fiberglass blanket insulation
- B. Approved Manufacturers:
 - 1. Johns-Manville R-4 Microlite (R-4 does not include the vapor barrier material).
 - 2. Owens-Corning faced duct wrap insulation FRK-25 ED-150
 - 3. Certainteed Standard Duct Wrap.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Insulate round air supply ducts.
- B. Facing shall overlap 2" at joints and shall be secured with outward clinch staples on 4" centers.
- C. Ducts over 30" in width shall have spot application of adhesive, weld pins or metal screws and caps on not more than 18" centers applied to underside.
- D. 3" wide vapor barrier paper shall be applied over seams and sealed with vapor barrier adhesive.
- E. Insulate attenuators.
- F. Insulate high and low pressure flex ducts.

END OF SECTION 23 0717

SECTION 23 0718 - DUCT LINING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install acoustic lining in following above ground metal ductwork as described in Contract Documents unless detailed otherwise:
 1. Supply air
 2. Return air
 3. Mixed air
 4. Transfer air
 5. Relief air
 6. Elbows, fittings, and diffuser drops greater than 12 inches in length.

1.3 SYSTEM DESCRIPTION

- A. Duct dimensions shown on Drawings are for free area inside insulation. Allowance must be made for insulation, where applicable.

1.4 RATINGS:

- A. Material shall have maximum air friction correction factor of 1.10 at 1000 FPM velocity and have a minimum sound absorption coefficient NRC of .60.

PART 2 - PRODUCTS

2.1 DUCT LINER

- A. One inch thick, 1-1/2 lb density fiberglass, factory edge coated.
- B. Duct lining materials are to meet the requirements of UL 181 for mold, humidity, and erosion resistance.
- C. Approved Manufacturers:
 1. Certaineed Ultralite 150 Certa Edge Coat
 2. Knauf - Type M
 3. Manville - Lina-Coustic
 4. Owen Corning Fiberglas - Aeroflex

2.2 ADHESIVE

- A. Water Base Type:
 1. Cain - Hydrotak
 2. Duro Dyne - WSA
 3. Kingco - 10-568
 4. Miracle - PF-101
 5. Mon-Eco - 22-67
 6. Techno Adhesive - 133
- B. Solvent Base (non-flammable) Type:
 1. Cain - Safetak
 2. Duro Dyne - FPG
 3. Kingco - 15-137
 4. Miracle - PF-91
 5. Mon-Eco - 22-24
 6. Techno Adhesive - 'Non-Flam' 106
- C. Solvent Base (flammable) Type:

1. Cain - HV200
2. Duro Dyne - MPG
3. Kingco - 15-146
4. Miracle - PF-96
5. Mon-Eco - 22-22
6. Techno Adhesive - 'Flammable' 106

2.3 FASTENERS

- A. Adhesively secured fasteners not allowed.
- B. Approved Manufacturers:
 1. AGM Industries Inc - "DynaPoint" Series DD-9 pin
 2. Cain
 3. Duro Dyne
 4. Omark dished head "Insul-Pins"
 5. Grip nails may be used if each nail is installed by "Grip Nail Air Hammer" or by "Automatic Fastener Equipment" in accordance with Manufacturer's recommendations.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install mat finish surface on air stream side. Secure insulation to cleaned sheet metal duct with continuous 100% coat of adhesive and with 3/4 inch long mechanical fasteners 12 inches on center maximum unless detailed otherwise on Drawings. Pin all duct liner.
- B. Accurately cut liner and thoroughly coat ends with adhesive. Butt joints tightly. Top and bottom sections of insulation shall overlap sides. If liner is all one piece, folded corners shall be tight against metal. Ends shall butt tightly together.
- C. In casings and plenums further contain insulation with wire mesh.

3.2 FIELD QUALITY CONTROL

- A. If insulation is installed without longitudinal and end joints butted together, installation will be rejected and work removed and replaced with work that conforms to this Specification.
- B. Insulation shall be installed in accordance with Duct Liner Application Standard SMACNA Manual 15.

3.3 ADJUSTING, CLEANING

- A. Keep duct liner clean and free from dust. At completion of project, vacuum duct liner if it is dirty or dusty.

END OF SECTION 23 0718

SECTION 23 0800 – FIRE STOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install fire stopping as described in Contract Documents.

1.3 QUALITY ASSURANCE

- A. Fire stopping material shall meet ASTM E814, E84 and be UL listed.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Material shall be flexible, long lasting, intumescent acrylic seal to accommodate vibration and building movement.
- B. Caulk simple penetrations with gaps of 1/4" or less with:
 - 1. Dow Corning Fire Stop Sealant
 - 2. Pensil 300
- C. Caulk multiple penetrations and/or penetrations with gaps in excess of 1/4" with:
 - 1. Dow Corning Fire Stop Foam
 - 2. Pensil 200
 - 3. IPC flame safe FS-1900
 - 4. Tremco "Tremstop 1A"

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Follow manufacturer's installation instructions explicitly.
- B. Seal penetrations of ductwork, piping, and other mechanical equipment through one-hour and two-hour rated partitions as shown on Architectural and Mechanical Drawings.
- C. Install fire stopping material on clean surfaces to assure adherence.

END OF SECTION 23 0800

SECTION 23 0933 –TEMPERATURE CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, and Section 23 0501 apply to this Section.
- B. The Facility Management and Control System (FMCS) Contractor shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control as herein specified. The system shall include all required computer software and licenses, hardware, controllers, sensors, transmission equipment, system workstations, local panels, conduit, wire, installation, engineering, database and setup, supervision, commissioning, acceptance test, training, warranty service and, at the owner's option, extended warranty service. Include all upgrades for a period of two years.
- C. The system system shall only employ BACnet or LonTalk communications in an open architecture with the capabilities to support a multi-vendor environment. The system shall be capable of integrating third party systems and utilizing the following standard protocols.
 - 1. BACnet communication according to ASHRAE standard ANSI/ASHRAE 135-2001.
 - 2. OPC server communications according to OPC Data Access 2.0 and Alarms and Events 1.0.
 - 3. LonWorks communication using LonTalk protocol.
 - 4. Modbus communication for integration to third party devices.
- D. The FMCS shall be web based and shall provide total integration of the facility infrastructure systems with user access to all system data either locally over a secure Intranet within the building or by remote access by a standard Web Browser over the Internet.
- E. The FMCS shall demonstrate, with (3) proof sources, integration with HVAC industry open standard protocols, including LonMark, BACnet, ModBus, OPC and Internet standard SQL database and HTTP / HTML / XML text formats.
- F. The FMCS shall communicate to third party systems such as VFD's, air handling systems, energy metering systems, other energy management systems, access control systems, fire-life safety systems and other building management related devices using any of the open, interoperable communication protocols referenced in Paragraph D.
- G. All materials and equipment used shall be standard components, regularly manufactured with standard part numbers and owners manuals for this and/or other systems. One of a kind, third party or custom integrations devices designed specially for this project will not be allowed.

1.2 RELATED WORK SPECIFIED ELSEWHERE:

- A. Drawings and general provisions of the Contract, including General and supplementary Conditions and Division-1 specification sections, apply to work of this section.
- B. Products furnished but not installed under this section:
 - 1. Automatic dampers to be installed under section 23 3114
- C. Coordination with electrical:
 - 1. Installation of all line voltage power wiring to division 26.
 - 2. Each motor starter provided under Division 26, shall be furnished with individual control power transformer to supply 120 volt control power and auxiliary contacts (one N.O. and one N.C.) for use by this section.

1.3 QUALITY ASSURANCE:

- A. The system shall be furnished, engineered, and installed by the manufacturers' locally authorized representative. The controls contractor shall have factory-trained technicians to provide instruction, routine maintenance, and emergency service within 24 hours upon receipt of request.
- B. At the time of bid, all FMCS Application Specific Controllers and Programmable Equipment Controllers shall be

listed as follows:

1. Underwriters Laboratory, UL 916
2. FCC Regulation, Part 15, Class B

1.4 SUBMITTALS:

- A. Submit 6 complete sets of documentation in the following phased delivery schedule:
 1. Valve and damper schedules
 2. Equipment data cut sheets
 3. System Schematics, including
 - a. Sequence of operation
 - b. point names
 - c. point addresses
 - d. point to point wiring
 - e. interface wiring diagrams
 - f. panel layouts.
 - g. system riser diagrams
 4. AutoCAD compatible as-built drawings.
 5. ATC Submittals shall be completed using HVAC Solution Software. AutoCAD files will be accepted on components and systems which HVAC Solution does not support. The main Bulk of the submittals shall be submitted using HVAC Solution.

- B. Upon project completion, submit operation and maintenance manuals, consisting of the following:
 1. Index sheet, listing contents in alphabetical order
 2. Manufacturer's equipment parts list of all functional components of the system, disk of system schematics, including wiring diagrams
 3. Description of sequence of operations.
 4. As built interconnection wiring diagrams
 5. User's documentation containing product, system architectural and programming information.
 6. Trunk cable schematic showing remote electronic panel locations, and all trunk data
 7. List of connected data points, including panels to which they are connected and input device (ionization detector, sensors, etc.)
 8. Conduit routing diagrams
 9. Copy of all warranty guarantee
 10. Operating and maintenance cautions and instructions
 11. Recommended spare parts list.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

- A. Delta Control
- B. Staefa Control System
- C. Automated Logic
- D. Johnson Controls
- E. Invinsys
- F. Seimons

2.2 THE FACILITY MANAGEMENT CONTROL SYSTEM :

- A. The Facility Management Control System (FMCS) shall be comprised of a network of interoperable, stand-alone digital controllers. The FMCS shall incorporate LonWorks technology using Free Topology Transceivers (FTT-10), or BACnet MSTP485 or Ethernet in all unitary, terminal and other device controllers. The system shall include:
- B. Programmable Equipment Controllers (PEC's) for control of primary mechanical systems and distributed system applications. Controllers shall be fully programmable to create custom control solutions.
- C. Network Area Controllers (NAC's) for distributed system applications, databases and networking functions.

- D. Application Specific Controllers (ASC's) for control of VAV terminal units, Fan coil terminal units, Unit Vent terminal units, Heat Pump units and other terminal equipment.
- E. Graphical User Interface (GUI), which includes the hardware and software necessary for a user to interface with the control system and devices.
- F. The controller network shall use twisted pair wiring or loop. The PEC and ASC network shall communicate at a minimum 78Kbps using BACnet or LonTalk. The GUI and NAC shall reside on a Ethernet backbone.
- G. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices.

2.3 NETWORK AREA CONTROLLER (NAC):

- A. The Network Area Controller (NAC) shall provide the interface between the field control devices, and provide global supervisory control functions over the control devices connected to the NAC. It shall be capable of executing application control programs to provide:
 - 1. Calendar functions
 - 2. Scheduling
 - 3. Trending
 - 4. Alarm monitoring and routing
 - 5. Time Synchronization
 - 6. Integration of LonWorks controller data
 - 7. Integration of BACnet and MODBUS networks
- B. The NAC shall provide multiple, concurrent user access to the system and support for ODBC or SQL. A database resident on the NAC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.
- C. The NAC shall support standard Web browser access via the Intranet/Internet. It shall be capable of supporting multiple users, expandable to fifty.
- D. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
 - 1. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up, telephone connection, or wide-area network.
 - 2. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including, but not limited to:
 - a. To alarm
 - b. Return to normal
 - c. To fault
 - 3. Provide for the creation of an unlimited number of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
 - 4. Provide timed (schedule) routing of alarms by class, object, group, or mode.
 - 5. Provide alarm generation from binary object "runtime" and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
- E. Alarms shall be annunciated in any of the following manners as user defined:
 - 1. Screen message text
 - 2. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
 - a. Day of week
 - b. Time of day
 - c. Recipient
 - 3. Pages via paging services that initiate a page on receipt of email message
 - 4. Graphic with flashing alarm objects
 - 5. Printed message, routed directly to a dedicated alarm printer.
 - 6. Cell phones.
- F. The following shall be recorded by the NAC for each alarm (at a minimum)
 - 1. Time and date
 - 2. Location (building floor, zone, office number, etc.)

3. Equipment (air handler, access way, etc.)
 4. Acknowledge time, date, and user who issued acknowledgement.
- G. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
- H. A log of all alarms shall be maintained by the NAC and/or a server and shall be available for review by the user.
- I. Provide a “query” feature to allow review of specific alarms by user defined parameters.
- J. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
- K. An Error Log to record system errors shall be provided and available for review by the user.
- L. Data Collection and Storage
1. The NAC shall collect data for any property of any object and store this data for future use.
 2. The data collection shall be performed by log objects, resident in the NAC that shall have, at a minimum, the following configurable properties:
 - a. Designating the log as interval or deviation.
 - b. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
 - c. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
 - d. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
 - e. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
 3. All log data shall be stored in a relational database in the NAC and the data shall be accessed from a standard Web Browser.
 4. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.
 5. All log data shall be available to the user in the following data formats:
 - a. HTML
 - b. XML
 - c. Plain Text
 - d. Comma or tab separated values
 6. The NAC shall have the ability to archive it’s log data either locally (to itself), or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties, at a minimum:
 - a. Archive on time of day
 - b. Archive on user-defined number of data stores in the buffer (size)
 - c. Archive when buffer has reached it’s user-defined capacity
- M. Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached it’s user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:
1. Time and date
 2. User ID
 3. Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.
- N. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time of day.
1. Copies of the current database and, at the most recently saved database shall be stored in the NAC. The age of the most recently saved database is dependent on the user-defined database save interval.
 2. The NAC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

2.4 PROGRAMMABLE EQUIPMENT CONTROLLERS (PEC)

- A. Programmable Equipment Controllers (PEC's) shall be stand-alone, multi-tasking, real-time digital control processors.
- B. The PEC's shall communicate via BACnet communication according to ASHRAE standard ANSI/ASHRAE 135-2001 or Lonworks FT110.
- C. The PEC must communicate peer-to-peer with all of the network application specific, programmable controllers and third party LonMark devices.
- D. The PEC software database must be able to execute all of the specified mechanical system controls functions. The programming software shall be able to bundle software logic to simplify control sequencing. All values, which make up the PID output value, shall be readable and modifiable at a workstation or portable service tool. Each input, output, or calculation result shall be capable of being shared/bound with any controller or interface device on the network.
- E. Provide programming, engineering, and configuration tools used for the project duly licensed to the owner for owner's use.
- F. PEC's shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
- G. A single process shall be able to incorporate measured or calculated data from any and all other PEC's on the network. In addition, a single process shall be able to issue commands to points in any and all other PEC's on the network.
- H. Each PEC shall support firmware upgrades without the need to replace hardware.
- I. Each PEC shall continuously perform self-diagnostics, which include communication diagnosis and diagnosis of all components.
- J. In the event of the loss of normal power, there shall be an orderly shutdown of all PEC's to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.
- K. Upon restoration of normal power, the PEC shall automatically resume full operation without manual intervention.
- L. All PEC's control programming and databases must be stored in Flash memory, therefore eliminating data loss, downtime and re-load time.
- M. Provide a separate PEC for each AHU or other HVAC system such that the inputs, calculations, and outputs shall reside on a single controller.

2.5 APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. Each Application Specific Controller (ASC) shall operate as a stand-alone Lon Mark or BacNet controller capable of performing its specified control responsibilities independent of other controllers in the network. Each ASC shall be a minimum 16-BIT microprocessor based, multi-tasking, multi-user, real time digital control processor.
- B. Controllers shall include all inputs and outputs necessary to perform the specified control sequences. Analog and digital outputs shall be industry standard signals such as 0-10V and 3-point floating control allowing for interface to a variety of industry standard modulating actuators. The ASC inputs and outputs shall consist of industry standards types. Inputs shall be electrically isolated from outputs, communications and power.
- C. All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the network is not acceptable.
- D. The control program shall reside in the ASC. The application program and the configuration information shall be stored in non-volatile memory with no battery back-up required.
- E. After a power failure the ASC must run the control application using the current setpoints and configuration. Reverting to default or factory setpoints are not acceptable.

2.6 GRAPHICAL USER INTERFACE SOFTWARE (GUI)

- A. Command of points from multiple manufacturers shall be transparent to the operator.
- B. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. The GUI software shall run on a Windows XP 32-bit operating system. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line FMCS alarms and monitoring information. If the software is unable to display several different types of displays at the same time, the FMCS contractor shall provide at least two operator workstations at each location specified.
- C. Real-Time Displays. The Graphical User Interface (GUI), shall at a minimum, support the following graphical features and functions:
 - 1. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures and streaming video.
 - 2. Provide programming, engineering, and configuration tools used for the project duly licensed to the owner for owner's use.
 - 3. A gallery of HVAC and automation symbols shall be provided, including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and symbols. The user shall have the ability to add custom symbols to the gallery as required.
 - 4. Graphic screens shall contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.
 - 5. Graphics shall include layering and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.
 - 6. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
 - a. Schedule times will be adjusted by mouse command using a graphical slider, without requiring any keyboard entry from the operator.
 - b. Holidays shall be set by mouse command using a graphical calendar, without requiring any keyboard entry from the operator.
 - 7. Commands to start and stop binary objects shall be done by mouse command from the pop-up menu. No entry of text shall be required.
- D. System Configuration. At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:
 - 1. Create, delete or modify control strategies.
 - 2. Add/delete objects to the system.
 - 3. Tune control loops through the adjustment of control loop parameters.
 - 4. Enable or disable control strategies.
 - 5. Generate hard copy records or control strategies on a printer.
 - 6. Select points to be alarmable and define the alarm state.
 - 7. Select points to be trended over a period of time and initiate the recording of values automatically.
- E. On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.
- F. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.
- G. All graphic displays shall be provided using web browser client as specified in 2.11.

- H. The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.
- I. When the Alarm Console is enabled, a separate alarm notification window will supercede all other windows on the desktop. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable. The alarm console shall be loaded and operated at the following locations.

2.7 WEB BROWSER CLIENTS

- A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer[□] or Netscape Navigator[□]. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.
- B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Web page access and control shall be from system Network Area Controllers, or the Workstation.
- C. The Web browser shall provide the same system view, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.
- D. The Web browser client shall support at a minimum, the following functions:
 - 1. User log-on identification and password security shall be required and implemented using Java authentication and encryption techniques to prevent unauthorized access. If an unauthorized user attempts access, a blank web page shall be displayed.
 - 2. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
 - 3. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
 - 4. Storage of the graphical screens shall be in the Network Area Controller (NAC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client machine are not acceptable.
 - 5. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
 - 6. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
 - a. Modify in a graphical manner, common application objects, such as schedules, calendars, and set points. Schedule times will be adjusted by mouse command using a graphical slider, without requiring any keyboard entry from the operator. Holidays shall be set by mouse command using a graphical calendar, without requiring any keyboard entry from the operator.
 - b. Commands to start and stop binary objects shall be done by mouse command right-click of the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
 - c. View logs and charts
 - d. View and acknowledge alarms
 - 7. The system shall provide the capability to specify a user’s home page (as determined by the log-on user identification). From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
 - 8. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

2.8 PROJECT SPECIFIC WEB PAGES:

- A. Home page shall include the following minimum web-based tree structure:
1. Documents Page: The document page shall include the O&M Manuals for the control system in PDF format along with AutoCAD drawings for each drawing provided in the control system O&M Manual. This document page shall include links between the control diagrams and associated data sheet in PDF format, such that the system user shall be able to click on the control device and retrieve, in PDF format, the factory O&M sheets associated with that device.
 2. Station Functions:
 - a. Logging separate sheet of station functions for a particular selected building shall be the viewing of one or more logs or the creation of logs in which any value at any point, or the mode of any point, shall be selected via the web to be trended against any other point with an adjustable frequency in seconds, minutes, hours or days.
 - b. The alarm acknowledgment via the web shall allow the viewing and acknowledgment of the alarms.
 - c. Audit log shall be provided via the web to show the operator actions as well as other audit logs as specified in section 2.4 Network Area Controller (NAC) paragraph “M” Data Collection and Storage.
 3. Floor Plans:
 - a. AutoCAD drawings of floor plans shall be provided in the control system such that via the web the user shall be able to turn layers on and off on the mechanical floor plans. These floor plans shall also include an overlay of the temperature control as-built wiring for the project showing thermostat locations, communication runs, transformer locations, controller locations, etc.
 - b. Floor Display Summaries. The operator shall be able to select floor plans displaying the following formats:
 - 1) All zone temperatures
 - 2) All zone heating percentages
 - 3) All zone cooling percentages
 - 4) All zone room names and numbers
 - 5) All zones cfm delivered.
 - c. Upon selecting a graphical floor plan layout the web page shall show all the zone temperature sensor locations on the floor. By clicking on the zone temperature location, an individual VAV box graphic shall be displayed with the following attributes:
 - 1) A manual menu that shall allow the operator to manually set the air flow set point, space temperature set point, damper position, cooling percentage, heating percentage, and zero the box.
 - 2) A 24 hour log chart that shows space temperature history, flow history, and allows the operator to build custom charts by comparing this log to other associated selectable logs.
 - 3) A display of the VAV box discharge temperature, air handler discharge temperature, space temperature, and space temperature set point.
 - 4) A bar graph that shows actual CFM, current air flow, and current air floor set point, percentage of heating and cooling in a thermometer-like fashion and changes color based on heating or cooling mode.
 - 5) The damper position, reheat valve position, occupancy status, room name and heating/cooling mode shall also be shown.
 4. Systems:
 - a. On selecting the systems menu, a tree structure shall allow the operator to select the air handlers, chillers, control valves, heat exchangers, med gas, etc. systems associated with that building. The graphics shall also show the piping and ductwork associated with the air handler as well as the safeties, temperature sensors, humidity sensors, dampers, VFD’s, associated with that fan system. See points lists for specifics.
 - b. All devices that provide dynamic function in the primary equipment, i.e., fans, pumps, coils, dampers shall be dynamic in nature showing their operating status/percentage of capacity by movement on the web page.
 - c. The set points for the various control loops shall be adjustable via the web page. Individual controlled devices, i.e., valves, dampers, fans shall be controlled via the web page and be stopped or started or placed in a command state or percentage of value output.

2.9 FIELD DEVICES

- A. Provide automatic control valves, automatic control dampers, thermostats, clocks, sensors, controllers, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer’s standard control system components as indicated by published product information, designed and constructed as recommended by manufacturer.
- B. Temperature Sensors:

1. Temperature Sensors: Temperature sensors shall be linear precision elements with ranges appropriate for each specific application.
 2. Space (room) sensors shall be available with setpoint adjustment and override switch.
 3. Duct mounted averaging sensors shall utilize a sensing element incorporated in a copper capillary with a minimum length of 20 feet. The sensor shall be installed according to manufacture recommendation and looped and fastened at a minimum of every 36 inches.
 4. Sunshields shall be provided for outside air sensors.
 5. Thermo-wells for all immersion sensors shall be stainless steel or brass as required for the application.
- C. Pressure Sensors: The differential pressure sensor shall be temperature compensated and shall vary the output voltage with a change in differential pressure. Sensing range shall be suitable for the application with linearity of 1.5% of full scale and offset of less than 3% of full scale. Sensor shall be capable of withstanding up to 150% of rated pressure without damage.
- D. Switches and Thermostats:
1. The FMCS Contractor shall furnish all electric relays and coordinate with the supplier of magnetic starters for auxiliary contact requirements. All electric control devices shall be of a type to meet current, voltage, and switching requirement of their particular application. Relays shall be provided with 24 VAC coils and contacts shall be rated at 10 amps minimum.
 2. Duct Smoke Detectors: Duct smoke detectors shall be supplied by others with an integral auxiliary contact to be used by the FMCS contractor to provide a digital input to the FMCS.
 3. Low Temperature Detection Thermostats: Shall be the manual reset type. The thermostat shall operate in response to the coldest one-foot length of the 20-foot sensing element, regardless of the temperatures at other parts of the element. The element shall be properly supported to cover the entire downstream side of the coil with a minimum of three loops. Separate thermostats shall be provided for each 25 square feet of coil face area or fraction thereof.
 4. Differential Pressure Switches: Pressure differential switches shall have SPDT changeover contact, switching at an adjustable differential pressure setpoint.
 5. Current Sensing Relays: Motor status indications, where shown on the plans, shall be provided via current sensing relays. The switch output contact shall be rated for 30 VDC, .15 amps.
 6. Flow Switches: Motor status indications, where shown on the plans, shall be provided via flow switches. Flow switches shall be of the paddle type equipped with SPDT contacts to establish proof of flow.
 7. Carbon Monoxide Detector and Controller shall meet or exceed UL 2034 standard and OSHA standards for CO exposure. Controller shall be solid state sensor. Fan relay shall activate at 35 ppm of CO averaged over 5 minutes. Alarm relay shall activate at 100 ppm after 30 minutes. Approved manufacturers shall be Macurco, Inc or approved equal.
- E. Control Valves
1. General: Control Valves up to 4 inches shall be globe valves and shall be sized for a 3 to 5 psi pressure drop. Valves shall be packless, modulating, electrically or magnetically actuated, with a control rangeability of 100 to 1. These valves shall have equal percentage flow characteristics in relationship to valve opening.
 2. ½ inch to 4 inch: Valves shall be equipped with handwheel, or manual position mounted dial adjacent to valve, to allow manual positioning of valve in absence of control power. (Valves with a rangeability of less than 200 to 1 shall utilize two valves in a 1/3 – 2/3 parallel arrangement in order to achieve control rangeability).
 3. 4 inches to 6 inches: Valves for heating shall be globe valves modulating electrically actuated, 2-way or 3-way as required, with a rangeability of 50 to 1. Valve body shall be flanged and shall be equipped with a handwheel, or manual position dial mounted adjacent to the valve, to allow manual positioning of the valve in the absence of control power. Valves for cooling shall be butterfly with a rangeability of 25 to 1.
 4. Butterfly Valves: 2-way and 3-way butterfly valves shall be cast iron valve body, with stainless steel stem, and available with disc seal for bubble-tight shut off.
 5. Steam Valves: Valves shall have an ANSI Class 250 lb. body, teflon v-ring packing rated to 377°F., stainless steel trim rated to 50 psi, with rangeability greater than 100:1, Class 4 leakage and close off rating, linear flow characteristics, via perforated throttling cylinder.
- F. Damper Actuators:
1. Actuators shall be of the push-pull or rotary type of modulating, 3-point floating, or 2-position control as required by the application. The actuator shall use an overload-proof synchronous motor or an electric motor with end switches to de-energize the motor at the end of the stroke limits. Control voltage shall be 24 VAC, 0-20 VDC, or 4-20 ma as required. Actuators shall be available with spring return to the normal position when required. Actuators shall have a position indicator

for external indication of damper position. Actuators shall have manual override capability without disconnecting damper linkage.

- G. Control Dampers:
1. Motorized dampers, unless otherwise specified elsewhere, shall have damper frames using 13 gauge galvanized steel channel or 1/8" extruded aluminum with reinforced corner bracing. Damper blades shall not exceed ten (10) inches in width or 48" in length. Blades are to be suitable for high velocity performance. Damper bearings shall be as recommended by manufacturer for application. Bushings that turn in the bearing are to be oil impregnated sintered metal. All blade edges and top and bottom of the frame shall be provided with replaceable, butyl rubber or neoprene seals. Side seals may be spring-loaded stainless steel. The seals shall provide a maximum of 1% leakage at a wide open face velocity of 1500 FPM and 4: W.C. close-off pressure. The damper linkage shall provide a linear flow or equal percentage characteristic as required. Provide Ruskin RCD46 model or equal.
 2. Control dampers shall be parallel or opposed blade type as scheduled on drawings or outdoor and return air mixing box dampers shall be parallel blade, arranged to direct air streams towards each other. All other dampers may be parallel or opposed blade types.

PART 3 - EXECUTION

3.1 PROJECT MANAGEMENT

- A. Provide a project manager who shall, as a part of his duties, be responsible for the following activities:
1. Coordination between the Controls Contractor and all other trades, Owner, local authorities and the design team.
 2. Scheduling of manpower, material delivery, equipment installation and checkout.
 3. Maintenance of construction records such as project scheduling and manpower planning and AutoCAD or Visio for project co-ordination and as-built drawings.
 4. Coordination/Single point of contact

3.2 INSTALLATION METHODS

- A. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable Division-16 sections of these specifications.
- B. The term "control wiring" is defined to include providing of wire, conduit, and miscellaneous materials as required for mounting and connecting electric or electronic control devices.
- C. To run BACnet on the ethernet network, the installer is required to run, at minimum, plenum rated CAT 5e cabling for all runs associated with this network.
- D. All exposed wiring, low and line voltage subject to mechanical damage, shall be run in conduit. Line and low voltage wiring shall be run in separate conduits. Concealed but accessible wiring, except in mechanical rooms and areas where other conduit and piping are exposed shall run in UL plenum rated cable as approved by local codes unless expressly restricted by requirements in Division 16 specification.
- E. All Controllers, Relays, Transducers, etc., required for stand-alone control shall be housed in a NEMA 1 enclosure with a lockable door.

3.3 SYSTEM ACCEPTANCE

- F. General: The system installation shall be complete and tested for proper operation prior to acceptance testing for the Owner's authorized representative. A letter shall be submitted to the Architect requesting system acceptance. This letter shall certify all controls are installed and the software programs have been completely exercised for proper equipment operation. Acceptance testing will commence at a mutually agreeable time within ten (10) calendar days of request. When the field test procedures have been demonstrated to the Owner's representative, the system will be accepted. The warranty period will start at this time.

- G. Field Equipment Test Procedures: DDC control panels shall be demonstrated via a functional end to end test. Such that:
 - 1. All output channels shall be commanded (on/off, stop/start, adjust, etc.) and their operation verified.
 - 2. All analog input channels shall be verified for proper operation.
 - 3. All digital input channels shall be verified by changing the state of the field device and observing the appropriate change of displayed value.
 - 4. If a point should fail testing, perform necessary repair action and retest failed point and all interlocked points.
 - 5. Automatic control operation shall be verified by introducing an error into the system and observing the proper corrective system response.
 - 6. Selected time and setpoint schedules shall be verified by changing the schedule and observing the correct response on the controlled outputs.

- H. As-Built Documentation: After a successful acceptance demonstration, the Contractor shall submit as-built drawings of the completed project for final approval. After receiving final approval, supply "6" complete as-built drawing sets, together with AutoCAD or Visio diskettes to the owner.

- I. Operation and Maintenance Manuals: Submit four copies of operation and maintenance manuals. Include the following:
 - 1. Manufacturer's catalog data and specifications on sensors, transmitters, controllers, control valves, damper actuators, gauges, indicators, terminals, and any miscellaneous components used in the system.
 - 2. An operator's manual that will include detailed instructions for all operations of the system.
 - 3. An operator's reference table listing the addresses of all connected input points and output points. Settings shall be shown where applicable.
 - 4. A copy of the warranty/guarantee.
 - 5. Operating and maintenance cautions and instructions.

3.4 TRAINING

- A. Contractor shall provide to the engineer a training class outline prior to any scheduled training.

- B. Factory trained control engineers and technicians shall provide training sessions for the Owner's personnel.

- C. The control contractor shall conduct three (3) four-hour training courses for the designated owners personnel in the maintenance and operation of the control system. One class shall be given before system acceptance and the next will be given during the season change, and the last will be at the end of the warranty time.

- D. The course shall include instruction on specific systems and instructions for operating the installed system to include as a minimum:
 - 1. HVAC system overview
 - 2. Operation of Control System
 - 3. Function of each Component
 - 4. System Operating Procedures
 - 5. Programming Procedures
 - 6. Maintenance Procedures

3.5 WARRANTY GUARANTEE

- A. The control system shall be warranted/guaranteed to be free from defects in both material and workmanship for a period of one (1) year of normal use and service. This warranty/guarantee shall become effective the date the owner accepts or receives beneficial use of the system.

PART 4 - SEQUENCE OF OPERATION

4.1 TOILET ROOM EXHAUST FANS

- A. The toilet exhaust fans shall be started and stopped by the building automation system. They will be controlled via a time schedule in the DDC system.

4.2 UNIT HEATERS AND ROOF MOUNTED EVAP UNITS FOR PARTS STORAGE AREA

- A. A space mounted thermostat shall be mounted as shown on the plans for each of the unit heaters in the parts storage area. The sensor shall be an input for a DDC controller that starts and stops the Unit heater and the associated roof mounted evaporative unit.
- B. The Controller shall compare the space temperature to the heating and cooling setpoints. If the space temperature falls below the heating setpoint, then the unit heater will be enabled and remain on until the space temperature rises above the heating setpoint. When the space temperature rises above the space temperature the controller shall enable the evaporative unit until the space temperature falls below the cooling setpoint. Either the heating or the cooling units shall be locked out if the other one is running.

4.3 BAY AREA TEMPERATURE CONTROLS

- A. An OFF/AUTO switch shall be mounted for each rooftop-Radiant Heating zone. If the switch is in the OFF position then the DDC controller shall keep all of the equipment off. The graphical display on the workstation shall show that the zone is in the manual Off mode. If the switch is in the auto position then the zone equipment shall operate as described below.
- B. A DDC controller shall monitor the space temperature via a space temperature sensor. The controller shall have adjustable heating and cooling setpoints. The space temperature sensor shall be mounted in a location that is not exposed to the radiate heaters.
- C. If the space temperature falls below the heating setpoint then the controller shall enable the radiant heating system. If the space temperature continues to fall then the controller shall enable the roof mounted makeup air units to heating and enable their gas fired burners as the second stage of heat. When the space temperature rises above the heating setpoint, then all of the heating equipment shall be turned off.
- D. If the space temperature rises above the cooling setpoint, the controller shall enable the makeup air units and enable the DX cooling system to deliver cooled air to the space. When the space temperature falls below the cooling set point, the makeup units shall be turned off.
- E. Any time the makeup air units are enabled to run then the associated Exhaust Fans for those units shall be enabled as well.

4.4 ROOFTOP HVAC

- A. The Rooftop Air Handling Unit (RT) shall be enabled whenever the system is occupied, or one of the zone sensors is in the override mode.

- B. When the RT is enabled the Supply Fan shall run continuously subject to the following safeties; High Duct static pressure, Low temperature switch, Fire Alarm interlock, and smoke(ionization) detectors. If any one of these are tripped the supply fan shall be hard wired to shut down and an alarm shall be generated thru the automation system to notify the owner of the problem.

- C. A DDC controller shall monitor the mixed air temperature via a mixed air temperature sensor. The controller shall compare the value to the mixed air temperature setpoint. The controller shall then modulate the economizer dampers between the minimum ventilation position and full open to maintain the mixed air temperature setpoint. When the return air temperature is less then the outside air temperature then the mixed air dampers shall go to the minimum ventilation position. When the outside air temperature falls below 35 degrees, the mixed air dampers shall go to their minimum position.

- D. A DDC controller shall monitor the AHU discharge air temperature. If the temperature rises above the discharge air high limit, then the controller shall enable the DX cooling. When the air temperature falls below the discharge air low limit the controller shall disable the DX cooling, and enable the gas heating

END OF SECTION 23 0933

SECTION 23 0950 – COMBUSTIBLE GAS DETECTOR CONTROLS

PART 1 - GENERAL

- 1.1 Provide a complete installation of a toxic gas detection system including stand-alone dual sensors and audible/visual alarm devices that can monitor two different gases.
- 1.2 The system shall include, but not be limited to, the following:
- Future expandability
 - Display of toxic gas concentration
 - Ability to modify alarm set points
 - Automatic and Manual fan start/stop
 - Display of alarm status

PART 2 - PRODUCTS

- 2.1 DETECTORS E³ POINT MODEL E3SA, E3SAH OR E3SAR, E3SARH WITH E3SRM REMOTE SENSOR OR E3DA (DUCT MOUNT)
- Transmitter will be powered by 24 V AC/DC (E3SA) or 120 Vac (E3SAH). The gas transmitter must be capable of monitoring a second gas when equipped with an E3SRM remote sensor. The gas transmitter will incorporate an electrochemical cell for toxic gas monitoring and catalytic bead sensor for combustible gases. Unit sensing cell must compensate for variation in relative humidity and temperature to maintain high levels of accuracy.
 - The transmitter will be capable of transmitting gas concentrations to a DDC system through its 4-20 mA output. For local activation of fans or louvers (or other equipment), two on-board DPDT relays 5 A, 30 Vdc or 250 Vac (restrictive load) will be activated at programmable set points (and programmable time delays). An LCD display will provide local gas concentration readings.
 - Transmitter will be capable of operating within relative humidity ranges of 5-95% non-condensing and temperature ranges of -4°F to 104°F.
 - Unit will be certified to ANSI/UL 61010-1 label and CAN/CSA-C22.2 No. 61010. Transmitter must be manufactured in and ISO 9001-2000 production environment.
 - The transmitter should have a plug-in capability for a gas cartridge with a smart sensor capable of self-testing.
 - For local activation of audible alarms, the transmitter shall have an on-board device able to generate an audible output of 85 dBA @ 10 ft.
 - Detector alarm levels are to be activated and the unit is to be installed in accordance with the following parameters:

GASES	1 ST ALARM SET POINT	2 ND ALARM	3 RD ALARM	MOUNTING HEIGHT	COVERAGE RADIUS
Carbon Monoxide (CO)	25 PPM	200 PPM	225 PPM	5 ft (150 cm) above finished floor	50 ft (15 m)
Nitrogen Dioxide (NO ₂)	0.72 PPM	2.0 PPM	9.0 PPM	1 ft (30 cm) from ceiling	50 ft (15 m)
Hydrogen Sulphide (H ₂ S)	10 PPM	15 PPM	20 PPM	1 ft (30 cm) above finished floor	23 ft (7 m)
Hydrogen (H ₂)	25% LEL	50% LEL	90% LEL	1 ft (30cm) from ceiling	23 ft (7 m)
Oxygen (O ₂)	19.5 % Vol	22.0 % Vol	22.5% Vol	5 ft (150cm) above finished floor	23 ft (7 m)
Methane (CH ₄)	25% LEL	50% LEL	90% LEL	1 ft (30cm) from ceiling	23 ft (7 m)
Propane (C ₃ H ₈)	25%LEL	50% LEL	90% LEL	1 ft (30cm) above finished floor	23 ft (7 m)

2.2 ACCESSORIES

- A. Strobe and Horn type STAS for 24 Vac, FHS-240 for 24 Vdc or STACKSTAS for 120 Vac:

Strobe & Horn unit will be capable of operating within relative humidity ranges of 0-100% and temperature ranges of -30° F to 150° F. Rating of horn will be no less than 72dBA at 10 feet. Intensity of light will be no less than 40W and will flash at frequency of 1 per second. Unit will be certified by CSA. Honeywell Analytics.

- B. Power Transformer type T100VA, T200VA, T300VA or Class 2 device type T100 VAC2, T200VAC2, or T300VAC2:

1. Transformer shall have an input voltage of 120 V AC and an output voltage of 24 Vac with a VA range of 50-300. Operating frequency shall be 60 Hz. Unit will provide insulation systems up to 130° C. Unit will operate at sound levels of less than 40 dBA. Transformers shall be of fused type.

- C. Detector Guards E3PT – GUARD:

1. The grid is made of a 9-gauge steel wire. The guard must be designed to allow calibration without removing the guards.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install hazardous gas monitoring equipment including sensors, audible alarms, as shown on Contract Drawing, and as recommended by manufacturer of equipment, and as required by authorities having jurisdiction.
- B. Install conduit and wiring from sensors to control panel and to the fan starters/HVAC control panel as recommended by manufacturer of equipment.

3.2 SEQUENCE OF OPERATION:

- A. If any NO₂ sensor detects 0.72 PPM gas, the exhaust fans operate and motorized dampers open. Low Alarm indicators light for point in alarm. If hazardous gas not cleared after 30 minutes or the level reaches 2 PPM, High Alarm indicator lights on the main panel and remote strobe & horn activate, Audible Alarm to sound and contacts to operate the exhaust fans.
- B. If any CO sensor detects 25 PPM gas, all fans operate and damper opens. Low Alarm LED lights for point in alarm. If any sensor detects 200 PPM gas, the Audible Alarm sounds and High Alarm indicator light on the main panel and remote & horn activate.

3.3 COMMISSIONING

- A. After installation, test and calibrate equipment to demonstrate operation of functions described above under sequence of operation by manufacturers certified service technician.
- B. Provide testing kits (including gas bottles) for testing and calibration by Commission technician.

3.4 WARRANTY:

- A. Limited Warranty – Honeywell Analytic, Inc. warrants to the original purchaser and/or ultimate customer (“Purchaser”) of Vulcain products (“Product”) that if any part thereof proves to be defective in material or workmanship within twelve (12) months, such defective part will be repaired, or replaced free of charge, at Honeywell Analytics’ discretion if shipped prepaid to Honeywell Analytics at 4005 Matte Blvd. Unit G, Brossard, Quebec, Canada, J4Y 2P4, in a package equal to or in the original container. The product will be returned freight prepaid and repaired or replaced if it is determined by Honeywell Analytics that the part failed due to defective materials or workmanship. The repair or replacement or any such defective part shall be Honeywell Analytics sole and exclusive responsibility and liability under this limited warranty.

END OF SECTION 23 0950

SECTION 23 1123 – NATURAL GAS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install gas piping and fittings within building and connect.

1.3 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Welders shall be certified and bear evidence of certification 30 days prior to commencing work on project. If there is doubt as to proficiency of welder, Owner's Representative may require welder to take another test. This shall be done at no cost to Owner. Certification shall be by Pittsburgh Testing Laboratories or other approved authority.

PART 2 - PRODUCTS

2.1 PIPE

- A. Meet requirements of ASTM A 53-89a, "Specification for Pipe, Steel, Black & Hot-Dipped Zinc-Coated Welded & Seamless".
- B. Carbon steel, butt welded, Schedule 40 black steel pipe.

2.2 FITTINGS

- A. Black Pipe:
 - 1. Welded forged steel fittings meeting requirements of ASTM A 234-89a, "Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures", or standard weight malleable iron screwed.

2.3 VALVES

- A. 125 psi bronze body ball valve, UL listed
- B. Approved Manufacturers & Models:
 - 1. ConBraCo - "Apollo" series 80-100
 - 2. Jenkins - FIG-30-A
 - 3. Jomar - Model T-204
 - 4. McDonald - 3410
 - 5. PGL Corp - "Red Cap" gas ball valve
 - 6. Watts - Model B-6000-UL

2.4 PRESSURE REDUCING REGULATORS

- A. Corrosion Resistant Brass Body.
- B. 1/2" to 4" Threaded NPT
- C. 2" and Above Flanged.
- D. Max Inlet Pressure 10 psi.
- E. Max Outlet Pressure 0.5 psi.
- F. Temperature Capabilities - ~20 to 180° F.

- G. Approved Manufactures and Models.
 - 1. Emerson Process Management.
 - 2. Maxitrol 3UP33
 - 3. Or approved equal.

- H. Seismic Gas Valves
 - 1. Seismic Valves:
 - a. Natural gas seismic shut-off valves.
 - 1) Rate at maximum 20 psi (138 kPA) pressure with positive seating from minus 40 deg F to plus 150 deg F (minus 40 deg C to plus 66 deg C) for exterior mounting near gas meter.
 - 2) UL listed valve, factory set for IBC Seismic Design Category D, E, or F.
 - 3) Size to be determined by total cu ft per hour gas flow requirement of building and following conditions: 0.1 inch water column maximum allowable pressure-drop through valve with available pressure of 4 oz.
 - 4) Category Four Approved Product. See Section 01 6200 for definitions of Categories:
 - a)KOSO HPF Series.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Pipe installed underground, through air plenums, in walls, and pipes 2-1/2 inches and larger shall have welded fittings and joints. Other pipe may have screwed or welded fittings.
- B. Install gas cocks on lines serving boilers, furnaces, duct heaters, and water heaters adjacent to boiler, furnace, or heater on outside of boiler, furnace, or heater cabinet and easily accessible.
- C. Install dirt leg with pipe cap, 6 inches long minimum, on each vertical gas drop to heating equipment.
- D. Use fittings for changes of direction in pipe and for branch runouts.

END OF SECTION 23 1123

SECTION 23 2300 - REFRIGERANT PIPING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install piping for refrigeration systems as described in Contract Documents.

1.3 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Refrigerant piping shall be installed by a refrigeration contractor licensed by State.

PART 2 - PRODUCTS

2.1 REFRIGERANT PIPING

- A. Meet requirements of ASTM B 280-88, "Specification for Seamless Copper Tube for Air Conditioning & Refrigeration Field Service", hard drawn straight lengths.
- B. Do not use pre-charged refrigerant lines.

2.2 REFRIGERANT FITTINGS

- A. Wrought copper with long radius elbows.
- B. Approved Manufacturers:
 - 1. Mueller Streamline
 - 2. Nibco Inc
 - 3. Grinnell
 - 4. Elkhart Products Corp

2.3 SUCTION LINE TRAPS

- A. Manufactured standard one-piece traps.

2.4 CONNECTION MATERIAL

- A. Brazing Rods:
 - 1. Copper to Copper Connections:
 - 2. AWS Classification BCuP-4 Copper Phosphorus (6% silver).
 - 3. AWS Classification BCuP-5 Copper Phosphorus (15% silver).
 - 4. Copper to Brass or Copper to Steel Connections:
 - 5. AWS Classification BAg-5 Silver (45% silver).
 - 6. Do not use rods containing Cadmium.

2.5 FLUX

- A. Approved Manufacturers:
 - 1. "Stay-Silv white brazing flux" by J W Harris Co
 - 2. High quality silver solder flux by Handy & Harmon

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Do not install refrigerant piping underground or in tunnels.

- B. Slope suction lines down toward compressor one inch/10 feet. Locate traps at vertical rises against flow in suction lines.
- C. Refrigeration system connections shall be copper-to-copper, copper-to-brass, or copper-to-steel type properly cleaned and brazed with specified rods. Use flux only where necessary.
 - 1. No soft solder (tin, lead, antimony) connections will be allowed in system.
- D. Braze valve, sight glass, and flexible connections.
- E. Circulate dry nitrogen through tubes being brazed to eliminate formation of copper oxide during brazing operation.

3.2 FIELD QUALITY CONTROL

- A. Make evacuation and leak tests in presence of Architect's Engineer after completing refrigeration piping systems. Positive pressure test will not suffice for procedure outlined below.
 - 1. Draw vacuum on each entire system with vacuum pump to 200 microns using vacuum gauge calibrated in microns. Do not use cooling compressor to evacuate system nor operate it while system is under high vacuum. Isolate compressor from system piping using shut-off valves prior to pulling vacuum.
 - 2. Break vacuum with freon to be used and re-establish vacuum test. Vacuum shall hold for 24 hours at 200 microns without compressor running.
 - 3. Conduct tests at 70 deg F ambient temperature minimum.
 - 4. Do not run systems until above tests have been made and systems started up as specified. Inform Owner's Representative of status of systems at time of final inspection and schedule start-up and testing if prevented by outdoor conditions before this time.
 - 5. After testing, fully charge system with refrigerant and conduct test with Halide Leak Detector.

END OF SECTION 23 2300

SECTION 23 3114 - LOW-PRESSURE STEEL DUCTWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install above-grade ductwork and related items as described in Contract Documents.

PART 2 - PRODUCTS

2.1 DUCTS

- A. Fabricate of zinc-coated lockforming quality steel sheets meeting requirements of ASTM 653A/653M, "Specification for Sheet Steel Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock Forming Quality", with G 60 coating.
- B. Use of aluminum, non-metallic, or round ducts is not permitted. [Specification writer: Use of aluminum ducts in areas with high chlorine content (eg.: ventilation for pools, spas, etc.) should be considered on a per job basis.]

2.2 DUCT JOINTS

- A. Ducts with sides up to and including 36 inches shall be as detailed in the SMACNA manual.
- B. Duct sizes over 36 inches shall be fabricated using SMACNA T-24 flange joints or pre-fabricated systems as follows:
 - 1. Ducts with sides over 36 inches to 48 inches:
 - a. transverse duct joint system by Ductmate/25, Nexus, Ward, or WDCI (Lite) (SMACNA "E" or "G" Type connection).
 - 2. Ducts 48 inches & larger:
 - a. Ductmate/35, Nexus, or WDCI (Heavy) (SMACNA "J" Type connection).
 - 3. Approved Manufacturers:
 - a. Ductmate Industries Inc, 10760 Bay Meadows Drive, Sandy, UT 84092 (801) 571-5308
 - b. Nexus, Exanno Corp, P O Box 729, Buffalo, NY 14206 (716) 849-0545
 - c. Ward Industries Inc, 1661 Lebanon Church Road, Pittsburg, PA 15236 (800) 466-9374
 - d. WDCI, P O Box 10868, Pittsburg, PA 15236 (800) 245-3188

2.3 ACCESS DOORS IN DUCTS

- A. At each manual outside air damper and at each motorized damper, install factory built insulated access door with hinges and sash locks. Locate doors within 6 inches of installed dampers. Construction shall be galvanized sheet metal, 24 ga minimum.
- B. Fire and smoke damper access doors shall have a minimum clear opening of 12" x 12" or as specified on Drawings to easily service fire or smoke damper. Doors shall be within 6 inches of fire and smoke dampers and in Mechanical Room if possible.
- C. Identify each door with 1/2" high letters reading "smoke damper" or "fire damper".
- D. Approved Manufacturers:
 - 1. AirBalance - Fire/Seal #FSA 100
 - 2. Air Control Products - HAD-10
 - 3. Cesco-Advanced Air - HAD-10
 - 4. Elgen - Model 85 A
 - 5. Kees Inc - ADH-D.
 - 6. Louvers & Dampers - #SMD-G-F
 - 7. Nailor-Hart Industries Inc - Series 0831
 - 8. National Controlled Air Inc - Model AD-FL-1

2.4 FLEXIBLE EQUIPMENT CONNECTIONS

- A. 30 oz closely woven UL approved glass fabric, double coated with neoprene.
- B. Fire retardant, waterproof, air-tight, resistant to acids and grease, and withstand constant temperatures of 250 deg F.
- C. Approved Manufacturers:
 - 1. Cain - N-100
 - 2. Duro Dyne - MFN
 - 3. Elgen - ZLN
 - 4. Ventfabrics - Ventglas

2.5 CONCEALED CEILING DAMPER REGULATORS

- A. Approved Manufacturers:
 - 1. Cain
 - 2. Duro Dyne
 - 3. Metco Inc
 - 4. Vent-Lock - #666
 - 5. Young - #303

2.6 VOLUME DAMPERS

- A. In Main Ducts:
 - 1. 16 gauge galvanized steel, opposed blade type with 3/8 inch pins and end bearings. Blades shall have 1/8 inch clearance all around.
 - 2. Damper shall operate within acoustical duct liner.
 - 3. Provide channel spacer equal to thickness of duct liner.
 - 4. Approved Manufacturers:
 - a. Air Balance - Model AC-2
 - b. Air Control Products - CD-OB
 - c. American Warming - VC-2-AA
 - d. Greenheck - VCD-1100
 - e. NCA, Safe Air
 - f. Vent Products - 5100
- B. In Sheet Metal Branch Ducts:
 - 1. Extruded aluminum, opposed blade type. When in open position, shall not extend beyond damper frame.
 - 2. Maximum blade length 12 inches.
 - 3. Damper Regulator shall be concealed type with operation from bottom or with 90 deg miter gear assembly from side.
 - 4. Approved Manufacturers:
 - a. Air Control Products - TCD-OB
 - b. Air Guide - OB
 - c. Arrow - OBDAF-207
 - d. CESCO - CDA
 - e. Reliable Metals - OBD-RO
 - f. Tuttle & Bailey - A7RDDM
 - g. Safe Air
 - h. Young - 820-AC
- C. Dampers above removable ceiling and in Mechanical Rooms shall have locking quadrant on bottom or side of duct. Otherwise, provide concealed ceiling damper regulator and cover plate.

2.7 BACKDRAFT DAMPER

- A. Backdraft blades shall be nonmetallic and shall be neoprene coated fiberglass.
- B. Stop shall be galvanized steel screen or expanded metal, 1/2 inch mesh.
- C. Frame shall be galvanized steel or extruded aluminum alloy.
- D. Approved Models & Manufacturers:
 - 1. Air Control Products - FBD
 - 2. American Warming - BD-15

3. CESCO - FBD 101
4. Ruskin - NMS2
5. Safe Air

2.8 DUCT HANGERS

- A. 1" x 18 gauge galvanized steel straps or steel rods as shown on Drawings, and spaced not more than 8 feet apart. Do not use wire hangers.
- B. Attaching screws at trusses shall be 1-1/2 inch No. 10 round head wood screws. Nails not allowed.

2.9 DUCT SEALER

- A. Cain - Duct Butter or Butter Tak
- B. Design Polymerics - DP 1010
- C. DSC - Stretch Coat
- D. Duro Dyne - S2
- E. Hardcast - #601 Iron-Grip or Peel-N-Seal Tape
 1. Kingco - 15-325
 2. Mon-Eco - 44-41
 3. Trans-Continental Equipment Co - Multipurpose Duct Sealant
 4. United - Sheet Metal duct-sealer

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Ducts:
 1. Straight and smooth on inside with joints neatly finished unless otherwise directed.
 2. Duct panels through 48 inch dimension having acoustic duct liner need not be crossbroken or beaded.
 3. Crossbreak unlined ducts and duct panels larger than 48 inch or bead 12 inches on center.
 4. Securely anchor ducts to building structure with specified duct hangers attached with screws. Do not hang more than one duct from a duct hanger.
 5. Brace and install ducts so they shall be free of vibration under all conditions of operation.
 6. Ducts shall not bear on top of structural members.
 7. Make duct take-offs to branches, registers, grilles, and diffusers as detailed on Drawings.
 8. Ducts shall be large enough to accommodate inside acoustic duct liner. Dimensions shown on Drawings are net clear inside dimensions after duct liner has been installed.
 9. Properly flash where ducts protrude above roof.
 10. Install internal ends of slip joints in direction of flow. Make joints air tight using specified duct sealer.
 11. Cover horizontal and longitudinal joints on exterior ducts with two layers of Hardcast tape installed with Hardcast HC-20 adhesive according to Manufacturer's recommendations.
 12. Paint ductwork visible through registers, grilles, and diffusers flat black.
- B. Install flexible inlet and outlet duct connections to each furnace, fan, fan coil unit, and air handling unit.
- C. Install concealed ceiling damper regulators.
 1. Paint cover plates to match ceiling tile.
 2. Damper regulators will not be required for dampers located directly above removable ceilings or in Mechanical Rooms.
- D. Provide each take-off with an adjustable volume damper to balance that branch.
 1. Anchor dampers securely to duct.
 2. Install dampers in main ducts within insulation.
 3. Dampers in branch ducts shall fit against sheet metal walls, bottom and top of duct, and be securely fastened. Cut duct liner to allow damper to fit against sheet metal.
 4. Where concealed ceiling damper regulators are installed, provide a cover plate.
- E. Install grilles, registers, and diffusers. Level floor registers and anchor securely into floor.
- F. Air Turns:

1. Permanently installed, consisting of single thickness curved metal blades with one inch straight trailing edge to permit air to make abrupt turn without appreciable turbulence, in 90 degree elbows of above ground supply and return ductwork.
2. 4-1/2 inch wide minimum vane rail. Do not use junior vane rails.
3. Double thickness vanes not acceptable.
4. Quiet and free from vibration when system is in operation. See SMACNA Manual

END OF SECTION 23 3114

SECTION 23 3346 - FLEX DUCT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install supply air branch duct runouts to diffusers as described in Contract Documents.

PART 2 - PRODUCTS

2.1 DUCTS

- A. Formable, flexible, circular duct which shall retain its cross-section, shape, rigidity, and shall not restrict air flow after bending.
- B. Nominal 1-1/2 inches thick, 3/4 lb/cu ft density fiberglass insulation with air-tight, polyethylene or polyester core, sheathed in seamless vapor barrier jacket factory installed over flexible assembly.
- C. Assembly, including insulation and vapor barrier, shall meet Class I requirement of NFPA 90A and be UL 181 rated, with flame spread of 25 or less and smoke developed rating of 50 or under.
- D. Length of flexible ductwork shall not exceed 8'-0".

2.2 APPROVED MANUFACTURERS

- A. ANCO-FLEX - 4625
- B. Flex-Aire - PF/UPC #090
- C. Hart & Cooley - F114
- D. Thermaflex - G-KM

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct in fully extended condition free of sags and kinks.
- B. Make duct connections by coating exterior of duct collar for 3 inches with duct sealer and securing duct in place over sheet metal collar with 1/2 inch wide metal cinch bands and sheet metal screws.

END OF SECTION 23 3346

SECTION 23 3400 - EXHAUST FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install exhaust fans as described in Contract Documents.

1.3 QUALITY ASSURANCES

- A. Requirements of Regulatory Agencies:
 - 1. Bear AMCA seal and UL label.

PART 2 - PRODUCTS

2.1 CEILING MOUNTED EXHAUST FANS

- A. Acoustically insulated housings.
- B. Sound level rating of 4.6 sones maximum for fan RPM and CFM listed on Drawings.
- C. Include chatterproof integral back-draft damper with no metal to metal contact.
- D. True centrifugal wheels.
- E. Entire fan, motor, and wheel assembly shall be easily removable without disturbing housing.
- F. Suitably ground motors and mount on rubber-in shear vibration isolators.
- G. Provide wall or roof cap, as required.
- H. Approved Manufacturers:
 - 1. Cook-Gemini
 - 2. Greenheck Sp
 - 3. Pace
 - 4. Penn Zephyr

2.2 ROOF MOUNTED EXHAUST FANS

- A. Direct drive or have adjustable pitch V-belt as noted on Drawings.
- B. Wheels shall be backward curved and housing shall be removable or hinged aluminum.
- C. Isolate motor with vibration dampeners.
- D. Provide quiet type back-draft dampers.
- E. Insulated, pre-fabricated metal roof curb shall be for flat or sloped roof as shown on Drawings.
- F. Approved Manufacturers:
 - 1. Fans:
 - a. Penn
 - b. Centri-Master
 - c. Cook
 - d. Greenheck G, GB
 - 2. Standard curbs:
 - a. Penn

- b. Cook
- c. Greenheck
- 3. Sound attenuating curbs:
 - a. Penn
 - b. Greenheck

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Anchor fan units securely to structure or curb.

END OF SECTION 23 3400

SECTION 23 3713 - AIR OUTLETS & INLETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install wall supply registers, transfer grilles, return air grilles, soffit grilles, ceiling diffusers, louvers connected to ductwork, and registers as described in Contract Documents.

PART 2 - PRODUCTS

2.1 GRILLES & REGISTERS

- A. Approved Manufacturers:
 - 1. Price
 - 2. Anemostat
 - 3. Krueger
 - 4. Titus
 - 5. Tuttle & Bailey
- B. Wall or Roof Caps:
 - 1. Aluminum Architectural style with backdraft damper.
 - 2. Category Four Approved Products. See Section 01 6200 for definitions of Categories:
 - a. PennBarry: WC10.

2.2 SPIN-IN FITTINGS

- A. Low pressure round take-offs to diffusers shall be made with spin-in fittings. They shall incorporate a manual balancing damper. The damper shall be spring loaded and a positive locking wing nut shall secure the damper position.
- B. Approved Manufacturers:
 - 1. Sheet metal fittings: Genflex DB-1DEL, Hercules

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Anchor securely into openings.
- B. Install with screws to match color and finish of grilles and registers.
- C. Touch-up any scratched finish surfaces.
- D. Install in accordance with manufacturer's instructions.
- E. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- F. Install diffusers to ductwork with air tight connection.
- G. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- H. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 9000.

END OF SECTION 23 3713

SECTION 23 4100 – DISPOSABLE FILTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install filters used in mechanical equipment.

PART 2 - PRODUCTS

2.1 AIR HANDLING UNIT FILTERS

- A. 2 inch thick, medium efficiency, disposable type pre-formed pleated design, having at least 4.5 sq ft of filtering media per sq ft of face area.
- B. Media shall be reinforced non-woven cotton fabric, treated with adhesive similar to "Vyclad B" and continuously laminated to supporting steel wire grid conforming to configuration of pleats.
- C. Media pack shall be sealed in a chipboard frame or beverage board.
- D. Filters shall have rated average efficiency of 25 to 30% on ASHRAE Test Standard 52-76 and be capable of operating with variable face velocities up to 500 FPM without impairing efficiency.
- E. Initial resistance shall not exceed 0.30 inches w.g. at 500 FPM or 0.14 inch w.g. at 300 FPM. Filter shall be listed Class 2 by UL.
- F. Approved Manufacturers:
 - 1. Type 30/30 by Farr Co
 - 2. Mark 80 by Serv-Aire
 - 3. HC Type 40 by Envopleat
 - 4. DP2-40 by Air Guard

END OF SECTION 23 4100

SECTION 23 5134 – FLUES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install flues as described in Contract Documents.

PART 2 - PRODUCTS

2.1 FLUES

- A. Sections shall be UL listed.
- B. Sections shall have:
 - 1. Outer jacket of aluminum-coated or galvanized steel.
 - 2. One inch minimum insulating air space.
 - 3. Inner gas carrying pipe of stainless steel.
 - 4. Capability of handling flue gas temperatures up to 1400 deg F on continuous basis.
- C. Furnish items which form part of assembly including but not limited to:
 - 1. Bracing and supports as recommended by Flue Manufacturer.
 - 2. Cleanout sections
 - 3. T-sections
 - 4. Necessary straight sections
 - 5. Ventilated roof thimble
 - 6. Flashing and counterflashing
 - 7. 'Backdraft preventer' installed at top of water heater and boiler flues.
- D. Approved Manufacturers:
 - 1. Metalbestos Model PS
 - 2. Metivent Model GTD
 - 3. Metal-Fab Inc All Fuel Chimney

2.2 VENT CAPS

- A. Non-backdraft type.
- B. Approved Manufacturers:
 - 1. Ameri-cap
 - 2. Breidert Type L
 - 3. Triangle AFL
 - 4. Acme Mastervent Type MVR.
 - 5. Dura-Vent

END OF SECTION 23 5134

SECTION 23 5414 – DIRECT GAS FIRED MAKE-UP AIR UNIT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Provide a direct gas fired make-up air unit as shown on plans.

PART 2 - PRODUCTS

2.1 AIR MAKE-UP UNIT

- A. Air make-up unit shall be Titan Air Incorporated or approved equal equipped with the following features:
 1. Blowers: Blowers shall be centrifugal, forward curved, double width, double inlet type mounted on a solid turned, ground and polished steel shaft with self-aligning bearings.
 2. Equipment Casing: Equipment casing to be (18 ga.) paint lock around an integral support frame of structural angle. Equipment shall be primed with acrylic enamel primer and a finish coat of acrylic enamel paint. Finish color to be Titan Industrial Gray.
 3. Unit Configuration: Unit configuration shall be horizontal, horizontal discharge. Right controls (facing control vestibule, discharge is right).
 4. Burner: Burner to be direct fired as manufactured by Midco International. Designed to operate with an air velocity of 2,850 FPM across the stainless steel air baffles. Burner to be designed to provide 100% thermal efficiency throughout the life of the equipment. Burner shall be of a design that produces less than 5 ppm CO throughout its modulating range. Turn down ratio of the burner shall be minimum of 25:1.
 5. Gas Train: Gas train shall be constructed to meet (Standard A.N.S.I., Factory Mutual, Industrial Risk insurance or a combination of these.) All gas train components shall be selected to operate at a minimum four PSIG gas pressure.
 6. Temperature Control: Temperature control shall be digital discharge temperature, Maxitrol Series 94.
 7. With the exception of indoor hanging equipment, all normal installations will have control vestibule accessible without the aid of service platforms or ladders.
 8. Optional Accessories to include:
 - a. Motorized intake damper
 - b. Unit casing insulation
 - c. Interior liner
 - d. Vibration isolation - neoprene type: blower/motor
 9. The factory packaged frequency drive air make-up shall operate from pressure differential sensed by a Dwyer 3000 series Photohelic.
 10. Optional Controls to include:
 - a. Burner "on-off" ductstat (economizer)
 - b. Circuit analyzer
 - c. Operating lights
 - d. Clogged filter light
 - e. Low gas pressure switch
 - f. High gas pressure switch
 - g. Proof of closure
 - h. Ionized smoke detector
 - i. Low fire start
 11. Unit to be ETL listed under ANSI Z83.18 (1987), (covering direct fired industrial heaters) as packaged variable frequency drive systems. Field conversion of listed air make-up will not be acceptable.

END OF SECTION 23 5414

SECTION 23 5416 – SEPERATED COMBUSTION UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMAR

- A. Furnish and install separated combustion unit heaters as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Provide high-efficiency, separated combustion, gas fired unit heaters as manufactured by Reznor. They are to be designed for a fuel use improvement of 25% and engineered for use in building areas with negative pressure and/or extremely dirty or mildly corrosive atmospheres. The use of a factory-installed power venter to draw combustion air from outside is to prevent dirt, lint, dust, or other contaminants present in the heated space from entering the unit. The combustion air supply pipe and flue exhaust pipe shall be run parallel to a factory-supplied (horizontal), (vertical) vent terminal assembly. The vent terminal assembly shall be arranged to provide preheating of the combustion supply air and to allow a single wall or roof penetration.
- B. The SC series shall be provided with a 24-volt control transformer, a(n) (single-stage), (two-stage), (electronic modulation) gas control system with a regulated combination redundant gas valve and an intermittent spark pilot with electronic flame supervision (and timed lockout). The SC is to include all limit and safety controls, including a combustion air pressure differential switch to verify proper vent flow before allowing operation of the gas valve.
- C. Each unit shall be equipped for use with (natural), (propane) gas and (120/1), (208/3), (203/3), (460/3) volt power supply. The heat exchanger shall be the Reznor Themrocore design of (aluminized), E-3 [408] stainless steel and include flared ports (burner air shutters) and a stainless steel insert. The units shall be designed for 80% thermal efficiency.
- D. These units are to be propeller fan(s), open drip-proof fan motor(s) with internal overloads, and safety fan guard(s). Horizontal (and vertical) louvers shall be provided for directing air flow. The unit must be arranged for ceiling suspension with threaded hanger connections (and provided with hanger kits). The cabinet shall be constructed of zinc grip steel and finished with baked-on enamel.
- E. All separated-combustion unit heaters must be design-certified by the American Gas Association and bear the A.G.A. label.

END OF SECTION 23 5416

SECTION 23 5418 – RADIANT HEATING SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install radiant heating system as described in Contract Documents.

1.3 QUALITY ASSURANCE

- A. Total heating system supplied shall be design certified by the American Gas Association and this per American National Standard Z83.6 - 1987 "Vented Infrared Radiant Heater".

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Burners shall be designed for firing in tandem without adverse effects from combustion gases from upstream burners.
- B. Burners shall be supplied to fire at the design of burners supplied and the design of burners supplied shall provide for maintaining a constant proportion of fuel gas to filtered combustion air. These conditions are met for burners in which the pressure of both fuel gas and combustion air are both introduced at zero (atmospheric) pressure and flow of each is established by a vacuum of downstream side of flow metering orifices.
- C. To assure a high degree of fail-safe operation, the design shall preclude flow of gas if any or all of the following abnormal conditions occur in the non-firing mode:
 - 1. Main valve fails in open position.
 - 2. Vacuum pump motor fails to operate.
 - 3. Power fails.
- D. To further assure a high degree of safety, the system will be under negative pressure at all times during operation to preclude the possibility of the escape of combustion gases inside the building.
- E. All combustion chambers and heat exchanger pipes connected to a vacuum pump shall be pre-purged with air for a period of at least 20 seconds (10 air changes minimum) prior to initiation of firing sequence.
- F. All combustion chambers and heat exchanger pipes connected to a vacuum pump shall be post-purged with air for a period of at least 20 seconds (10 air changes minimum) after shutdown of the last burner firing into the vacuum pump.
- G. All vacuum pump motors shall be provided with vacuum switches to prevent energization of gas valves until vacuum is proven.
- H. Burner: Each burner shall consist of heavy-duty cast iron burner head, pre-wired gas controls with electric ignition and combustion air filter. Each burner and control assembly will be factory equipped with means to attach a safety chain to facilitate safe remove. Each burner will be supplied with a device which will prevent the removal of the burner control doors until the entire burner and control assembly is removed to a work area.
- I. Reflectors: To maximize downward directive release of infrared energy and minimize upward convection losses, all reflectors shall be designed and equipped as follows:
 - 1. Reflectors shall be of "deep dish" design with both lower edges protruding past the bottom of the heat exchanger tube.
 - 2. The end of each reflector run is to be provided with an end cap.
 - 3. All heat exchanger elbows and tees shall be covered with a reflector joint piece that connects the reflectors with no spaces allowed for loss of radiant energy.
- J. Vacuum Pump: The housing shall be heavy-duty cast iron. The impeller shall be cast aluminum alloy dynamically balanced and mounted for direct drive on the motor shaft. The vacuum pump shall be acoustically isolated from the

system with a flexible connector with temperature rating of 350 deg. F. minimum. The motor in the vacuum pump shall be secured with rubber mounts for acoustical isolation. Vacuum pump motor shall be 230/115V, 60 Hz, 3450 RPM, reversible rotation, with at least 3/4 HP, TEFC capacitor start, ball bearing and thermally protected.

- K. Heat Exchanger: Radiant pipe (between burners and 20 feet downstream of last burner) shall be of 4" O.D. steel pipe (i.e. tubing). The balance of pipe shall be 4" O.D. steel tubing with an internal coating of acid-resistant porcelain. All heat exchanger (pipe) connections shall be made with stainless steel coupling assemblies. These will be of two types as follows: Unlined coupling for use with uncoated tubing or joints to connect uncoated tubing to coated tubing. The maximum input firing rate shall not exceed 2,400 BTU per hour per square foot of exterior radiating surface of heat exchanger for the heating system in total. The total heat exchanger surface is that associated with one vacuum pump.
- L. Burner Control Modules: All burners shall be pre-wired with a three conductor electrical cord and plug with the third wire for ground circuit.
- M. Panelbox for System Controls: Pre-wired system control circuits shall be supplied in a panelbox with each vacuum pump. The panelbox for the standard burners shall provide relays and terminals to accommodate up to four temperature zones with a thermostat and associated control circuits for the burners for each temperature zone. Provide complete with one thermostat.
- N. Approved Manufacturers:
 - 1. Superior Radiant
 - 2. or approved equal

END OF SECTION 23 5418

SECTION 23 6210 – EVAPORATIVE AIR COOLING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Includes But Not Limited To:
 - 1. Furnish and install rooftop evaporative air handlers as described in Contract Documents.
- B. Related Sections:
 - 1. Section 23 0501: Common HVAC Requirements.

1.2 DELIVERY, STORAGE, AND HANDLING

- A. Ship units with lifting sky hooks.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Units shall be completely factory assembled and tested. UL507 listed.
- B. Units shall include following components and features
 - 1. Casing:
 - a. Hot-dipped galvanized steel with epoxy powder coat finish. Double thick corners.
 - b. Unit braced by factory supplied support legs.
 - c. Curb and curb counter-flashing.
 - d. Auto-damper with grille diffuser.
 - e. Provide easy access to external distributor clean outs.
 - f. Height from top of curb to top of unit 3 feet maximum.
 - g. Provide make-up water, over-flow drain, and power utilities through bottom of unit and within curb.
 - 2. Fan:
 - a. Axial, propeller type fan, dynamically balanced and with corrosion resistant finish. Down discharge. Self-aligning, heavy duty, greaseable, pillow block, ball bearing.
 - b. Belt driven, keyed steel shaft with self-tensioning belt.
 - c. Adjustable motor sheave.
 - d. Provide slide frame accessibility to fan, motor and drive.
 - 3. Motor: Totally enclosed for wet environment.
 - 4. Pads: 8 inch thick cross-fluted 80 percent efficient media with side access removal.
 - 5. Water Distribution:
 - a. Provide distribution system for uniform flow thru media.
 - b. Centrifugal pump.
 - c. Cold water make-up valve with float.
 - 6. Performance Standard: United Metal Products, 'FAN-AIR' UMP-724 with UFD33-2 diffuser and full size barometric damper.
 - 7. Type One Acceptable Manufacturers:
 - a. United Metal Products, Tempe, AZ www.unitedmetal.com.
 - b. Equal as approved by Architect before bidding. See Section 01 6200.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units on factory supplied curb. Completely enclose wiring and piping within curb. Penetrations through curbs and roofing membrane are not allowed.
- B. Install barometric damper in discharge duct.
- C. Coordinate attachment of cooler support legs with Architect. Anchor leg supports to roof structure. However, attachment shall not distract from roofing system's integrity nor impact life expectancy of roofing system.
- D. Coat non-finished or unprotected surfaces with two coats of approved corrosion-resistant paint after installation. Color as selected by Architect.

END OF SECTION 23 6210

SECTION 23 6220 – ROOFTOP HEATING-COOLING UNIT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 QUALITY ASSURANCE

- A. Unit shall be AGA certified.

1.3 WARRANTY

- A. Provide five-year warranty on compressors.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Unit shall be one piece combination air-to-air DX mechanical cooling system and gas fired heating system complete with automatic controls.
- B. Equipment shall be shipped completely assembled, pre-charged, piped and wired internally ready for field connections.
- C. Roof mounting frame shall be furnished and installed. Frame shall be steel and mate to bottom perimeter of equipment. When flashed into roof, it shall make a unit mounting curb and provide weather-proof duct connection and entry into conditioning area.
- D. Power Saver: (Fresh Air Dampers)
 - 1. Provide complete with all controls and air mixing damper assembly, including fresh air, recirculated air, and exhaust air dampers.
 - 2. Fresh air section shall be equipped with air filters.
 - 3. Mixing box sections shall contain low leakage dampers with edge seals and inflatable blade seals.
- E. Cooling System:
 - 1. Coils shall be non-ferrous construction with aluminum fins mechanically bonded to seamless copper tubes.
 - 2. Condenser coil shall have sub-cooling rows.
 - 3. Compressor shall be resiliently mounted, have built-in 3-mode crankshaft lubrication, crankcase heater, discharge temperature limiter, current and temperature sensing motor overloads.
 - 4. Cooling system shall be protected by high and low pressure switches and compressor timed off control.
 - 5. Provide with hail guard over condenser coil.
- F. Heating System:
 - 1. Automatic controls furnished to give 50/50 2-stage operation.
 - 2. Cylindrical tube and drum exchanger constructed of Duraglas coated steel or stainless steel.
 - 3. Stainless steel burner listed for operation at low outdoor air temperatures.
 - 4. Visual inspection of burner flame possible through observation port at rear of heat exchanger.
 - 5. Power vented.
- G. Air Movers:
 - 1. Twin centrifugal conditioned air blowers with permanently lubricated ball bearings, adjustable belt drive or direct drive as shown on drawings.
 - 2. Condenser fans shall be direct driven.
 - 3. Motors shall have inherent protection devices.

- H. Frame and Casing:
 - 1. Frame shall be welded construction.
 - 2. Casing shall be galvanized panels with baked-on outdoor enamel finish.
 - 3. Entire cabinet shall be insulated with 1" thick fiberglass.
 - 4. Provide coil guards on exposed condenser coils.

- I. Furnish two sets of 2" throw away filters.

- J. Provide with 7 day programmable thermostat equal to Honeywell T7350.

- K. Approved Manufacturers:
 - 1. Lennox
 - 2. Trane
 - 3. Carrier
 - 4. York

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

- A. Provide manufacturer's startup and warranty.

END OF SECTION 23 6220

SECTION 23 8127

SPLIT-SYSTEM HEATING AND COOLING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Indoor ductless fan & coil units.

1.2 RELATED REQUIREMENTS

- A. Section 22 1005 - Plumbing Piping: Indoor coil condensate drain.
- B. Section 26 0519 – Line-Voltage Electrical Power Conductors and Cables: Electrical characteristics and wiring connections and installation and wiring of thermostats and other controls components.

1.3 REFERENCE STANDARDS

- A. AHRI 210/240 - Standard for Performance Rating of Unitary Air Conditioning and Air-Source Heat Pump Equipment; Air-Conditioning, Heating, and Refrigeration Institute; 2008.
- B. AHRI 270 - Sound Rating of Outdoor Unitary Equipment; Air-Conditioning, Heating, and Refrigeration Institute; 2008.
- C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2010 (ANSI/ASHRAE Std 15).
- D. NEMA MG 1 - Motors and Generators; National Electrical Manufacturers Association; 2009, Revision 1 - 2010.
- E. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association; 2009.
- F. UL 207 - Refrigerant-Containing Components and Accessories, Nonelectrical; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. See Section 01 3300 – for submittal procedures.
- B. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.
- C. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.
- D. Design Data: Indicate refrigerant pipe sizing.
- E. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.
- F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- G. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.
- H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Substitutions: See Section 01 2500.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Installer Qualifications: Company specializing in performing the work of this section with minimum 3 years of experience and approved by manufacturer.

1.6 WARRANTY

- A. See Section 01 7700 - Closeout Procedures, for additional warranty requirements.

- B. Provide five year manufacturer's warranty for compressors.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Mitsubishi: www.mitsubish.com.
- B. Sanyo: www.sanyo.com.
- C. Daikin: www.dainkin.com.
- D. LG: www.lg.com.
- E. Substitutions: See Section 01 2500

2.2 SYSTEM DESIGN

- A. Split-System Heating and Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
 - 1. Heating and Cooling: Air-source electric heat pump located in outdoor unit with evaporator.
 - 2. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.
- B. Performance Requirements: See Drawings for additional requirements.
 - 1. Efficiency:
 - a. Seasonal Energy Efficiency Ratio: 10.0, minimum.
 - b. Energy Efficiency Ratio: 12.
 - c. Heating Seasonal Performance Factor: 6.8, minimum.

2.3 INDOOR UNITS FOR DUCTLESS SYSTEMS

- A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, evaporator coil, and wall mounted controls; wired for single power connection with control transformer.
 - 1. Location: Ceiling or wall.
 - 2. Power: Run from outdoor unit.
 - 3. Cabinet: Galvanized steel.
 - a. Finish: White.
 - 4. Fan: Line-flow fan direct driven by a single motor.
 - 5. Filter return air with washable, antioxidant pre-filter and a pleated anti-allergy enzyme filter.
- B. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
 - 1. Construction and Ratings: In accordance with AHRI 210/240 and UL listed.
 - 2. Manufacturer: System manufacturer.
- C. Remote: Wall mounted controller/thermostat.

2.4 OUTDOOR UNITS

- A. Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.
 - 1. Comply with AHRI 210.
 - 2. Refrigerant: R-410A.
 - 3. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
 - 4. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23 and UL listed.
 - 5. Sound Rating: 69 dBA, when measured in accordance with AHRI 270.
- B. Compressor: AHRI 520; hermetic, two speed 1800 and 3600 rpm, resiliently mounted integral with condenser, with positive lubrication, crankcase heater, high pressure control, motor overload protection, service valves and drier. Provide time delay control to prevent short cycling and rapid speed changes.
- C. Air Cooled Condenser: ARI 520; Aluminum fin and copper tube coil, with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
 - 1. Condenser Fans: Direct-drive propeller type.
 - 2. Condenser Fan Motor: Enclosed, 1-phase type, permanently lubricated.
- D. Coil: Air-cooled, aluminum fins bonded to copper tubes.

- E. Accessories: Filter drier, high pressure switch (manual reset), low pressure switch (automatic reset), service valves and gage ports, thermometer well (in liquid line).
 - 1. Provide thermostatic expansion valves.
 - 2. Provide heat pump reversing valves.
- F. Operating Controls:
 - 1. Control by room thermostat to maintain room temperature setting.
 - 2. Low Ambient Kit: Provide refrigerant pressure switch to cycle condenser fan on when condenser refrigerant pressure is above 285 psig (1965 kPa) and off when pressure drops below 140 psig (965 kPa) for operation to 0 degrees F (-18 degrees C).
- G. Mounting Pad: Roof mounted curb to maintain units 12 inches above roofing. Cover curb with roofing material and maintain roof integrity.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.
- B. Verify that proper power supply is available and in correct location.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions and requirements of local authorities having jurisdiction.
- B. Install in accordance with NFPA 90A and NFPA 90B.
- C. Install refrigeration systems in accordance with ASHRAE Std 15.

END OF SECTION 23 8127

END OF DIVISION 23