

DIVISION 23 SPECIFICATION

SECTION 23 0000	GENERAL PROVISIONS
SECTION 23 0500	BASIC MATERIALS AND METHODS
SECTION 23 0510	PIPE AND PIPE FITTINGS
SECTION 23 0523	VALVES
SECTION 23 0529	SUPPORTS AND ANCHORS
SECTION 23 0548	MECHANICAL EQUIPMENT, SOUND, SEISMIC AND VIBRATION ISOLATION
SECTION 23 0593	TESTING, ADJUSTING, AND BALANCING
SECTION 23 0700	MECHANICAL INSULATION
SECTION 23 0923	DIRECT DIGITAL CONTROL SYSTEM
SECTION 23 3300	AIR DISTRIBUTION
SECTION 23 7000	HVAC

## 1 GENERAL

- 1.01 GENERAL REQUIREMENTS: Drawings and general provisions of the Contract, including General and other conditions and Owner - General Requirements Sections apply for the work specified in this Section.
- 1.02 SCOPE OF WORK: The work covered by this Specification shall include furnishing all labor, materials, equipment and services to construct and install the complete mechanical system as shown on the Drawings and specified herein. Verify all conditions on the job site and lay out work accordingly.
- 1.03 RELATED WORK:
- A. The General Provisions apply to this Division, including but not limited to:
1. Drawings and Specifications.
  2. Contract Modifications, addendums, and change orders.
- B. Owner's General Requirements, applies to this Division, including but not limited to:
1. Summary of Work.
  2. Coordination. In addition, it shall be the responsibility of each trade performing work specified under Division 23 to coordinate with all others for proper and adequate installation clearance.
  3. Cutting and Patching. The cost of cutting and patching required work of Division 23 and not shown in other Divisions of Work shall be included in the cost of Division 23.
  4. Shop Drawings, Product Data and Samples.
  5. Temporary Facilities and Controls.
  6. Material and Equipment.
  7. Substitutions and Product Options.
  8. Contract Closeout:
    - a. Project Record Documents. Keep up to date marked up Drawings on site.
    - b. Operations and Maintenance Data.
    - c. Start-up.

- C. Related work provided in Divisions 2 through 14:
  - 1. Pipe chases and formed concrete work except as specified hereunder.
  - 2. Framed openings in masonry, concrete, wood, and other architectural and structural elements.
  - 3. Wood grounds and nailing strips in masonry and concrete.
  - 4. Installation only of access panels in ceilings, walls, etc. Provide access panels as part of mechanical work.
  - 5. Painting except as specified hereunder.
  - 6. Curbs and roof flashings for openings through roofs, except for roof drain and vent pipe flashing.
  
- D. Related Work provided in Division 26 and 28:
  - 1. Motor disconnect switches and installation except as specified herein.
  - 2. Motor starters and installation except as herein specified.
  - 3. Power wiring except as specified herein.

#### 1.04 QUALITY ASSURANCE:

- A. Regulatory Requirements:
  - 1. All work, installations, materials, and equipment shall comply with the provision of the following codes, standards, and regulations, except where more stringent requirements are shown or specified:
    - a. State of Oregon International Mechanical Code. (IMC)
    - b. State of Oregon Plumbing Specialty Code. (UPC)
    - c. State of Oregon Structural Specialty Code. (IBC)
    - d. National Electrical Code. (NEC)
    - e. National Fire Protection Agency. (NFPA)
    - f. All City, County, State and Federal applicable laws and regulations.
    - g. Regulations and standards set forth by ASME, ASHRAE, SMACNA, AGA and ARI.
  - 2. Should there be any direct conflict between Codes and the Drawings and Specifications, the Codes, rules, and regulations shall govern.
  - 3. Where two or more codes or regulations apply, the more stringent of the two shall be exercised.

4. Should the Documents indicate a condition, which will conflict with the Codes, the Contractor shall inform the Owner's Representative and refrain from installing that portion until resolved. Any work installed in violation of the Codes will be removed and correctly installed as part of the Contract work.
  5. If the Drawings and Specifications indicate a higher quality than code, the Drawings and Specifications shall govern.
  6. Electrical products shall bear the U.L. label.
- B. The entire mechanical system shall operate correctly at full capacity without objectionable noise, vibration or decrease of efficiency.
- C. Materials and Equipments:
1. Equipment furnished shall meet all requirements of the Drawings and Specifications and be suitable for the installation. Equipment not meeting all requirements will not be acceptable.
  2. Where two or more units of the same class of equipment are furnished, use products of the same manufacturer.
  3. Furnish all materials and equipment, new and of size, type and quality herein specified.
- D. Workmanship:
1. Follow manufacturers' instructions. If they are in conflict with the Drawings and Specifications, obtain clarification from the Engineer prior to beginning the work.
- E. Cutting and Patching:
1. Provide for cutting, patching, and repairing for the installation of the work specified, including masonry work, concrete work, carpentry work and painting. Work shall be performed by skilled craftsmen of the respective trade.

#### 1.05 DRAWINGS:

- A. The Drawings and Specifications are complementary and what is called for by one shall be as if called for by both. All items shown on the Drawings are not necessarily included in the Specifications. All directives and instructions to furnish, provide, install, complete and test described in the design documents shall be interpreted as directives unless clearly specified otherwise.
- B. Bring obscure or questionable items to the attention of the Owner's Representative prior to bid date. Necessary directions and explanations will be given by the Owner's Representative in Addendum Form.

- C. Should the Documents indicate a condition which will conflict with the Governing Codes and Regulations, the Contractor shall refrain from installing that portion of the work until receiving verification from the Owner's Representative. Should rearrangement or rerouting of duct or piping be necessary, provide for approval the simplest layout possible for that particular portion of the work. Any work installed in violation of the Governing Codes will be removed and correctly installed by the Contractor as part of the Contract work.
- D. Drawings are diagrammatic. They do not show every offset, bend, tee, or elbow which may be required to install work in the space provided. Do not scale drawings for roughing-in measurements, nor use as shop drawings. Make field measurements and prepare shop drawings as required. Coordinate work with shop drawings of other trades. Provide any bends, offsets and elbows where required by local conditions from measurements taken at the Building (subject to approval) and without additional cost to the Project. The right is reserved to make any reasonable changes in outlet location prior to rough-in.
- E. It is the intent of these specifications that the field wiring of all systems provided and modified under this contract shall be complete and operable. Refer to all drawings and specifications, especially the electrical drawings, to determine voltage, phase, circuit ampacity and number of connections indicated. Bring to the attention of the Engineer all conflicts, incompatibilities, and discrepancies prior to bid.
- F. Where equipment is shown, dimensions have been taken from typical equipment of the class indicated. Carefully check the Drawings to see that the equipment under consideration for installation will fit the space provided and that all connections may be made thereto without impairment of space and height requirements and of Code required clearances. Contractor is responsible for all changes required by equipment dimensions different than those shown.
- G. Where equipment manufacturer and model number are listed it is the most recent and/or desired to describe function and quality of equipment to be supplied and installed. Since manufacturers may change model numbers without notification, should the model specified be unavailable, furnish and install the model number that is equal to or better than the one listed.
- H. The location of all utilities, wires, conduits, pipes, duct, or other service facilities are shown in a general way only on the Drawings and are taken from existing public records. Ascertain whether any additional facilities other than those shown on the plans may be present and determine the exact location and elevations of all utilities prior to commencing installation.
- I. Prior to bid, contact the local utility companies to verify requirements. Provide all material and labor by utilities.
- J. The Contractor, before submitting a Bid on the work, must visit the site to become familiar with all visible existing conditions. As a result of having visited the premises, the Contractor shall be responsible for the installation of the work as it relates to such visible existing conditions. The submission of the bid will be considered an acknowledgement of the part of the Bidder of visitation to the site.
- K. The Contractor is responsible to apply for and obtain all necessary permits, fees and inspections required by any public authority having jurisdiction. Refer to General Conditions for additional information.

## 1.06 SUBSTITUTION AND PRODUCT OPTIONS:

- A. The use of manufacturer's names, models and numbers in the Drawings and Specifications is intended to establish style, quality, appearance, and usefulness. The model numbers listed are the last available to the designer, if no longer current, substitute equipment equal to or better than that represented by the model number listed. Items noted "or equivalent" will require prior acceptance.
- B. Submit for the Owner's Representative's review, manufacturer's detailed specifications and data sheets for all proposed substitutions. Submittals shall consist of a single sheet, or specific data need for consideration of approval. All pertinent data listed in the Specifications and on the Drawings shall be furnished, including all special features. See that all submittals are in proper order, and that all equipment will fit the space provided.
- C. All requests for approval of substitutions for materials other than those specified must be submitted in accordance with Instruction to Bidder.
- D. Substitution products from approved manufacturers do not need prior approval. Ensure substitutions meet all requirements of the Specifications.
- E. All changes required due to product substitutions are the responsibility of the Contractor.

## 1.07 PROJECT RECORD DRAWINGS:

- A. Obtain drawings from Engineer.
- B. Keep Drawings clean, undamaged, and up to date.
- C. Record and accurately indicate the following:
  - 1. Depths, sizes, and locations of all buried and concealed piping.
  - 2. Locations of all clean-outs.
  - 3. Changes, additions, and revisions due to contract modifications.
  - 4. Locations of tracer wire terminal points.
- D. Drawings to be available for Engineer review.
- E. Submit as a part of Project Closeout Documents

## 1.08 PROJECT CONDITIONS:

- A. Existing Conditions: Prior to bidding, verify and become familiar with all existing conditions by visiting the site and include all factors which may affect the execution of this work. Include all related costs in the initial bid proposal.

- B. Coordinate exact requirements governed by actual job conditions. Check all information and report all discrepancies before fabrication work. Report changes in the time to avoid unnecessary work. Make changes as directed by Owner's Representative.

1.09 CONTRACT MODIFICATIONS:

- A. In addition to the requirements of the General provisions, all supplemental cost proposals for this Division of work shall be accompanied by a complete itemized breakdown of labor and materials for each item. No exceptions will be made. Contractor's estimating sheets for supplemental cost proposals shall be made available upon request. Labor must be separated and allocated to each item of work. Changes or additions subject to additional compensation made without written authorization based on agreed price shall be at Contractor's own risk and expense.

1.10 STORAGE AND HANDLING:

- A. Delivery: Deliver to project site with manufacturer's labels intact and legible.
- B. Handling: Avoid damage.
- C. Storage: Store material inside, protected from weather, dirt and construction dust. Where necessary to store outside, elevate well above grade and enclose with durable, waterproof wrapping.

1.11 WARRANTY:

- A. Provide a written guaranty covering the work of this Division for a period of one calendar year from the date of acceptance of the entire project as required by the General Provisions.
- B. Provide manufacturer's written warranties for material and equipment furnished under this Division insuring parts and labor for a period of one year from the date of acceptance of the entire project.
- C. Correct warranty items promptly upon notification.

1.12 OPERATIONS AND MAINTENANCE DATA:

- A. Prior to final inspection, provide three (3) copies of manufacturer's maintenance manuals for each piece of equipment or items requiring service. Manual shall include manufacturer's operation and maintenance instruction manuals and parts list for each piece of equipment or item requiring servicing. Include in the manual manufacturer's service data, wiring diagrams and parts lists for all major items of equipment, valve charts, balancing data, final control diagrams showing final set points and any additional equipment added by contract modification. Comply with provisions of Section 01700 where applicable.
- B. Submit bound in 8-1/2 x 11 inch text pages, three ring binders with durable plastic covers.

- C. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS", title of project, and subject matter of binder when multiple binders are required.
- D. Internally subdivide the binder contents with permanent page dividers, logically organized with tab titling clearly printed under reinforced laminated plastic table.

#### 1.13 SUBMITTALS:

- A. Shop Drawings: The Contract Drawings indicate the general layout of the piping, ductwork, and various items of equipment. Prepare and submit for review Shop Drawings of all installation not detailed on the Contract Drawings and all changes to the Contract Drawings.
- B. Product Data:
  - 1. Submit for review manufacturer's detailed shop drawings, specifications and stat sheets for all equipment to be furnished, as well as any wiring diagram showing field installed wiring and devices. Arrangement of mechanical equipment has been based on items of specific manufacturer intended as somewhat typical of several makes, which may be approved.
  - 2. Indicate construction, capacities, accessories, etc. Manufacturer's abbreviations or codes are not acceptable.
  - 3. List the name of the motor manufacturer for each piece of equipment.
- C. Submission Requirements:
  - 1. Shop Drawings and Product Data:
    - a. Submit all equipment and product data for Work of Division 23 together in a group in a 3-ring loose-leaf binder, with each item field under a tab, and labeled with its respective specification section number, article and paragraph, and mark if applicable.
    - b. Include a complete index in the original submittal. Indicate both original items submitted and note stragglers that will be submitted at a later date to avoid delay in submitting.
    - c. Additional product data submitted after return of the original binder shall include a tab similar to the originally submitted. Upon receipt of the return submittal, insert them in the previously submitted binder.
    - d. Refer to Owner General Provisions for number of shop drawing copies to be submitted.
  - 2. Sample: Submit samples required by each Section of Division 23 at the same time that shop drawings and product data are submitted.
- D. It shall be the Contractor's responsibility to:
  - 1. See that all submittals are in proper order.

2. Ensure that all equipment will fit in the space provided. Assure that all deviation from Drawings and Specification are specifically noted and called to the attention of the Engineer/Contracting Officer in the submittals. Failure to comply will void approval automatically.
3. Deviation, discrepancies, and conflicts between the submittals and the contract documents discovered prior to or after the review process shall not relieve the Contractor of this responsibility to comply with the contract documents.

E. Electronic Submission Requirements:

1. Shop Drawings and Product Data:

- a. Submit all equipment and product data for Work of Division 23 together in a group in a single PDF format file, with each item filed behind a cover sheet, and labeled with its respective specification section number, article and paragraph, and mark if applicable.
- b. Include a complete index in the original submittal. Indicate both original items submitted and note stragglers that will be submitted at a later date to avoid delay in submitting.
- c. Additional product data submitted after return of the original file shall include a cover sheet similar to that originally submitted. Upon receipt of the return submittal, insert them in the previously submitted electronic file.
- d. Submission of overall line or general catalog data will not be accepted, submittals must be tailored to specific model being submitted on.
- e. Indication of unit, model, features, etc being submitted must be marked by bold arrow, bold circle or other clear means that will reproduce in black and white. Use of highlights, colored text or other colored indicators cannot be used.
- f. Electronic submissions review and comment will be in electronic PDF format only. Submission in an electronic format will be considered acceptance of this review process and format.
- g. Refer to Owner's General Provisions for number of shop drawing copies to be submitted.

1.14 START-UP:

- A. Coordinate schedule for start-up of various equipment and systems.
- B. Notify Owner's Representative seven days prior to start-up of each item.
- C. Verify that each piece of equipment of system has been checked prior to start-up for proper lubrication, drive rotation, belt tension, control sequence, or other conditions, which may cause damage.

- D. Verify that tests, meter readings and specified electrical characteristics agree with those required by the equipment or system manufacturer.
  - E. Verify that wiring and support components for equipment are completed and tested.
  - F. Execute start-up under supervision of responsible manufacturer's representative or Contractor's personnel in accordance with manufacturer's instructions.
- 1.15 FEES, PERMITS AND INSPECTIONS: The Contractor is responsible to apply for and obtain all necessary permits, fees and inspections required by any public authority having jurisdiction. Refer to General Conditions for additional information.
- 1.16 DEFINITIONS:
- A. "Furnish: Means to supply and deliver to the project site, ready for unloading, unpacking, assembly, installation and similar operations.
  - B. "Install": Describes operations at project site including actual unloading, temporary storage, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning and similar operations.
  - C. "Provide": Means to furnish and Install, complete and ready for intended use.

## 2 PRODUCTS

### 2.01 MATERIAL:

- A. All materials and products used for construction shall be new, of the best grade, and latest products as listed in printed catalog data. All articles of a kind shall be the standard product of a single manufacturer. Trade names and manufacturers names denote a character and quality of equipment desired and shall no be construed as limiting competition.
- B. Asbestos: Do not use products made of or containing asbestos.

### 2.02 QUALITY ASSURANCE:

- A. Refer to Section 01640 Material and Equipment for information regarding available alternatives to materials and equipment specified herein. Product listings are for informational purposes only and establish a general standard of quality.
- B. Provide products which are compatible with other portions of the work and provide products with the proper and correct power and fuel burner characteristics and similar adaptations for the project.

### 2.03 INSPECTION:

- A. All work and materials are subject to field observation at any and all times by the Owner's Representative.

- B. The Contractor shall notify the Owner's Representative a minimum of two days prior to testing any piping system which must be witnessed and accepted before it is covered up or enclosed.
- C. If an observer finds any material or work not conforming to these Specifications, within three days after being notified, remove the materials from the premises and replace with approved materials. If the material has been installed, the entire expense of removing and replacing shall be borne of the Contractor.

### 3 EXECUTION

#### 3.01 EQUIPMENT PROTECTION:

- A. Keep pipe, ductwork and conduit openings closed by means of plugs or caps to prevent the entrance of foreign matter. Protect piping, conduit, ductwork, fixtures, equipment, and apparatus against dirty water, chemical or mechanical damage both before and after installation. Restore damaged or contaminated fixtures, equipment or apparatus to original conditions or replace at no cost to the Owner.
- B. Protect bright finished shafts, bearing housings, and similar items until in service. No rust will be permitted.
- C. Cover or otherwise suitably protect equipment and materials stored on the job site.

#### 3.02 CLEANING:

- A. General: Clean mechanical and plumbing equipment, fixtures, piping and ductwork of stampings and markings (except those required by codes), iron cuttings, and other refuse.
- B. Painted Surfaces: Clean scratched or marred painted surfaces of rust or other foreign mater and paint with matching color industrial enamel, except as otherwise noted.
- C. Before operating any equipment or systems, make thorough check to determine that systems have been flushed and cleaned as required and equipment has been properly installed, lubricated, and serviced. Check factory instructions to see that installations have been made accordingly and that recommended lubricants have been used.
- D. Use particular care in lubricating bearings to avoid damage by over-lubrication and blowing out seals. Check equipment for damage that may have occurred during shipment, after delivery or during installation. Repair damaged equipment as approved or replace with new equipment.

#### 3.03 LAYOUT AND COORDINATION:

- A. Site Examination: Before starting work, carefully examine site and all contract Drawings so as to become thoroughly familiar with conditions governing work on this project. Verify all indicated elevations, building measurements, roughing-in dimensions, and equipment locations before proceeding with any of the work.

- B. The existence of any wires, conduits, pipes, ducts or other service facilities are shown in a general way only. It will be the duty of the Contractor to visit the site and make exact determination of the existence of any such facilities prior to submitting a bid. It is understood that the Contractor will be responsible for making the exact determination of the location and condition of these facilities.
- C. The location of all utilities indicated on the plans is taken from existing public records. The exact location and elevation of all public utilities must be determined by the Contractor. It shall be the duty of the Contractor to ascertain whether any additional facilities other than those shown may be present.
- D. Sleeves, Insets, Cast-in-Place Work: provide sleeves, inserts, anchoring devices, cast-in-place work, etc. which must be set in concrete sequenced at the proper time for the project schedule.
- E. Coordination:
  - 1. Where the work must be sequenced and positioned with precision in order to fit into the available space, prepare accurate scale shop drawings showing the actual physical dimensions required for the installation and submit prior to purchase-fabrication-installation of any of the elements involved in the coordination.
  - 2. Cooperate with other trades in furnishing material and information for sleeves, bucks, chases, mountings, backing, foundations, and wiring required for installation of mechanical items.
  - 3. Coordinate all work with other trades and determine in advance where interfacing of the mechanical work and other work are required to be connected together. Provide all materials and equipment to make those connections. Submit shop drawings showing required connections where special conditions exist.
- F. Discrepancies: Report immediately any error, conflict or discrepancy in Plans, Specifications and/or existing conditions. Do not proceed with any questionable items of work until clarification of same has been made. Should rearrangement or re-routing of ducts or piping be necessary, provide for approval the simplest layout possible for that particular portion of the work.

#### 3.04 TEMPORARY FACILITIES AND CONTROLS:

- A. Comply with Owner's requirements.
- B. Permanent mechanical systems' equipment utilized for temporary heating, ventilating, and cooling shall be started with all controls and safeties installed and operational. Start-up shall be done by a factory approved mechanic only.
- C. Owner's warranties shall not be abridged by Contractor's use of the permanent systems' equipment prior to final acceptance. Warranty period shall begin at final completion.

#### 3.05 MECHANICAL WORK CLOSEOUT:

- A. General: Refer to the Owner's General Provision sections for general closeout requirements. Calibrate all equipment requiring same.

- B. Record Drawings: Submit record set of drawings required in Owner's General Provisions, Submittals and as previously specified in this Section.
- C. Closeout Equipment/Systems Operations: Sequence operations properly so that work of project will not be damaged or endangered. Coordinate with seasonal requirements. Operate each item of equipment and each system in a test run of appropriate duration with the Engineer present, and with the Owner's operating personnel present, to demonstrate sustained, satisfactory performance. Adjust and correct operations as required for proper performance. Clean and lubricate each system, and replace dirty filters, excessively worn parts and similar expendable items of the work.
- D. Operation and Instruction: Provide eight (8) hours of on-site training to Owner's personnel on all mechanical systems and equipment. Training shall include maintenance, lubrication, troubleshooting and repair. Contractor shall provide necessary written manuals and training aides explaining operational diagrams, emergency and alarm provisions, sequencing requirements, seasonal provisions, security, safety, and similar features of the installed system. Three (3) copies of written manuals shall be left with Owner at end of training.

END OF SECTION

## 1 GENERAL

## 1.01 SECTION INCLUDES:

- A. Items common to more than one section of Division 23 and general construction procedures and products. Work described in this Section applies to all Sections of Division 23.

## 1.02 STORAGE AND HANDLING:

- A. Deliver materials to the project site with manufacturer's labels intact and legible. Handle materials with care to avoid damage. Store materials inside protected from weather, dirt and construction dust. Where necessary to store outside, elevate well above grade and enclose with durable, waterproof wrapping. Label equipment as soon as it arrives at job site.

## 1.03 SUBMITTALS:

- A. Submit product data under provisions of Section 23 0000 and Division 1.
- B. Provide submittals for:
  - 1. Motors.
  - 2. Starters.
  - 3. Alarm Panels.
  - 4. Pipe sleeves
  - 5. Escutcheons.
  - 6. Piping and Equipment Identification.
  - 7. Valve Schedule.
  - 8. Variable Frequency Drives

## 2 PRODUCTS

## 2.01 QUALITY ASSURANCE:

- A. Refer to Owner's Division 1 Material and Equipment for information regarding available alternatives to materials and equipment specified herein. Product listings are for informational purposes only and establish a general standard of quality.
- B. Provide products which are compatible with other portions of the work and provide products with the proper and correct power and fuel burner characteristics and similar adaptations for the project.

## 2.02 MATERIALS:

- A. All materials and products used for construction shall be new, of the best grade, and the latest products as listed in printed catalog data.
- B. All articles of a kind shall be the standard product of a single manufacturer.
- C. Provide products which are compatible with other portions of the work and products which have the proper electrical power and fuel-burning characteristics for this project.
- D. Trade names and manufacturers names denote the character and quality of equipment desired and shall not be construed as limiting competition.

## 2.03 ELECTRIC MOTORS:

- A. Enclosure Type: Open drip-proof for normal concealed indoor use, guarded where exposed to employees or occupants. Type II for outdoor use, except weather-protected Type I where adequately housed.
- B. Bearings: Ball or roller bearings, and design for thrust where applicable; permanent or pressure lubricated anti-friction. Sleeve-type bearings permitted only where indicated for light-duty fractional horsepower motors.
- C. Construction: General purpose, continuous duty; NEMA design "B", except "C" for high starting torque applications.
- D. Frames: For single phase motor sizes NEMA No. 48, except 56 for heavy-duty applications. NEMA "T" frames for 1 horsepower and larger polyphase motors.
- E. Phases and Current: 1/3 horsepower and smaller capacitor-start single-phase; 1/2 horsepower and larger, squirrel-cage induction polyphase. Coordinate with actual current characteristics; specified in Division 26 and do not use 230/460 voltage motors on 208 voltage power or vice versa.
- F. Service Factor: 1.35 for single-phase; 1.15 for polyphase.
- G. Overload Protection: Built-in thermal with internal sensing device for stopping motor, and for signaling where indicated on single phase motors.
- H. Speed: Not faster than synchronous speeds of 1800 RPM except where otherwise indicated.
- I. Temperature Rating: Class B insulation, except where otherwise indicated or required for service indicated.
- J. Starting Capability: As required for service indicated, but not less than 5 starts per hour.
- K. Efficiency: The manufacturer's highest efficiency motors tested under procedures recommended by NEMA Premium (IEEE Standard 112, Test Method B). Minimum 84% efficiency at 3 HP increasing to 90% above 15 HP. Submit manufacturer's data if motor nameplate does not indicate minimum efficiency.

- L. Manufacturers: Century, General Electric, Lincoln, Louis Allis, Baldor, Wagner, Westinghouse, or accepted substitute. Where selection of motor manufacturer is within Contractor's control (independent of mechanical equipment selection), provide motors produced by a single manufacturer.
- M. VFD duty: Provide inverter type with shaft grounding rings.

#### 2.04 STARTERS AND SWITCHES:

- A. General: Provide each motor with starter or switch as approved and recommended by manufacturer of motor or equipment of which motor is a part.
- B. Magnetic Starters: Provide for ½ horsepower and larger motors, and for smaller motors on automatic control or with interlock switch. Include pilot lights, reset, trip-free relay on each phase, Hand-Off-Auto switch in cover, and devices for coordination with control system (including transformer for control circuit, verify holding coil voltage requirements with control system design). Provide automatic ambient temperature compensation for starter heaters.
- C. Manual Switches: Provide on motors 1/3 horsepower and smaller except where automatic control or interlock is indicated. Include pilot light. Provide overload protection where not protected by panel board circuit breaker or fused disconnect switch.
- D. Starter Characteristics: Type I general purpose enclosure with padlock ears and mounting supports. Starter type and size as recommended by motor manufacturer.
- E. Manufacturers: General Electric, ITE, Allen Bradley, Cutler-Hammer, Square D or accepted substitute.

#### 2.05 ELECTRICAL EQUIPMENT:

- A. Equipment Wiring: Interconnecting wiring within or on a piece of mechanical equipment shall be provided with the equipment unless required otherwise. Provide all necessary field wiring and devices from the point of connection indicated on the electrical drawings to each equipment item.
- B. Control Wiring: All control wiring for mechanical equipment shall be provided under Section 23 0923 or 23 0933, Controls, and Instrumentation.
- C. Codes: All electrical equipment and products shall bear the U.L. and/or C.S.A. label as required by governing codes and ordinances. Refer to paragraph 1.3, Quality Assurance for definition of testing agency certification requirements.

#### 2.06 DRIVES:

- A. General: "V" section belt drives, multiple as required, sized on 1.5 times installed motor horsepower. Provide variable pitch motor sheaves on all one or two belt drives and standard slide rails or approved means of adjustment for each motor with belt drive. Use standard section belts and no sheave smaller than cataloged industry standard; provide countersunk center on shaft ends to receive speed counter tip.
- B. Manufacturers: Dayton, Gates, Browning, or accepted substitute.

## 2.07 MACHINERY GUARDS:

- A. Furnish guards for protection on all rotating and moving parts of equipment. Provide guards for all metal fan drives and motor pulleys, regardless of being enclosed in a metal cabinet.
- B. Design guards so as not to restrict air flow at fan inlets resulting in reduced capacity.
- C. Provide 2-1/2 inches diameter access opening holes in guards for easy use of tachometers at pulley centers. Guards shall be easily removable for pulley adjustment or removal and changing of belts.
- D. All guards shall meet OSHA requirements including back plates.

## 2.08 ACCESS PANELS:

- A. Access panels shall have same fire rating as surface where mounted.
- B. Provide flush key cylinder locks on all access panels less than 8 feet above the floor in public spaces. Turn keys over to Owner at project completion. Screwdriver latches on all others.
- C. Steel, 24" x 24" or as required. Complete with steel frame, hinged locating door, and prime coat finish. Type to match building construction.
- D. Manufacturers: INRYCO/MILCOR Style DW, K or M panels as required by construction. Bilco, Potter-Roemer or accepted substitute.

## 2.09 PIPE SLEEVES:

- A. Interior Wall Sleeves: 12 gage galvanized steel, flush with wall on both sides.
- B. Interior Floor Sleeves: 12 gage galvanized steel and extend 2-inches above finished floor.
- C. Exterior Wall Sleeves: Cast iron, flush with wall on both sides.
- D. On Grade Floor Sleeves: Same as exterior wall sleeves.

## 2.10 ESCUTCHEONS:

- A. Brass material, chrome plated finish. Size sufficient to cover all pipe openings through wall, floor, or ceiling. Set screw or spring to secure to pipe.

## 2.11 UNIONS:

- A. Steel pipe union shall be 150-pound malleable iron, brass to iron seat, ground joint, black or galvanized to match pipe.
- B. Copper pipe union shall be 200 psig working pressure. Bronze body. Solder ends.

- C. Insulating unions shall be 250 psig working pressure. Pipe ends and material to match piping. Electric current below 1% of galvanic current. Gasket material as recommended by manufacturer. Epco or approved.

#### 2.12 ROOF FLASHING:

- A. Use flashing products specifically designed for and compatible with metal roofing system used.

#### 2.13 MISCELLANEOUS STEEL:

- A. Provide steel as required for adequate support of all mechanical equipment, angle or channel, I or H sections as required by application. Provide suitable base plates for stands and anchors for hanging equipment. Drill support holes only in flanges of structural center of length as possible. Apply on coat of black rust inhibitive enamel primer to shop fabricated items before delivery to job; other painting as specified herein. Provide shop drawings of supports especially constructed for this project. Burning of holes is not permitted.

#### 2.14 PAINTING:

- A. Apply one coat of black rustoleum primer to shop fabricated items before delivery to job. Other painting as specified herein.

#### 2.15 IDENTIFICATION MARKERS:

##### A. Pipe Markers:

1. Adhesive pipe markers of width, letter size and background color conforming to ANSI A13.1.
2. Acceptable Manufacturers: Brady B350 with banding tape. Seaton, Zeston, Porter or accepted substitute.

##### B. Nameplates:

1. Engraved nameplates, 1/16 inches thick, laminated 3-ply plastic, center ply white, outer ply black, letters formed by exposing center ply.
2. Size: 3 inches by 5 inches nameplates with 1/4-inch high letters.
3. Manufacturers: Lamicoid. Seaton, Brady, Zeston or accepted substitute.

##### C. Valve Tags:

1. 1-1/2 inches diameter, 18-gauge polished brass tags with 3/16-inch chain hole and 1/4 inch high stamped, black-filled service designation.
2. Manufacturers: Seaton Style 250-BL, Brady, Zeston or accepted substitute.

## D. Lettering and Graphics:

1. Coordinate names, abbreviations and other designations used in mechanical identification work with designations shown or scheduled. Provide numbers, lettering and wording as indicated for identification of mechanical systems and equipment.
2. Multiple Systems: Where multiple systems of same name are shown provide identification which indicates individual equipment number as well as service (examples: Chiller (CH) No. 1, Chiller (CH) No. 2, Air Conditioning Unit No. 1 (AC) No. 1, Air Conditioning Unit (AC) No. 2.)

## 2.16 VALVE SCHEDULES:

- A. Schedules: Valve schedule for each piping system, typewritten and reproduced on 8-1/2 by 11-inch paper. Indicate valve number, piping system, location of valve (room or space) and normal setting (open, closed, etc.). Mark valves which are intended for emergency shutoff and similar uses by special notation. In addition to mounted copies, furnish five (5) extra copies for maintenance manuals.

## 2.17 CONCRETE FOR MECHANICAL WORK:

- A. Provide strength classes per Building Code.

## 2.18 VARIABLE-FREQUENCY MOTOR CONTROLLERS:

- A. Acceptable Manufacturers: Allen Bradley, Robicon, ABB, Trane, Yasakawa, Siemens, Emerson Industrial Automation, or approved equal.
- B. General Description:
  1. AC motor variable frequency controller (VFC) shall be of pulse width modulated (PWM) inverter type. The VFC shall be designed to convert 60 Hz input power to adjustable frequency output power to provide positive speed control to standard induction motors. The VFC shall be dedicated variable torque design for specific use with centrifugal loads.
  2. Provide complete solid state variable frequency power and logic unit.
  3. Frequency control shall be stepless throughout the range under variable torque load on a continuous basis. Frequency controlled by remote building energy management systems providing 4-20MA input signal to drive and remote start/stop signal. Coordinate with other work of Division 23.
  4. Provide adjustable frequency control with diode bridge/capacity input designed to provide high, constant power factor of 0.95 regardless of load or speed and eliminate SCR line noise.
  5. Each VFD shall contribute no more than 5 percent total harmonic voltage distortion at the VFD input terminals while operating under full-load conditions. If proposed VFD equipment is anticipated to exceed these limits, multi-pulse converters and/or harmonic filtering devices shall be provided.

6. Equipment shall be designed and manufactured in accordance with applicable NEMA and IEEE recommendations and be designed for installation in accordance with NEC. Equipment shall have UL and/or CSA approval.
  7. Control shall be suitable for operation in ambient temperature of 0 to 40°C.
  8. Every VFD shall be factory tested with an AC induction motor 100 percent loaded and temperature cycles within an environmental chamber at 104°F.
- C. Self-Protection and Reliability Features:
1. Adjustable current limit from 60 to 110 percent of drive rating
  2. Adjustable instantaneous over current trip.
  3. Under voltage trip.
  4. Over temperature trip.
  5. Short circuit protection phase to phase and phase to ground faults phase rotation insensitive.
  6. Momentary power loss, more than 17 milliseconds.
  7. Transient protection against all normal transients and surges in incoming power line.
  8. Orderly shutdown in event of any above conditions, drive shall be designed to shut down safely without component failure.
  9. Provide visual indication and manual reset.
- D. Standard Features:
1. Drive logic shall be microprocessor based. Control logic shall be isolated from power circuitry.
  2. Standalone operation to facilitate startup and troubleshooting procedures.
  3. VFD shall have a lockable circuit breaker disconnect and be UL 508c listed for use on distribution systems with 22,000 AIC.
  4. Door interlock protection which shall be defeatable by qualified personnel to troubleshoot during operation as required.
  5. Input power 460V 60Hz, 3-phase output voltages shall be equal to applied input voltage.
  6. Isolated signal inputs.

7. Frequency Stability: Output frequency shall be held to +0.1 percent of maximum frequency regardless of load, +10 percent input voltage change or temperature changes within ambient specification.
8. Built-in digital display located in panel face shall indicate output frequency, voltage and current and shall provide indication of over current, over voltage, current limit, ground fault, over temperature, input power on, minimum or maximum speed adjustment, power on, and fault condition.
9. Start/Stop Control: Controlled decelerated stop.
10. Primary and secondary fused for a control circuit transformer.
11. Minimum and maximum speed control.
12. Adjustable Accel/Decel: Independently adjustable 10-100 second.
13. Hands-off auto switches.
14. Programmable auto restart after power outage.
15. Fused disconnects shall include auxiliary contacts to isolate control circuit when disconnect is in "off" position.
16. Remote contacts for fault, and on/off status.
17. Adjustable motor output voltage.
18. Analog output voltage of 0-10 VDC, 4-20MA proportional to control output frequency.
19. RS232 communications port, and programming software capability.

E. Additional Features:

1. NEMA 1 enclosure shall isolate each motor starter and control section with its associated disconnect switch.
2. Manual speed control for each motor.
3. Manual bypass shall provide ability to service control while motor is operational.
4. Provide radio frequency and electromagnetic interference noise suppression network to limit radio frequency and electromagnetic interference.
5. Provide isolated analog output signals for volts, amps, and frequency, from each VFD for connection to the building energy management system.
6. Provide line (input) reactors.
7. Provide output filters for all VFD's located more than 150 conductor feet from the motor they serve.

8. VFD shall be designed to catch a spinning load in forward and reverse direction.
9. Harmonic calculations shall be performed on a manufacturer-supplied harmonic analysis program for conformance with IEEE 519.

### 3 EXECUTION

#### 3.01 ACCESS PANELS:

- A. Furnish and install access panels required for mechanical work. Access panels shall have same fire ratings as surface where mounted. Furnish panels of adequate size for valves and equipment requiring service and installed above ceilings, behind walls or in furring, complete with correct frame for type of building construction involved. Exact size, number and location of access panels are not necessarily shown. Use no panel smaller than 12 inches by 12 inches for simple manual access or smaller than 16 inches by 20 inches where personnel must pass through. Paint with color and finish to match surrounding architectural features, where exposed.

#### 3.02 PIPE SLEEVES:

- A. Sleeves: Large enough in diameter to provide ¼-inch clearance around pipes or insulation. Caulk with watertight rated, UL listed foam-in-place barrier.
- B. Layout: Lay out work in advance of pouring of slabs or construction of wall and furnish and set inserts and sleeves necessary to complete the work.
- C. Coordination: Cutting or patching required as a result of lack of coordination of this operation shall be at no change in contract amount.

#### 3.03 FLOOR, WALL AND CEILING ESCUTCHEONS:

- A. Install on piping passing through finished walls, floors, ceilings, partitions, and plaster furrings. Escutcheons shall completely cover opening around pipe.
- B. Secure wall and ceiling escutcheons to pipe or structure.
- C. Escutcheons shall not penetrate insulation vapor barriers.
- D. Escutcheons not required in mechanical rooms or unfinished spaces.

#### 3.04 MECHANICAL EQUIPMENT WIRING:

- A. Provide all mechanical equipment motors, automatic temperature, limit, float and similar control devices required, with wiring complete from power source indicated on Electrical Drawings.
- B. Provide properly rated motor overload and under voltage protection and all manual or automatic motor operating devices for all mechanical equipment.

- C. Equipment and systems shown on the Drawings and/or specified, are based upon requirements of specific manufacturers which are intended as somewhat typical of several makes which may be approved. Provide all field wiring and/or devices necessary for a complete and operable system including controls for the actual selected equipment/system.
- D. Provide all starters for mechanical motors. Review Electrical Specifications and Drawings to determine which mechanical motor starters will be provided under the Electrical Specification Sections and provide all others.

### 3.05 PAINTING:

- A. General: Coordinate painting of mechanical equipment and items with products and methods specified under Section 09900, Painting.
- B. Painting Materials: material shall comply with Section 09900, Painting.
- C. Uninsulated Piping: Paint black or galvanized uninsulated piping located buried in ground, in concrete or masonry one (1) coat acid-resisting black paint. Paint black or galvanized uninsulated piping in moist equipment rooms, crawl spaces without vapor barriers or exposed to weather one (1) coat black asphaltum varnish.
- D. Iron Work: Paint hangers, rods, anchors, guides, threads of galvanized pipe, bases, supports, uncoated sheet metal and other iron work without factory finish, exposed to weather, located in moist concealed spaces and moist equipment rooms one coat acid-resisting black paint. Apply one (1) coat Dixon's Aluminum Graphite No. 209 paint over the (1) coat primer as recommended by paint manufacturer to all hot metal surfaces.
- E. Sheet Metal: Apply one coat of zinc chromate to mechanical sheet metal exposed to weather, except no painting required on aluminum or stainless steel. Apply one coat of flat black paint to the inside of unlined ducts behind all grilles and registers.
- F. Insulated Piping and Other Insulated Surfaces: Paint insulated piping in half-round, split tile, or other inaccessible locations, one (1) coat asphalt emulsion.

### 3.06 MECHANICAL SYSTEM IDENTIFICATION:

- A. Piping System: Indicate each pipe system by its generic name (abbreviated) as shown; except vent and drainage piping. Comply with ANSI A13.1 for marker locations, letter sizes, and colors. Include arrows to show direction of flow and "Electric Traced" signs to identify heat cable wrapped piping.
- B. Valve Identification: Tag all valves with brass disc and chain. Prepare valve charts indicating valve number, size, location, function and normal position. Use no duplicate numbers in Plumbing and Heating systems. Mount glazed frames containing one set of valve charts in the building as directed.
- C. Each new piece of equipment shall bear a permanently attached identification plate, listing the manufacturer's name, capacities, sizes and characteristics. In addition to the manufacturer's identification plate, provide nameplates of black phenolic resin laminate and identify new equipment by name and number 1/2" high letters.

- D. Mount valve schedule(s) as directed by Owner.

3.07 ACCESSIBILITY:

- A. Locate valves, thermometers, cleanout fittings and other indicating equipment or specialties requiring frequent reading, adjustments, inspection, repairs and removal or replacement conveniently and accessibly with reference to the finished building.
- B. Thermometers and Gages: Install thermometers and gages so as to be easily read from the floors, platforms and walkways.

3.08 INSTALLATION:

- A. Locating and Positioning Equipment: Comply with all Codes, Regulations and observe good common practice in locating and installing mechanical equipment and material so that completed installation presents the least possible hazard. Maintain adequate clearances for repair, service and operation to all equipment and comply with Code requirements. Set all equipment level or as recommended by manufacturer.
- B. Arrangement: Arrange ductwork and piping parallel with primary lines of the building construction, and with a minimum of 7' overhead clearance in all areas where possible. Conceal all piping and ductwork. Locate operating and control equipment properly to provide easy access. Give right-of-way to piping which must slope for drainage. Set all equipment level as recommended by manufacturer. Under no conditions shall beams, girders, footings or columns be cut for mechanical items. Casting of pipes into concrete is prohibited unless so shown on Drawings.
- C. Anchorage: Anchor and/or brace all mechanical equipment, piping, and ductwork to resist displacement due to seismic action, include snubbers on equipment mounted on spring isolators.
- D. Drip Pans: Provide drip pans under all above ceiling in-line pumps and cooling coils. Locate pan immediately below piping and equipment and extend a minimum of 6 inches on each side and lengthwise 18 inches beyond equipment being protected. Fabricate pans 2 inches deep, or reinforced sheet metal (20 gauge copper, or 16 gauge steel with 2 ounces zinc finish hot dipped after fabrication) with rolled edges and soldered or welded seams. Provide 3/4 inch copper drainage piping, properly discharged to over floor drain or as shown on the Drawings. Comply with Mechanical Code overflow protection and pipe sizing.
- E. Adjusting: Adjust and calibrate all automatic mechanical equipment, mixing valves, flush valves, float devices, etc. Adjust flow rates at each piece of equipment or fixture.
- F. Building Vapor Barrier: Wherever the building insulation vapor barrier is penetrated by mechanical piping, hangers, conduits, ductwork, etc., provide clear self-adhesive tape recommended by the insulation manufacturer around the penetrations.

3.09 SYSTEM ADJUSTMENT:

- A. Adjust and calibrate all automatic mechanical equipment, mixing valves, float devices, etc. Adjust flow rates at each piece of equipment or fixture. Open and close all shutoff and control valves several times to insure tight glands.

3.10 CUTTING AND PATCHING:

- A. General: Comply with the requirements of Owner's Division 1 for the cutting and patching of other work to accommodate the installation of mechanical work. Do all necessary cutting and patching of existing yard surfaces required for completion of the mechanical work. Patch to match finish and color of adjacent surfaces.

END OF SECTION

## 1 GENERAL

## 1.01 WORK INCLUDED:

- A. Provide all pipe, piping fittings and all related components required for complete piping system. Refer to each specification section for each system for pipe application.

## 1.02 REFERENCES:

- A. ANSI/ASME Sec. 9 - Welding and Brazing Qualifications.
- B. ANSI/ASTM B32 - Solder Metal.
- C. ANSI/AWS D1.1 - Structural Welding Code.
- D. ASME - Boiler and Pressure Vessel Code.
- E. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.
- F. ASTM A120 - Pipe, Steel, Black and Hot-Dipped Zinc Coated (Galvanized), Welded and Seamless, for Ordinary Uses.
- G. ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- H. AWS A5.8 - Brazing Filler Metal.
- I. AWWA C601 - Standard Methods for the Examination of Water and Wastewater.

## 1.03 QUALITY ASSURANCE:

- A. Conform to ANSI/ASME B31.9 for pressurized system as well as all applicable codes.
- B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulations.
- C. Welders Certification: In accordance with ANSI/ASME Sec 9. and ANSI/AWS D1.1.

## 1.04 SUBMITTALS:

- A. Submit product data under provisions of Section 23 0000 and Division 1.
- B. Include data on pipe materials, pipe fittings and accessories.

## 1.05 DELIVERY, STORAGE, AND HANDLING:

- A. Deliver products to site under provisions of Section 23 0000.

- B. Store and protect products under provisions of Section 23 0000 and provide factory applied end caps each length of pipe and tubes to prevent damage to pipe-ends and eliminate dirt and moisture from inside of pipes and tubes.

## 2 PRODUCTS

## 2.01 NATURAL GAS PIPING, ABOVE GRADE:

- A. Above Grade:
  - 1. Steel Pipe: ASTM A53 or A120, Schedule 40 black. Fittings: ANSI/ASME B16.3, malleable iron, or ASTM A234, forged steel welding type. Joints: Screwed for pipe two inches and under; ANSI/AWS D1.1, welded, for pipe over two inches.
- B. Coiling: PE Pipe and tubing shall be furnished in coils. The amount of footage per coil shall be as specified below unless otherwise specified on the purchase order. Each coil shall consist of a single length of pipe. Joints shall not be permitted. 4" IPS, and 6" IPS PE pipe shall be furnished in straight lengths 40 feet long. A straight length shall consist of a single length of pipe. Joints will not be permitted.
- C. Fittings: ASTM D2513 socket type. Joints: fusion welded. Provide minimum 14 gauge single strand, copper wire with orange color insulating coating.

## 2.02 EQUIPMENT AND COOLING COIL DRAINS AND OVERFLOWS:

- A. Copper Tubing: ASTM B88, Type L, hard drawn. Fittings: ANSI/ASTM B16.22, cast brass, or ANSI/ASME B16.29 solder wrought copper. Joints: ASTM B32, solder, Grade 95TA or ANSI/AWS A5.8, BCuP silver braze.

## 2.03 MISCELLANEOUS PIPING MATERIAL:

- A. Welding Materials: Provide welding materials as determined by the installer to comply with installation requirements. Comply with Section 2-C, ASME Boiler Code for welding materials.
- B. Soldering and Brazing Materials: Provide soldering materials as determined by the installer to comply with installation requirements.
  - 1. Tin-Antimony Solder: ASTM B32, Grade 95TA.
  - 2. Lead-Free Solder: ASTM B32, Grade HB. Harris "Bridgit" approved.
  - 3. Silver Solder: ASTM B32, Grade 96.5TS.
- C. Gaskets for Flanged Joints: ANSI B16.21; full-faced for cast-iron flanges; raised-face for steel flanges. Pressure and temperature rating required for the service indicated.
- D. Sleeve Seal: Rubber-link pipe wall and casing closure. Thunderline Link-Seal. For fire rated wall, floor or ceiling penetrations, 3-M "CP-25" caulk, "No. 303" putty and/or "PSS 7904" sealing system.
- E. Tracer Wire: 14 gauge, single strand, copper wire with blue insulation for water, green for sanitary and storm sewers, and orange for gas. 3M "DBY" direct bury splice kit required at all splices.

## 2.04 FLANGES, UNIONS, AND COUPLINGS:

- A. Pipe Size 2 Inches and Under: 150 psig malleable iron unions for threaded ferrous piping; bronze unions for copper pipe, soldered joints.
- B. Pipe Size Over 2 Inches: 150 psig forged steel slip-on flanges for ferrous piping; bronze flanges for copper piping; neoprene gaskets for gas service; 1/16 inch thick performed neoprene bonded to asbestos.
- C. Grooved and Shouldered Pipe End Couplings: Malleable iron housing clamps to engage and lock, designed to permit some angular deflection, contraction, and expansion; "C" shape composition sealing gasket; steel bolts, nuts, and washers; galvanized couplings for galvanized pipe.
- D. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier. Victaulic "Clear Flow", Epcor or accepted substitute.

## 3 EXECUTION

## 3.01 PREPARATION:

- A. Ream pipe and tube ends. Remove burrs or bevel plain end ferrous pipe.
- B. Remove scale and dirt, on inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

## 3.02 INSTALLATION:

- A. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- B. Route piping in orderly manner, maintain gradient and conceal all piping unless otherwise indicated.
- C. Install piping to conserve building space, not to interfere with use of space or access panels and parallel with walls.
- D. Group piping whenever practical at common elevations.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Provide loops, swing joints, pinchers, runouts and spring pieces to prevent damage to piping or equipment.
- F. Provide clearance for installation of insulation and access to valves and fittings.
- G. Where piping is installed in the exterior building envelope or in any component of the exterior building envelope it shall be located on the warm building interior side of the building envelope insulation.
- H. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

- I. Prepare pipe, fittings, supports, and accessories not prefinished, ready for finish painting. Refer to Section 23 0500.
- J. Establish invert elevations, slopes for drainage to 1/4 inch per foot minimum. Maintain gradients.
- K. Pitch vent piping at 1/4 inch per 10 feet minimum.
- L. Unions and Flanges: At all equipment to permit dismantling and elsewhere as consistent with good installation practice.
- M. Expansion and Flexibility: Install all work with due regard for expansion and contraction to prevent damage to piping, ductwork, equipment, building and its contents. Provide piping offsets, loops, approved type expansion joints, anchors, or other means to control piping movement and to minimize pipe forces.

3.03 CLEANING:

- A. General: Clean all dirt and construction dust and debris from all mechanical piping systems and leave in a new condition. Touch up paint where necessary.
- B. Gas Piping: Blow clear of debris with nitrogen or oil free air. Clean all low point strainers and pockets.

3.04 TEST:

- A. Natural Gas Piping: One half hour minimum air at 60 psig for 2 psig gas, and 15 minutes at 10 psig for 7 inch water gauge natural gas or as approved and certified by serving utility.

END OF SECTION

## 1 GENERAL

## 1.01 WORK INCLUDED:

- A. The requirements of this Section apply to the valving for the systems specified elsewhere in Division 23.

## 1.02 QUALITY ASSURANCE:

- A. Provide valves from a single manufacturer where possible with manufacturer's name and pressure rating marked on valve body.
- B. All castings used for valve bodies shall be date stamped for quality assurance and traceability.
- C. Valve size shall be the same as connecting pipe size unless otherwise noted.
- D. Grooved end valves shall be of the same manufacturer as the adjoining couplings.

## 1.03 SUBMITTALS:

- A. Submit product data under provisions of Section 23 0000.
- B. Include data on valves and accessories.

## 2 PRODUCTS

## 2.01 BALL, CHECK, STOP CHECK, NON SLAM CHECK, BUTTERFLY, GATE, GLOBE, LUBRICATED PLUG VALVE TYPES:

- A. Manufacturers: Crane, ITT, Grinnell, Hammond, Jenkins, Kennedy, Mueler, Lunkenheimer, Milwaukee, Nibco, Powell, Apollo, Stockham, Walworth, Legend, or accepted substitute. Grooved end valves Victaulic, Gustin-Bacon, or accepted substitute. Victaulic (grooved end) and Grinnell (screwed/flanged) numbers are given except as noted.
- B. Natural Gas:
  - 1. 5 psig or less, 2 inches and smaller ball valves, Watts 6000UL. Threaded, 250 psi, 2 pieces, bronze.
  - 2. 5 psig or less, 2-1/2 inches and larger, 125 psi, all bronze or cast iron body/bronze trim. AGA approved.

## 2.02 GAS PRESSURE REGULATORS:

- A. Size and capacity as required for connected load. Style and model as approved by gas supplier.
- B. Manufacturers: Maxitrol, Rockwell, Fisher, Reliance, or accepted substitute.

3 EXECUTION

3.01 INSTALLATION:

- A. Provide clearance for installation of insulation and access to valves and fittings.
- B. Provide access where valves and fittings are not exposed. Coordinate size and location of access door with Section 23 0500.
- C. Install valves with stems upright or horizontal, not inverted.
- D. Provide one plug cock wrench for every five plug cocks sized 2 inches and smaller. Provide each plug cock sized 2-1/2 inches and larger with a wrench with set screw.

END OF SECTION

## 1 GENERAL

## 1.01 WORK INCLUDED:

- A. Provide pipe and equipment hanger, support, anchors, and all related items for complete systems.

## 1.02 QUALITY ASSURANCE:

- A. Provide pre-manufactured horizontal piping and ductwork hangers, clamps, hanger rod, shields, supports, etc.
- B. Seismic requirements: Provide seismic restraints in accord with the latest edition of "Seismic Restraint Manual Guidelines" as published by SMACNA. Seismic Hazard Level (SHL) of "A". A lower SHL will be allowed provided the contractor provides calculations stamped by a registered professional structural engineering in the state the project is located indicating a lower SHL is acceptable.

## 1.03 SUBMITTALS:

- A. Submit product data under provisions of Section 23 0500.
- B. Submit construction details, and performance characteristics for each type and size of anchor, hanger and support.

## 2 PRODUCTS

## 2.01 HANGERS AND SUPPORTS:

- A. Listed Types: The Manufacturers Standardization Society (MSS) Piping Types listed with Grinnell figure numbers in parentheses where applicable (or another manufacturer's as noted). ITT Grinnell, Elcen, Michigan, Super Strut, Kindorf, Unistrut or accepted substitute.
- B. Horizontal Piping Hangers and Supports:
  - 1. Adjustable Clevis Hanger: MSS Type 1 (Fig. 260).
  - 2. Adjustable Band Hanger: MSS Type 7 (Fig. 97), fabricated from steel.
  - 3. Adjustable Swivel-Band Hanger: MSS Type 10 (Fig.70).
  - 4. Clamp: MSS Type 4 (Fig. 212, 216).
  - 5. Double-Bolt Clamp: MSS Type 3 (Fig. 295A, 295H), including pipe spacers.
  - 6. Pipe Anchors: (Carpenter & Peterson Fig. 145CI) Steel weld type to pipe for sizes up to 20 inches in diameter.
  - 7. Single-Roll Support: MSS Type 42 (Fig. 174), including axle-roller and threaded sockets.

8. Adjustable Roller Hanger: MSS Type 43 (Fig. 181), including axle-roller and clevis.
  9. Adjustable Roll/Base: MSS Type 46 Fig. 274), including roller, adjustable base, and stand.
  10. Rollers for Channel Support Systems: Grinnell Fig. 1901, 1902, 1911, 815, or 816 for pipe sizes up to 18 inches in diameter.
  11. Sliding Support Base: MSS Type 35 (Grinnell 600 series). Base and guide.
  12. Adjustable Saddle-Support: MSS Type 36 (Fig. 258) and MSS Type 37 (Fig. 259), including saddle, pipe, and reducer. Fabricate base-support from steel pipe and include cast-iron flange or welded-steel plate.
- C. Equipment and Piping Supports:
1. Channel Support System: Galvanized, 12 gauge channel and bracket support systems, single or double channel as indicated on the Drawings or as required by piping and equipment weights. Grinnell "Power "Strut" channel.
  2. Steel Brackets: Welded structural steel shapes complying with one of the following:
    - a. Light Duty: MSS Type 31 (Fig. 194).
    - b. Medium Duty: MSS Type 32 (Fig. 195).
    - c. Heavy Duty: MSS Type 33 (Fig. 199).
- D. Vertical Pipe Clamps:
1. Two-Bolt Riser Clamp: MSS Type 8 (Fig. 261).
  2. Four-Bolt Riser Clamp: MSS Type 42 include pipe spacers at inner bolt-holes.
- E. Hanger Rod Attachment:
1. Hanger Rod: Right hand threaded, (Grinnell Fig. 140 or 146 for all sizes).
  2. Turnbuckles: MSS Type 13 (Fig. 230).
  3. Weldless Eye-Nut: MSS Type 17 (Fig. 290).
  4. Malleable Eye-Socket: MSS Type 16 (Fig. 110R).
  5. Clevises: MSS Type 14 (Fig. 299).
- F. Building Attachments:
1. Concrete Inserts: MSS Type 18 (Fig. 282), steel or Grinnell Power-Strut PS349 continuous channel.

2. Clamps: MSS Type 19 (Fig. 285, 281), Type 20, 21 (Fig. 225, 226, 131), Type 23 (Fig. 86, 87,88), Type 25 (Fig. 227), Type 27 through 30 where applicable.

#### 2.02 SADDLES AND SHIELDS:

- A. Listed Types: The Manufacturers Standardization Society (MSS) Piping Types listed with Grinnell figure numbers in parentheses where applicable (or another manufacturer's as noted).
- B. Protection Saddles: MSS Type 39 (Fig. 160).
- C. Protection Shields: MSS Type 40 (Fig. 167).
- D. Preinsulated Pipe Supports: Pipe Shields Inc. or accepted substitute.
  1. Pipe supported on rods - Model A1000, through A4000 and A9000.
  2. Pipe supported on flat surfaces - Model A1000, A2000, A5000 through A7000.
  3. Pipe supported on pipe rolls - Model A3000 through A6000 and A8000.

#### 2.03 MISCELLANEOUS HANGER MATERIALS:

- A. Metal Framing: Provide products complying with NEMA STD ML 1.
- B. Steel Plates, Shapes and Bars: ASTM A-36.
- C. Cement Grout: Portland Cement (ASTM C-150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C-404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume with only the minimum amount of water required for placement and hydration.
- D. Heavy Duty Steel Trapezes: Fabricate from steel shapes selected for the loads required; weld steel in accordance with AWS Standards.
- E. Pipe Guides: Provide factory-fabricated guides, of cast semi-steel or heavy fabricated steel, consisting of a bolted two-section outer cylinder and base with a two-section guiding spider bolted tight to the pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of the length recommended by the manufacturer to allow indicated travel.
- F. Standard Bolts and Nuts: ASTM A 307, Grade A.
- G. Concrete Anchors: Rawl Lok/Bolt, Hilti "HSL," ITT Phillips, Red Head Wedge Anchors, Ramset Trubolt or Dynabolt or accepted substitute.
- H. Shop Primer: Manufacturer's standard rust inhibitive primer.

## 2.04 ROOF EQUIPMENT SUPPORTS:

- A. General: Coordinate the location and type of each roof equipment support with the roofing system supplier. Systems to maintain roof warranty. Minimum 18 gauge galvanized steel with fully mitered and welded corners, internal bulkhead reinforcing, integral base plates, pressure-treated wood nailer and 18 gauge galvanized steel counterflashing. Compensate for roof slope so top of support is level. Construct curb to meet or exceed all seismic forces.
- B. Manufacturers: Thycurb, Custom Curb, Vibrex or accepted substitute.

## 3 EXECUTION

## 3.01 INSTALLATION OF HANGERS AND SUPPORTS:

- A. General: Proceed with the installation of hangers, supports and anchors only after the required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) the proper placement of inserts, anchors and other building structural attachments.
  - 1. Install hangers, supports, clamps, and attachments to support piping and equipment properly from the building structure. Use no wire or perforated metal to support piping, and no supports from other piping or equipment. For exposed continuous pipe runs, install hangers and supports of the same type and style as installed for adjacent similar piping.
  - 2. Prevent electrolysis in the support of copper tubing by the use of hangers and supports which are copper plated, or by other recognized industry methods.
  - 3. Arrange supports to prevent eccentric loading of joists and joist girders. Locate supports at panel points only.
  - 4. Install hangers and supports to provide the indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 are not exceeded. Comply with the following installation requirements:
    - a. Clamps: Attach clamps, including spacers (if any), to piping outside the insulated piping support. Do not exceed pipe stresses allowed by ANSI B31.
    - b. Insulated Pipe Supports: Insulated pipe supports shall be supplied and installed on all insulated pipe and tubing.
    - c. Load Rating: All insulated pipe supports shall be load rated by the manufacturer based upon testing and analysis in conformance with ASME B31.1, MSS SP-58, MSS SP-69 and MSS SP-89.
    - d. Support Type: Manufacturer's recommendations, hanger style and load shall determine support type.

- e. Insulated Piping Supports: Where insulated piping with continuous vapor barrier or where exposed to view in finished areas is specified, install hard maple wood insulation shields (Elcen Fig. 216) or steel pipe covering protection shields (MSS type 39) at each hanger.

B. Provisions for Movement:

- 1. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate the action of expansion joints, expansion loops, expansion bends and similar units.
- 2. Install hangers and supports so that equipment and piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

C. Pipe Hangers and Supports:

- 1. Vertical Spacing: Support at base, every floor height not exceeding 10 feet and required by Code and just below roof line.
- 2. Screwed or Welded Steel or Copper Piping: Maximum hanger spacing shall be as follows:

	Steel	Copper
1-1/4 inches and smaller	6 foot span	5 foot span
1-1/2 inch pipe	9 foot span	6 foot span
2 inch pipe	10 foot span	10 foot span
2-1/2 inch	11 foot span	10 foot span
4 inches and larger	12 foot span	10 foot span

- 3. Install additional hangers or supports at concentrated loads such as pumps, valves, etc. to maintain alignment and prevent sagging.
- 4. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
- 5. Place a hanger within 12 inches of each horizontal elbow.
- 6. Support Rod: Hanger support rods sized as follows:

Pipe Size	Rod Diameter	Max. Load
2 inches and smaller	3/8 inch	610 lb.
2-1/2 to 3 inches	1/2 inch	1130 lb.
4 inches	5/8 inch	1810 lb.
6 inches	3/4 inch	2710 lb.
8 through 12 inches	7/8 inch	3770 lb.

- D. Adjust hangers and supports to bring piping to proper levels and elevations.

- E. Provide all necessary structural attachments such as anchors, beam clamps, hanger flanges and brackets in accordance with MSS SP-69. Attachments to beams wherever possible. Supports suspended from other piping, equipment, metal decking, etc., are not acceptable.
- F. Horizontal banks of piping may be supported on common steel channel member spaced not more than the shortest allowable span required on the individual pipe. Maintain piping at its relative lateral position using clamps or clips. Allow lines subject to thermal expansion to roll axially or slide. Size channel struts for piping weights.

### 3.02 INSTALLATION OF ANCHORS:

- A. Install anchors at the proper locations to prevent stresses from exceeding those permitted by ANSI B31, where recommended in SMACNA "Seismic Restraint Manual" or exceeding manufacturer's recommended loading, and to prevent the transfer of loading and stresses to connected equipment.
- B. Welding: Provide anchor by welding steel shapes, plates, and bars to the piping and/or equipment and to the structure. Comply with ANSI B31 and AWS standards and SMACNA "Seismic Restraint Manual."
- C. Bolting: Provide standard plate washers under heads and nuts of bolts bearing on wood. Soap threads of lag bolts prior to installing.
- D. Structural Blocking: Locate as indicated and as required to support mechanical piping and equipment.
- E. Where expansion compensators are indicated, install anchors in accordance with the expansion unit manufacturer's written instructions, to limit movement of piping and forces to the maximums recommended by the manufacturer of each unit.
- F. Anchor Spacings: Install anchors at the ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends. Make provisions for presetting of anchors as required to accommodate both expansion and contraction of piping.
- G. Painting: Refer to Section 23 0500.

### 3.03 ROOF EQUIPMENT SUPPORTS, EQUIPMENT CURBS AND PIPE CURB ASSEMBLIES:

- A. Provide prefabricated units for all roof penetrations for mechanical equipment. Set supports on the structural deck. Do not set supports on insulation or roofing. Provide level supports by prefabricated slope built into curb.
- B. Equipment supports: Provide for roof mounted equipment which does not require a structural roof deck penetration.
- C. Equipment Curbs: Provide for equipment which requires a structural roof deck penetration other than piping or conduit.
- D. Pipe Curb Assemblies: Provide for piping and electrical conduit which penetrates the roof deck to service equipment above the roof.

END OF SECTION

## 1 GENERAL

## 1.01 WORK INCLUDED:

- A. Provide seismic, sound and vibration isolation with all related components for mechanical equipment specified elsewhere.

## 1.02 REFERENCES, CODES AND STANDARDS:

- A. ASHRAE - Guide to Average Noise Criteria Curves.
- B. Seismic Requirements: Seismic restraint manual, latest edition, SMACNA.
- C. IBC.
- D. State and local codes.
- E. NFPA.

## 1.03 QUALITY ASSURANCE:

- A. Maintain ASHRAE criteria for average noise criteria curves for all equipment at full load condition.

## 1.04 SUBMITTALS:

- A. Submit shop drawings and product data under provisions of section 23 0000.
- B. Provide submittals for products as follows:
  - 1. Descriptive Data: Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the specification. Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive drawings.
  - 2. Shop Drawings: Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations. Provide all details of suspension and support for ceiling hung equipment. Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe to be included. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

3. Seismic Certification and Analysis: Seismic restraint calculations to be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer licensed in Oregon. Analysis to indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment structure. Analysis to detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the seismic force level per code requirements.

#### 1.05 CERTIFICATES:

- A. Submit manufacturer's certificate that isolators are properly installed and properly adjusted to meet or exceed specified requirements.

## 2 PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS:

- A. Manufacturers:
  1. Equipment: Amber/Booth, Mason, Vibrex or accepted substitute.
  2. Ductwork and piping: Amber/Booth, Mason, Vibrex, I.S.A.T. or accepted substitute.
  3. Mason numbers used as basis of design.

#### 2.02 NEOPRENE PAD (NP):

- A. 5/16" thick neoprene pad consisting of square waffle modules minimum size 2-inch x 2-inch. Load distribution to be sized as required. Mason "W".

#### 2.03 SPRING ISOLATORS WITH NEOPRENE, LIMITED TRAVEL (SINLT):

- A. Restrained spring mountings to have an SLF mounting as described in B above, within a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing to serve as blocking during erection. Steel spacer to be removed after adjustment. Limit stops to be out of contact during normal operation. Provide an internal isolation pad. Mason "SLR".

#### 2.04 SPRING HANGERS AND NEOPRENE (SHN):

- A. Hangers to consist of rigid steel frames containing minimum 1-1/4" thick neoprene elements at the top and a steel spring. Seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup to have neoprene bushings projecting through the steel box. Spring diameters and hanger box lower hole sizes to be large enough to permit the hanger rod to swing through a 30 degree arc from side to side before contacting the rod bushing. Mason "30N".

## 2.05 SEISMIC SWAY BRACE (SSB):

- A. Seismic Cable Restraints to consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Cable end connections to be steel assemblies that swivel to final installation angle and utilize clamping bolts to provide proper cable engagement. Cable assemblies Mason "SCB", "SSB", "SCBH" and "SCBV".
- B. Seismic solid braces to consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors to be steel assemblies that swivel to the final installation angle and utilize two through bolts to provide proper attachment. Mason "SSB".
- C. Steel angles, sized to prevent buckling, to be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods is not acceptable. Mason "SRC".
- D. Pipe clevis cross bolt braces are required in all restraint locations. Preformed channels deep enough to be held in place by bolts passing over the cross bolt. Mason "CCB".

## 2.06 FLEXIBLE DUCT CONNECTION (FDC):

- A. Neoprene loaded vinyl material or neoprene loaded canvas with vapor barrier. Flame spread rating of 25 or less and a smoke spread rating of 50 or less, per ASTM E84. Not affected by temperatures as low as minus 10°F or as high as 200°F.
- B. Flexible Connections: Ventglass manufactured by Ventfabrics, Amatex or accepted substitute.

## 2.07 SEISMIC PIPE LOOPS:

- A. General: Seismic connectors for straight pipe runs to be "V" design with sufficient live length on each flexible leg to provide a minimum of 2-inches of movement in all directions. In addition to the flexible legs, construct connectors with two 45 degree elbows and a 90 degree elbow return.
- B. Materials: Type 321 stainless steel hose and braid with carbon steel elbows and ends. Flanged connectors will be used in steel piping 2-1/2-inch or larger and threaded connectors for piping smaller than 2-1/2-inch. Carbon steel FNPT drain pot will be utilized on all connectors for steam systems. For copper piping systems, manufacture "V" connectors with bronze hose and braid and copper elbows and sweat ends. Guide seismic "V" connectors per manufacturer's guidelines.
- C. Pressure Rating: 150 PSI.
- D. Manufacturers: Unisource V-SF21 or V-BF11 or accepted substitute.

### 3 EXECUTION

#### 3.01 GENERAL:

- A. All vibration isolators, sound isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.
- B. Installation of vibration isolators and seismic restraints must not cause any change of position of equipment, piping, or duct work, resulting in stresses or misalignment.
- C. Coordinate work with other trades to avoid rigid contact with the building.
- D. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor to submit loads to the structural engineer or record for review.
- E. Drill-in concrete anchors for ceiling and wall installation to be full diameter and the standard product of the manufacturer.
- F. Vibration isolation manufacturer to furnish integral structural steel bases as required.
- G. Where piping passes through walls, floors, or ceilings the vibration isolation manufacturer to provide split wall seals.
- H. Locate isolation hangers as near to the overhead support structure as possible.

#### 3.02 VIBRATION ISOLATION PIPING:

- A. Riser Isolation: Risers to be suspended from SHN hangers or supported by SIN mountings, anchored with pipe guides. Steel springs to be a minimum of 0.75" except in those expansion locations where additional deflection is required to limit load changes to plus or minus 25% anticipated expansion and construction at each support point, initial and final loads on the building structure, spring deflection changes and seismic loads.

#### 3.03 SEISMIC RESTRAINT OF PIPING:

- A. Seismically restrain all piping listed as .1, 2. or 3. below. Use SSB cables:
  - 1. Fuel oil piping, gas piping, medical gas piping, and compressed air piping that is 1" or larger.
  - 2. Piping located in boiler rooms, mechanical equipment rooms, and refrigeration equipment rooms that is 1-1/4" and larger.
  - 3. All other piping 2-1/2" and larger.
- B. Transverse piping restraints to be at 40' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

- C. Longitudinal restraints to be at 80' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
- D. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided, they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.
- E. For fuel oil and all gas piping transverse restraints must be 20' maximum and longitudinal restraints at 40' maximum spacing.
- F. Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24" of the elbows.
- G. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints.
- H. Branch lines may not be used to restrain main lines.

#### 3.04 VIBRATION ISOLATION OF DUCTWORK:

- A. All discharge runs for a distance of 50' from the connected equipment to be isolated from the building structure by means of SHN hangers or SIN floor isolators. Spring deflection to be a minimum of 0.75".
- B. All duct runs having air velocity of 1000 fpm or more to be isolated from the building structure by SHN hangers or SIN floor supports. Spring deflection to be a minimum of 0.75".
- C. Flexible Duct Connections: Squarely align sheet metal ducts with the fan prior to installation of the flexible connection. Install connections so the fan is able to move 1-inch in any direction without causing metal-to metal contact or stretching taught the flexible connection. Install the connections so that the clear space is minimum 4-inches, and the connection has a minimum of 1-1/2-inch of slack material. Install flexible connections per SMACNA.

#### 3.05 SEISMIC RESTRAINT OF DUCTWORK:

- A. Seismically restrain all duct work with SSB restraints as listed below:
  - 1. Restrain rectangular ducts with cross sectional area of 6 sq. ft. or larger.
  - 2. Restrain round ducts with diameters of 28" or larger.
  - 3. Restrain flat oval ducts the same as rectangular ducts of the same nominal size.
  - 4. Ductwork suspended by hangers 12 inches or less from the structure is excluded from isolation.
- B. Transverse restraints to occur at 30' intervals or at both ends of the duct run if less than the specified interval. Transverse restraints to be installed at each duct turn and at each end of a duct run.

- C. Longitudinal restraints to occur at 60' intervals with at least one restraint per duct run. Transverse restraints for one duct section may also act as a longitudinal restraint for a duct section connected perpendicular to it if the restraints are installed within 4' of the intersection of the ducts and if the restraints are sized for the larger duct. Duct joints to conform to SMACNA duct construction standards.
- D. The ductwork must be reinforced at the restraint locations. Reinforcement to consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper and lower trapeze.
- E. Walls, including gypsum board nonbearing partitions, which have ducts running through them may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

### 3.06 MECHANICAL EQUIPMENT:

- A. All mechanical equipment to be vibration isolated and seismically restrained as per the schedule.

- B. Equipment Schedule:

1.	<u>Equipment:</u>	<u>Type:</u>
	Air Handler Fans	SINLT
	Air Handler Casings	NP
	Piping, ducts, flues	SHN
2.	<u>Motors:</u>	
	<10 HP	¾ inch deflection
	>15 HP	1-1/2 inch deflection
	>50 HP	2 inch deflection

END OF SECTION

**1 GENERAL****1.01 WORK INCLUDED:**

- A. After completion of the work of installation, test and regulate all components of the heating, air conditioning and ventilating systems to verify air flow rates shown.
- B. Testing, adjustment, and balancing of air systems.
- C. Measurement of final operating condition of mechanical systems.

**1.02 REFERENCES:**

- A. AABC - National Standards for Field Measurement and Instrumentation, Total System Balance.
- B. ASHRAE – Measurements, Instruments and Testing, Adjusting and Balancing.
- C. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

**1.03 QUALITY ASSURANCE:**

- A. Agency shall be company specializing in the adjusting and balancing of systems specified in this Section with minimum five years documented experience.
- B. Testing, adjusting, and balancing shall be performed by a firm with 10 years of experience and certified for direct digital control systems.

**1.04 SUBMITTALS:**

- A. Submit name of adjusting and balancing agency for approval within 30 days after award of Contract.
- B. Submit test reports as a submittal under provisions of Section 23 0000.
- C. Prior to commencing work, submit draft reports indicating adjusting, balancing, and equipment data required.
- D. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Engineer and for inclusion in operating and maintenance manuals.
- E. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets and indicating thermostat locations.

**2 PRODUCTS****2.01 EQUIPMENT:**

- A. Provide all necessary personnel, equipment, and services.

## 2.02 REPORT FORMS:

- A. Submit reports on forms.
- B. Forms shall include the following information:
  - 1. Title Page:
    - a. Company name.
    - b. Company address.
    - c. Company telephone number.
    - d. Project name.
    - e. Project location.
    - f. Project Engineer.
    - g. Project Contractor.
    - h. Project altitude.
    - i. Outdoor conditions.
  - 2. Instrument List:
    - a. Instrument.
    - b. Manufacturer.
    - c. Model.
    - d. Serial number.
    - e. Range.
    - f. Calibration date.
  - 3. Air Handling Units, Make-up Air Unit, Exhaust Fans and Fan Coil Units:
    - a. Location.
    - b. Manufacturer.
    - c. Model.
    - d. Supply air flow specified and actual.
    - e. Return and/or outside air flows, specified and actual.
    - f. Total and external static pressure specified and actual.

- g. Inlet pressure.
  - h. Discharge pressure.
  - i. Fan RPM.
  - j. Cooling and heating coils inlet/outlet water and air temperature including flow rates.
4. Air Flow:
- a. Identification/ location.
  - b. Design air flow.
  - c. Actual air flow.
  - d. Supply air temperature.
  - e. Return air temperature.
5. Electric Motors and VFD's:
- a. Manufacturer.
  - b. HP/BHP.
  - c. Phase, voltage, amperage; nameplate, and actual.
  - d. RPM.
  - e. Service factor.
  - f. Starter size, rating, heater elements.
6. V-Belt Drive:
- a. Identification/location.
  - b. Required driven RPM.
  - c. Driven sheave, diameter, and RPM.
  - d. Belt, size, and quantity.
  - e. Motor sheave, diameter, and RPM.
  - f. Center to center distance, maximum, minimum, and actual.

## 3 EXECUTION

## 3.01 EXAMINATION:

- A. Before commencing work, verify that systems are complete and operable. Ensure the following:
1. Equipment is operable and in a safe and normal condition.
  2. Temperature control systems are installed complete and operable.
  3. Proper thermal overload protection is in place for electrical equipment.
  4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
  5. Duct systems are clean of debris.
  6. Correct fan rotation.
  7. Fire and volume dampers are in place and open.
  8. Coil fins have been cleaned and combed.
  9. Access doors are closed, and duct end caps are in place.
  10. Air outlets are installed and connected.
  11. Duct system leakage has been minimized.
- B. Report any defects or deficiencies noted during performance of services to Engineer.
- C. Promptly report abnormal conditions in mechanical systems or conditions which prevent system balance.
- D. If, for design reasons, system cannot be properly balanced, report as soon as observed.
- E. Beginning of work means acceptance of existing conditions.

## 3.02 PREPARATION:

- A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Engineer to facilitate spot checks during testing.
- B. Provide additional balancing devices as required.

## 3.03 INSTALLATION TOLERANCES:

- A. Adjust air handling systems to plus or minus 5 percent for supply, return and exhaust systems from figures indicated.
- B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

- C. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

#### 3.04 ADJUSTING:

- A. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- B. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- C. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

#### 3.05 AIR SYSTEM PROCEDURE:

- A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities.
- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Measure air quantities at air inlets and outlets.
- D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- E. Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan.
- I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- K. Where modulating dampers are provided, take measurements and balance at extreme conditions.
- L. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.

- M. Test and record entering and leaving air dry-bulb temperature for both heating and cooling cycles of each fan system.

3.06 VERIFICATION OF CONTRACTOR'S PERFORMANCE:

- A. Balancing data may be spot checked with instruments similar to that used by the balancing firm.
- B. If there are discrepancies between balancing data and spot check data, readjust and rebalance the systems at no additional project cost.

END OF SECTION

## 1 GENERAL

## 1.01 WORK INCLUDED:

- A. Provide ductwork insulation including jacketing, adhesive and all related accessories for complete insulated system.

## 1.02 QUALITY ASSURANCE:

- A. Applicator: Company specializing in piping insulation application with three years minimum experience.
- B. Insulation, Jacket, and all Related Materials: Flame spread rating of 25 and smoke developed rating of 50.
- C. Codes: Comply with all applicable codes.
- D. Installation: Install in accordance with Manufacturer's recommendations.
- E. Prohibited substances: The following substances are prohibited in the State of Oregon for use in manufacturing duct insulation, wraps, or covers and pipe insulation, wraps or covers. Products containing these substances are not allowed for use.
  - 1. Pentabrominated diphenyl ether CAS#32534-81-9.
  - 2. Octobrominated diphenyl ether CAS#32536-52-0.
  - 3. Decabrominated dphenyl ether CAS#1163-19-5.

## 1.03 SUBMITTALS:

- A. Submit product data and installation instructions under provisions of Section 23 0000.
- B. Include product description, list of materials and thickness for each service, and locations.

## 1.04 DELIVERY, STORAGE AND HANDLING:

- A. Deliver product to site under provisions of Section 23 0000.
- B. Store and protect product under provisions of Section 23 0000.
- C. Store insulation in original shipping container with labeling in place. Do not install damaged insulation.

## 1.05 FIRE HAZARD CLASSIFICATION:

- A. Maximum fire hazard classification of the composite insulation to be not more than a flame spread of 25, fuel contributed of 50 and smoke developed of 50 as tested by ASTM E84, NFPA 255 and UL 723 method.

- B. Test duct insulation in accordance with ASTM E84 and ASTM C1071 and bear the UL label.

1.06 LINING MATERIALS:

- A. Materials to be mold, humidity, and erosion resistant surface to meet the requirements of UL 181.

2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

- A. Insulating Manufacturers: Johns Manville, Knauf, Armstrong, Owens-Corning, Pabco, IMCOA, Certain Teed or accepted substitute.
- B. Adhesive Manufacturers: Benjamin Foster, 3M, Borden, Kingco or Armstrong.

2.02 DUCT INSULATION AND JACKETS:

- A. Duct Wrap: 1 1/2 inch flexible glass fiber; ANSI/ASTM C612; commercial grade; 'k' value of 0.27 at 75 degrees F. 1.0 pcf.
- B. Duct liner: ASTM 1071; flexible blanket. 'K' Value: ASTM C518, 0.25 at 75°F. Noise Reduction Coefficient: 0.65 or higher based on "Type A mounting." Maximum Velocity on Mat or Coated Air Side: 5,000 FPM. Adhesive: UL listed waterproof type. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened. Mold, humidity, and erosion resistant surfaces: UL 181.
- C. Jacketing and Fasteners:
  - 1. Indoor Jacket: Foil-Skrim-Kraft.
  - 2. Outdoor Jacket: Coated glass fiber sheet, 30 lb/sq yd.
  - 3. Lagging Adhesive: Fire resistive to ASTM E84, NFPA 255, and UL 723.
  - 4. Impale Anchors: Galvanized steel, 12 gauge, self-adhesive pad.
  - 5. Joint Tape: Glass fiber cloth, open mesh.
  - 6. Tie Wire: Annealed steel, 16 gauge (1.5 mm).
- D. SoftR® Duct Wrap Paper-free ASJ and VaporWick® or equal approved.

2.03 DUCT INSULATION ACCESSORIES:

- A. Staples, bands, wires, tape, anchors, and accessories as recommended by insulation manufacturer.

2.04 DUCT INSULATION COMPOUNDS:

- A. Cements, adhesives, coatings, sealers, finishes and accessories as recommended by insulation manufacturer.

## 2.05 OUTDOOR DUCTING:

- A. Aluminum Jacket: 0.016-inch thick sheet, smooth/embossed finish, with longitudinal slip joints and 2-inch laps.
- B. Nonwater vapor retarder, nonburning weatherproof coating for use over insulation where "breathing" is required.
- C. UV resistant polyvinyl chloride covering with joints secured and sealed.

## 3 EXECUTION

## 3.01 PREPARATION:

- A. Install materials after ductwork and equipment has been tested and approved.

## 3.02 DUCTWORK INSULATION INSTALLATION:

- A. Install materials in accordance with manufacturer's instructions.
- B. Installation:
  - 1. Butt insulation joints firmly together and install jackets and tapes securely.
  - 2. Apply duct insulation continuously through sleeves and openings. Apply vapor barrier materials to form a vapor seal over the insulation.
  - 3. Cover breaks in the jacket material with patches of the same material as the vapor barrier. Extend the patches 2-inches beyond the break in all directions and secure with adhesive.
  - 4. Seal insulation terminations and pin punctures with a reinforced vapor barrier coating.
  - 5. Continue insulation at fire dampers up to and including those portions of the fire damper frame which are visible at the outside of the rated barrier.
  - 6. Do not conceal duct access doors with insulation.
  - 7. Duct Liners: Install mat finish surface on air stream side. Secure insulation on sheet metal duct with a continuous 100 percent coat of adhesive. For widths over 20-inch, additionally secure the liner with mechanical fasteners 15-inch on center. Cut liner and coat ends with adhesive. Butt joint tightly. Top and bottom sections of insulation overlap sides. Keep duct liner clean and free from dust. If insulation is installed without horizontal, longitudinal and end joints butted together, installation will be rejected.

8. Duct Wrap: Cover supply air ducts except ducts internally lined or where fiberglass ductboard is utilized. Wrap tightly with all circumferential joints butted and longitudinal joints overlapped minimum of 2-inch. Adhere insulation with 4-inch strips of insulating bending adhesive at 8-inch on center. On ducts over 24-inch wide, additionally secure insulation with suitable mechanical fasteners at 18-inch on center. Circumferential and longitudinal joints stapled with flare staples 6-inch on center and covered with 3-inch wide foil reinforced tape.

C. Continue insulation with vapor barrier through penetrations.

D. Internally Lined Ductwork: Where internally lined ductwork is indicated, no exterior insulation is required. Lap the ends of the exterior insulation a minimum of 6 inches past the interior insulation unless otherwise shown. Seal the end of vapor barrier jacket to the duct with mastic where the vapor barrier is required.

3.03 DUCTWORK SURFACES TO BE INSULATED:

<u>Ductwork</u>	<u>Duct Size</u>	<u>Insulation Thickness</u>
Supply and return ductwork (except where duct is lined or where ductboard is utilized)	all	1-1/2" Duct wrap
Supply and return ductwork (exposed to weather and in unheated areas)	all	2" Duct wrap
Outside air ducts	all	2" Duct liner
HVAC plenums	all	2" Duct liner

END OF SECTION

## 1 GENERAL

## 1.01 WORK INCLUDED:

- A. Furnish a complete and fully operating Microsoft Windows based Direct Digital Control system (DDCS) in accordance with this specification section. All components of system shall conform to most recent open protocol requirements of BACnet by ASHRAE. BACnet gateways, integration modules and portals are not allowed. Items of work included are as follows.
1. System shall be compatible with district wide Johnson FX DDC system.
  2. Provide all necessary hardware and software to meet the specified functional requirements.
  3. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols.
  4. System architecture shall provide secure Web access using MS Internet Explorer from any computer on the owner's LAN.
  5. The Owner shall have full ownership and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BMS. Provide all software keys needed so Owner is not locked into any one service contractor or vendor for future work on system.
  6. Prepare individual hardware layouts, interconnection drawings and control loop configuration data from project design data.
  7. Implement the detailed design for all system input/output points, distributed control and system data bases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.
  8. Design all equipment cabinets, panels, and the data communication network cables including all associated hardware.
  9. Provide and install all cabinets, panels, and data communication network cables including all associated hardware.
  10. Provide and install all interconnecting cables between supplied cabinets, controllers, and output devices.
  11. Provide and install all interconnecting cables between all operator terminals and peripheral devices (such as printers, etc.) supplied under this section.
  12. Provide complete specifications for all items supplied by the Vendor from others (such as printers, instruments, etc.).

13. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, start-up and commissioning. Existing and new systems shall be commissioned to follow Sequence of Operations below.
14. Provide a comprehensive operator and technician training program as described herein.
15. Provide as-built documentation, software, and all DDC control logic and all associated support documentation on approved media which accurately represents the final system.
16. Provide CO2 sensors as shown on Drawings for demand control ventilation.
17. Remove all components of existing control system not needed for new controls. Do not abandon in place.

#### 1.02 RELATED WORK:

- A. Related work in other sections of the specifications:
  1. Section 23 0500 Basic Materials and Methods

#### 1.03 SYSTEM DESCRIPTION:

- A. General Requirements:
  1. Provide a Distributed Processing System complete with Direct Digital Control (DDC) and Direct Analog Control (DAC) software. This system is to control all HVAC items throughout the building, including but not limited to: Rooftop units, dampers, supply fans and exhaust fans without intervening conventional controls.
  2. New DDC system components shall replace existing components.
  3. All DDC Controllers for rooftop units, supply fans, exhaust fans, and dampers and Windows based operators' terminal(s) shall communicate with each other and share information.
  4. The controls contractor shall assume complete responsibility for the entire controls system as a single source and shall certify that he has on staff under his direct employ on a day to day basis, factory trained technical personnel, qualified to engineer, program, debug, and service all portions of the DDC control system, including central system Operators terminal, global controllers, terminal unit controllers, and all other portions of the DDC control system.
  5. Bring all existing software resident on Owner's existing operator's terminal onto new operator's terminal.

## B. Basic System Features:

1. Zone by zone DDC control of space temperature, usage scheduling, optimum starting, equipment failure reporting, and override timers for off-hours usage. A zone is the area served by one HVAC terminal unit (mixing box, damper, heat pump, fan coil, etc.)
2. Operator Terminal software shall be latest Windows application program. Software shall be multitasking, capable of executing and displaying multiple instances in individual windows while running concurrently with other Windows programs such as word processors or database programs. Software shall completely support Windows Dynamic Data Exchange (DDE) and Object Linking and Embedding (OLE) interfaces. Software shall strictly follow Microsoft Windows API guidelines. Systems using proprietary software or Windows formats other than above are strictly prohibited. Operation of the terminal software shall be simple and intuitive. Provide a complete, on-line, context sensitive help system. Help system shall contain all of the information contained in the system manuals, so that hard copies of the system manual are not required for operation.
3. Complete energy management firmware, including self-adjusting optimum start, demand limiting, global control strategies and logging routines for use with total control systems. All energy management firmware shall be resident in field hardware and not dependent on the Operators Terminal for operation. Operator's terminal software is to be used for access to field based energy management control firmware only.
4. Match existing system access security features for new equipment. Each user shall have an individual password. Each user shall be assigned which control functions they have access to.
5. Equipment monitoring and alarm function including information for diagnosing equipment problems.
6. The complete system including but not limited to terminal unit controllers, Global controllers and Operator terminals shall Auto-restart, without operator intervention, on resumption of power after a power failure. Database stored in Global Controller memory shall be battery backed up for a minimum of 30 days. Unitary controllers shall utilize EEPROM for all variable data storage. Battery backed up unitary controllers shall not be allowed.
7. Modular system design of proven reliability.
8. Each field panel capable of independent control.
9. All software and/or firmware interface equipment for connection to remote monitoring station from field hardware or the Operators Terminal.
10. Equipment runtime totalization of fans, heaters, boilers, etc., capable of alarm generation and alarm dial out to remote sites.
11. Room sensors with bias levers and unoccupied schedule override

12. All DDC hardware and software shall be designed and manufactured by U.S. corporations. All hardware shall be U.L. listed with integral labels showing rating.

1.04 QUALITY ASSURANCE:

- A. Responsibility: The supplier of the DDCS shall be responsible for inspection and Quality Assurance (QA) for all materials and workmanship furnished by him.
- B. Component Testing: Maximum reliability shall be achieved through extensive use of high-quality, pre-tested components. Each and every controller, sensor, and all other DDC components shall be individually tested by the manufacturer prior to shipment.
- C. Tools, Testing and Calibration Equipment: Provide all tools, testing and calibration equipment necessary to ensure reliability and accuracy of the DDCS.
- D. System shall be installed by a local authorized representative, providing sales and service in the local area for no less than the last five years. Installation Contractor shall have a minimum of 5 certified AX technicians within a 75-mile radius of project site.

1.05 REFERENCE STANDARDS:

- A. The latest edition of the following standards and codes in effect and amended as of date of Supplier's Proposal, and any subsections thereof as applicable, shall govern design and selection of equipment and material supplied:
  1. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers
  2. IBC: International Building Code, including local amendments
  3. UL 916 Underwriters Laboratories Standard for Energy Management Equipment
  4. NEC: National Electrical Code
- B. City, county, state, and federal regulations, and codes in effect as of date of purchase.
- C. Except as otherwise indicated, vendor shall secure and pay for all permits, inspections, and certifications required for his work and arrange for necessary approvals by the governing authorities.

1.06 SUBMITTALS:

- A. Drawings:
  1. Within four weeks after award of contract, the Supplier shall submit review drawings, installation and operation instruction and a recommended spare parts list.
  2. Drawings shall be standard sizes (24 inches x 36 inches) or (11 inches x 17 inches).

3. Provide three copies of submittal drawings.
- B. System documentation by the Vendor shall include the following as a minimum:
1. System configuration diagrams in simplified block format.
  2. Input/Output point and alarm point summary listing.
  3. Electrical drawings showing all system internal and external connection points, terminal block layouts and terminal identification.
  4. Complete written description of system sequence of operation.
  5. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
  6. Overall system operation and maintenance instructions, including preventive maintenance and troubleshooting instructions.
  7. Complete recommended spare parts list.

1.07 SCHEDULING AND COORDINATION:

- A. The Vendor shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases.
- B. The schedule shall show all the target dates for transmission of project information and documents and will indicate system installation, debug, and commissioning timing dates.
- C. Contractor shall work closely with Owner to verify that work shall not interfere with Owner's operation requirements for building.

1.08 WARRANTY:

- A. Warranty shall cover all costs for parts, labor, and associated travel, and expenses for a period of one year from completion of system demonstration.
- B. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the Vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours.
- C. This warranty shall apply equally to both hardware and software.

2 PRODUCTS

2.01 SYSTEM MANUFACTURER:

- A. DDC control system shall be BACnet MS/TP system with Johnson FX front-end (web-based, open protocol, etc.) and installed by a local authorized representative, providing sales and service in the local area for no less than the last five years. Installation Contractor shall have a minimum of 5 certified technicians within a 75-mile radius of project site. Manufacturers: Johnson FX or Approved Equal.
- B. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system utilizing the BACnet technology communication protocol in one open, interoperable system.

## 2.02 SYSTEM TERMINAL:

- A. Displays:
  - 1. Operator Terminal shall display all data associated with project as specified. Terminal software shall accept either PCX or Windows BITMAP format graphic files for display purposes. Graphic files shall be created utilizing scanned full color photographs of system installation, Autocad drawing files of field installation drawings and wiring diagrams from as-built drawings. System shall be capable of displaying graphic file, text and dynamic point data together on each display. Information shall be labeled with descriptors and shall be shown with the appropriate engineering units. Terminal shall allow user to change all field resident EMS functions associated with the project such as set points, time schedules, holiday schedules, etc. This shall be done without any reference to point addresses or other numeric/mnemonic indications.
  - 2. All displays shall be generated and customized in such a manner by the local DDCS supplier that they fit the project as specified. Canned displays shall not be acceptable. Displays shall use standard English (or specified language) for labeling and readout. Systems requiring factory programming for graphics or DDC logic are specifically prohibited. All graphics and DDC programming shall be supported locally by the installing contractor without factory dependency or assistance.
  - 3. Digital points shall be displayed as On/Off or with customized text. Text shall be justified Left, Right or Center. Also allow digital points to be displayed as individual bitmap objects on the display screen as an overlay to the system graphic. Each digital point displayed in this manner shall be assigned up to three bitmap files for display when the point is On, Off or in Alarm. For Digital Output points, toggle the points commanded status when the bitmap is selected with the system digitizer (mouse) by the operator (i.e. selecting a picture of a switch or light with the mouse shall toggle the points status and display a different picture). Also allow digital points to be displayed as an animated graphic. Animated graphic points shall be displayed as a sequence of multiple bitmaps to simulate motion (i.e. when a pump is in the OFF condition, display a stationary picture of the pump. When the operator selects the picture with the mouse, the points status is toggled, and the picture of the pump rotates the vanes in a time based animation). Allow operator to change bitmap file assignment and also create new and original bitmaps online. System shall be supplied with a library of standard bitmaps which may be used unaltered or be modified by the operator. Systems that do not allow customization or creation of new bitmap objects by the operator shall not be allowed.

4. Analog points shall be displayed with operator modifiable units. Analog Input points may also be displayed as individual bitmap objects on the display screen as an overlay to the system graphic. Each analog input point may be assigned to a minimum of five bitmap files each with High/Low limits for automatic selection and display of the bitmaps. As an example, a graphic representation of a thermometer would rise and fall in response to either the room temperature or its deviation from the controlling setpoint. Analog Output points, when selected with the mouse, shall be displayed as a prompted dialog box, adjustable knob or slide bar. Selection for display type shall be individual for each point.
  5. Analog points may also be assigned to an area of a system graphic, where the color of the defined area would change based on the analog points value. As an example, an area of a floor plan graphic served by a single control zone would change color respective to the temperature of the zone or its deviation from setpoint. Selection of the graphic area to be done using a "Roller Brush Flood Fill" tool similar to ones used in painting programs. All editing and area assignment shall be created or modified on-line, using simple icon tools.
  6. A Customized Menu Label shall be used for display selection. Menu items on a display shall allow penetration to lower level displays or additional menus. Dynamic point information and menu items may be mixed on the same display to allow sub displays to exist for each item. Each display may be protected from viewing unless operator has appropriate security level. A separate display security level may be assigned to each display and system point.
  7. All dynamic point information shall be updated on the Operators terminal display CRT once every 1 second. Any changes by the operator shall be acted on by devices in the field within 2 seconds maximum.
  8. A Mouse or other form of digitizer shall be used to move pointer arrow to desired item for selection of new display or to allow the operator to make changes to point data.
  9. Displays may be modified on site or via remote communications.
  10. Display resolution shall be limited by the physical monitor properties and software driver. A minimum resolution of 1024x768 @16bit (65,536 colors). Entire system shall operate without dependency on the Operator's terminal.
  11. Entire system shall operate without dependency on the Operator's terminal.
- B. Security System:
1. Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator terminal's functions unless user is logged on. This includes displays as outlined above.

2. Each Operators Terminal shall provide security for 100 users minimum. Each user shall have an individual password. Password and Username shall each be up to 30 alpha numeric characters, case sensitive. Each User shall be individually assigned which control functions and menu items the user has access to. All passwords, usernames and access assignments shall be adjustable on-line, at the operator's terminal.
  3. System shall maintain a log of all user activities while logged onto the system. Provide for easy viewing of all items in user log, including time and date of login, logoff, and all activities in between.
- C. Display of Scheduling Information:
1. Display of Weekly schedules shall show all information in easy to read 7 day (week) format for each schedule. This includes all on/off times for each day along with all optimum start information.
  2. Holiday schedules shall show all dates that are to be holidays. Holidays shall be shown on the terminal in a graphical calendar format showing all scheduled days for a given month. User shall be able to easily scroll through the months for each year for up to 20 years into the future as a minimum. Each day assigned as a holiday shall display as "All Off" or show the times scheduled for that day.
  3. Event schedules shall be shown in the same graphical calendar format and manner as Holiday schedules. Event schedules allow for scheduling of special events up to 20 years into the future. After event has elapsed, control returns to normal schedule.
  4. Operator shall be able to change all information for a given Weekly, Holiday or Event schedule if logged on with the appropriate security access. This includes all information that has to do with optimum start assignments such as sensors to use and heating/cooling factors.
- D. Alarm Indication:
1. System Terminal shall provide audible, visual, and printed means of alarm indication. The Alarm Dialog box shall always become the Top Dialog box regardless of the application(s) being run at the time (such as a word processor). Printout of alarms shall be sent to the assigned terminal and port.
  2. Provide log of alarm messages. Alarm log shall be archived to the hard disk of the system terminal. Each entry shall include point descriptor and address, time and date of alarm occurrence, point value at time of alarm, time and date of point return to normal condition, time and date of alarm acknowledge.
  3. Alarm messages shall be in plain English (or specified language) and shall be user definable on site or via remote communication. System shall provide a minimum of 20 user definable messages for each zone controlled.

## E. Trend Log Information:

1. System shall periodically gather samples of point data stored in the field equipment (see section 2.2.D) and archive the information on the Operator terminals hard disk. Archive files shall be appended with new sample data, allowing samples to be accumulated over several years. Systems that write over archived data shall not be allowed. Samples may be viewed at the operator's terminal in a Trend Log. Trend log displays shall be in spreadsheet format. Provide a minimum of 100 Trend Log displays at each terminal. Each trend log display shall be capable of a minimum of 100 trended points, with a minimum of 10,000 samples for each trended point. Provide capability for operator to scroll through all trend log data vertically (time axis) and horizontally (point sample columns). System shall automatically open archive files as needed to display archived data when operator scrolls through the data vertically. Display all trend log information in standard engineering units.
2. System software shall be capable of graphing the trend log point data. Software shall be capable of creating graphs in the following forms as a minimum:
  - a. Bar charts, Log/Linear graphs, Bubble graphs,
  - b. x-y graphs, Log/Log graphs, Area graphs(2D or 3D),
  - c. Pie charts, Scatter graphs, Polar graphs,
  - d. High-Low-Close graphs
3. Operator shall be able to change trend log setup information as well. This includes information to be trend logged as well as interval at which information is to be logged. All points in the system may be logged. All operations shall be password protected.

## F. Energy Log Information:

1. System shall periodically gather energy log data stored in the field equipment (see section 2.2.H) and archive the information on the Operator terminals hard disk. Archive files shall be appended with the new data, allowing data to be accumulated over several years. Systems that write over archived data shall not be allowed. Log data may be viewed at the operator's terminal in a spreadsheet format. Provide a minimum of 100 Energy Log displays at each terminal. Provide capability for operator to scroll through all Energy log data vertically (time axis) and horizontally (point sample columns). System shall automatically open archive files as needed to display archived data when operator scrolls through the data vertically. Display all Energy log information in standard engineering units.
2. System software shall be capable of graphing the Energy log data. Software shall be capable of creating graphs in the following forms as a minimum:
  - a. Bar charts, Log/Linear graphs, Bubble graphs,
  - b. x-y graphs, Log/Log graphs, Area graphs(2D or 3D),

- c. Pie charts, Scatter graphs, Polar graphs,
    - d. High-Low-Close graphs
  - 3. Operator shall be able to change the Energy log setup information as well. This includes which meters to be logged and meter pulse value. All meters monitored in the system may be logged. All operations shall be password protected.
- G. Controller Status:
- 1. Provide means for operator to view communication status of all controllers connected to the system. Display shall include controller, status, and error count. Status will show if controller is communicating or not. Error count shall show actual count of communication errors between system and controllers in the field.
  - 2. Provide means for operator to reset error count for all controllers to zero.
  - 3. Provide capability to select alarm indication for each controller.
- H. Configuration/Setup: Provide means for operator to display and change system configuration. This shall include but not be limited to system time, day of the week, date of day light savings set forward setback, printer type and port addresses, modem port and speed, etc. Items shall be modified utilizing easy to understand terminology using simple mouse/cursor key movements.
- I. Custom Report Generator:
- 1. Custom report generator shall allow the operator to create multiple custom reports utilizing system point information, text and outputs of other software modules such as trend logging, controller status, point values, etc. Operation shall be similar to a word processing program allowing easy manipulation of report text, content, font and initiation parameters. Reports may be manually or automatically printed to system printer. Automatic printing initiation may be by assignment to a schedule (Weekly, Holiday or Event schedules), point Change Of State (COS), point alarm condition, or point value.
  - 2. Reports shall fully support Windows DDE and OLE allowing information from other software programs (such as spreadsheet programs) to be part of the report.
- J. Occupant Override Logging and Billing: Night cycle override of zone temperature control, lighting, etc., shall be automatically logged by field devices (Global Controllers) on a zone by zone basis. See section 2.2.G for description. Operator Terminal software shall allow zones to be grouped for totalization of all zones within the area over an adjustable time period. System shall include a billing program for creation of charges based on the billing rate and the totaled override usage from specified begin and end dates.

## K. Terminal Hardware:

1. Provide Operator terminal at location instructed by Owner. Operator terminal shall include the following as a minimum:
  - a. PC compatible, utilizing ISA architecture
  - b. Intel processor Q8400 Core 2 Quad @2.66GHz, 1333FSB
  - c. 2GB RAM minimum
  - d. 500GB Hard Drive
  - e. DVD-R
  - f. Microsoft Windows 7 Ultimate 32-Bit
  - g. USB Optical Mouse
  - h. USB QWERTY Keyboard

## L. Campus Local Area Network:

1. In addition to the LAN communication between the Operator Terminals and the Global Controllers (hereafter called a LOCAL system), the local system shall also be capable of connecting to other local systems or Operator terminals via a Campus LAN. The Campus LAN shall be any of the ETHERNET type LANs available. Provide all ETHERNET hardware and Windows Network software necessary for a complete and operational system.
2. Any point in the interconnected system, comprised of all local systems connected together with the Campus LAN, shall be available for any and all functions of any one of the local systems. As an example, an electric meter input to one of the local systems shall be capable of being utilized in any of the other local systems demand limiting program(s).

## 2.03 GLOBAL CONTROLLER:

## A. General:

1. Global controller shall provide battery backed real time clock functions. It shall also provide system communications to programmable and application specific controllers as noted in section 2.3 in the field. Global controller shall interface with Operator terminal(s) for information display. Global controllers shall share information in a Peer-to-Peer manner utilizing a high speed LAN communication network. Global Controller shall be capable of 1 Meg baud LAN communication rates.

2. Global controller shall decide global strategies for system based on information from any points in the system regardless if the point is directly monitored by the controller. Program that implements these strategies shall be completely flexible and user definable. Any system utilizing factory pre-programmed global strategies that cannot be modified by field personnel on site or downloaded via remote communications are not acceptable. Changing global strategies via firmware changes is also unacceptable. Program executed speed shall be once per second as a minimum.
  3. Programming shall be object oriented using control program blocks. Provide documentation in flow chart form for all programming as part of the final system As-Built documentation. Include samples of flow chart documentation in submittals. All flow charts shall be generated with CAD system and automatically downloaded to controller. No reentry of data base shall be necessary.
  4. Provide means to view inputs and outputs to each program block in real time as program is executing. This function may be done via the Operators Terminal, field computer, or via modem.
  5. Controller shall have a minimum of 1 Mb battery backed Static RAM, expandable to 2 Mb, along with 256 Kb of EPROM. Battery shall retain static RAM memory and clock functions for a minimum of 30 days. Battery shall be a field replaceable lithium type. Battery shall automatically re-charge on resumption of local power.
  6. Communication to field devices shall be via four individual two wire communication trunks. Communication baud rate shall be at 156k baud. All field devices shall automatically search and detect the communication rate to match the Global controller. All field devices on the communication trunk shall be optically isolated. Ground referenced communications to field devices is prohibited. Routing of communication trunk may be daisy chained, run in star patterns or any other configuration that makes wiring easiest.
  7. Controller shall have at a minimum, four (4) additional communication ports in addition to the LAN port. Two of the ports shall be RS-232, one for communication to portable field computer and one for a modem for remote communications. The other two ports shall be RS-485 for connection to a permanent panel mounted display device (see 2.2 for description), and for future connection to other devices.
- B. Remote Communications:
1. Provide all functions that will allow remote communications via internet to off-site locations.
  2. Provide Windows 7 Ultimate compatible software for off-site computer which allows operator to view and change all information associated with system on color graphic displays if desired. Operator shall be able to change all parameters in this section from off-site location including all programming of global controllers and programmable terminal unit controllers.

3. Global Controller shall have capability to call out alarm conditions automatically if desired. Alarm message and site description may be sent to offsite computer or serial printer. If desired, controller may also send encoded message via text message or email. All Global controllers connected to the local LAN shall be capable of calling out alarm messages through one shared modem connected to one of the Global controllers on the local LAN.
4. Owner shall provide internet for remote communication function.

C. Schedules:

1. Schedules shall be arranged in a three tiered hierarchy as follows:
  - a. Highest level: Event Schedules
  - b. Middle level: Holiday Schedules
  - c. Lowest level: Weekly Schedules
2. Each Global Controller shall have at a minimum:
  - a. 100 Weekly time schedules (7 day)
  - b. 100 Holiday schedules (400 programmable days each)
  - c. 20 Event schedules (400 programmable days each) With 8 schedule entries per day.
3. Each schedule may be assigned to any point, controller, or program in the system.
4. Each schedule (Weekly, Holiday and Event) shall be capable of performing an optimum start. Optimum start calculation shall be based on outside air temperature, zone air temperature deviation from zones daytime heating and cooling setpoints, and individual zone adaptive heating and cooling coefficients that are adjusted each day based on performance parameters of the individual zone. Each schedule may use identical or individual sensors in its calculations.
5. Holiday schedule shall be provided to allow operation of system based on different schedule on specified holidays. Display of Holiday schedule shall be via a monthly calendar format. Operator shall be able to scroll through months and years. Operator shall be capable of scheduling dates a minimum of 20 years into the future.
6. Event schedules shall be identical to Holiday schedule format and requirements.
7. Operator may define and setup all schedule information from system terminal, via portable computer on site or via remote communications. This includes all times, dates, and optimum start parameters. These functions shall be password protected.

## D. Logging Capabilities:

1. Each Global Controller shall log as a minimum 256 user selectable points with a minimum of 1440 samples per point. Sample time interval shall be from 1 to 1000 seconds. Sample initiation may be by any of the following conditions:
  - a. Selectable begin and end date and time
  - b. Point COS (Any system point)
  - c. Point Alarm Status (Any system point)
  - d. Schedule ON status (Weekly, Holiday or Event schedules)
2. Any point in the system whether it is real or calculated may be logged.
3. Logs may be viewed both onsite and off-site via remote communication.
4. Global controller shall periodically upload trended data to Operator terminal for long term archiving if desired.

## E. Alarm Generation:

1. Alarms may be generated for any condition of the system. This includes things such as analog point high/low alarm limits, digital point COS, communication failure to terminal unit controllers, etc. Controller shall have a minimum of 6 alarm types with 7 categories for each type.
2. Each alarm may be dialed out as noted in paragraph B. above.
3. Provide alarm log for viewing of alarms. Log may be viewed on site at the system terminal or off-site via remote communications.

## F. Demand Limiting:

1. System shall monitor energy demand. Energy demand may be from any type of energy source such as electrical or gas. Provide a Demand Limiting routine which shall shed assigned points or zones in the system to prevent the demand from exceeding preset limits. Demand limiting routine shall be a priority shed type allowing automatic override of zone or point shed when assigned temperature sensor exceeds operator set limits. Routine shall be able to change between 4 sets of demand limit and restore setpoints based on time of day or operator command.
2. Zone shed method shall be by either preventing operation of heating and cooling, or by shifting the zones heating and cooling setpoints.
3. All parameters of the Demand Limiting routine shall be modifiable from the Operators Terminal or via remote communications.

- G. Occupant Override Logging and Billing:
1. Night cycle override of zone temperature control, lighting, etc., shall be automatically logged on a zone by zone basis. Zones may be grouped into areas for totalization of all zones within the area over an adjustable time period. System shall include a billing program for creation of charges based on the billing rate and the totaled override usage from specified begin and end dates.
  2. Provide Global Controller capacity to total override usage for a minimum of 100 areas with up to 256 zones per area and 30 overrides per zone. Global controller shall periodically upload the override information to the System terminal for long term archiving and billing generation.
- H. Energy Logging:
1. Each global controller shall have ability to provide for a minimum of 10 Energy Logs. When required by specified sequence of operation, each log shall monitor an energy meter and record or calculate the following information for each Day, Month and Year:
    - a. Energy consumption
    - b. Demand peak value and time of peak
    - c. Outside air temperature minimum, maximum and average value
    - d. Heating and Cooling degree day calculation
  2. Energy meter input may be from any type of energy source such as electric or gas. Input type shall be dry contact pulse.
- I. Field Interface/Display Terminal: Provide a field interface and display terminal as located on the project plans. Field Terminal(s) shall connect to the Global controller via a two conductor RS-485 cable in a star or tee tap configuration allowing easy addition of terminals in the future. Field Terminals shall be capable of displaying and commanding any and all points in the system utilizing customizable menus and data displays. Field Terminal data displays shall be independent of Operator Terminal displays. Field Terminal operation shall not be dependent on Operator terminal operation and shall be provided by a handheld device such as a smart phone or tablet.
- J. Memory Modules: Global Controller data storage memory shall be modular, allowing additional memory to be added in the field (two modules minimum). Additional memory may be allocated by the operator to increase the storage capability of any or all routines requiring memory for storage of data. Modules shall be battery backed static RAM in Single In-line Modules (SIMM) or other easily insertable package.

## 2.04 TERMINAL UNIT CONTROLLERS:

## A. General:

1. Provide programmable and application specific Terminal Unit Controller as needed to comply with sequence of operation, point list and drawings. All Terminal Unit Controller units shall be completely stand-alone with no loss of control if communication with global controller is interrupted. All control parameters, DDC programs and local variables such as setpoint information shall be stored in EEPROM on board each Terminal Unit Controller allowing the operator to change information as desired. Controllers that utilize a battery to backup control parameters, etc., shall not be allowed.
2. All points on drawings, in sequence of operation and on point list shall be connected to and controlled by DDC units. No control shall be done by external devices such as thermostats or analog controls that are not part of the DDC system.
3. Programmable Terminal Unit Controllers shall be used in custom applications such as central plant, built up air handlers, fume hoods or when application specific controllers' sequence of operation is not applicable.
4. Communication from Global controller to Terminal Unit Controllers shall be via two wire communication trunks as specified for Global Controllers above. Any type of Terminal Unit Controller shall communicate on the same communication trunk. System shall communicate to one Terminal Unit Controller regardless of whether other Terminal Unit Controllers on the same communication line are powered and connected. Ground referenced communications is prohibited.

## B. Programmable Terminal Unit Controllers:

1. Each programmable Terminal Unit Controller shall be completely programmable from the system terminal, via field computer or via remote communications. Program execution rate shall be ten times per second minimum (once every 100 milliseconds).
2. This controller shall be programmed to perform custom strategies for system based on information from all points in the field. Program that implements these strategies shall be completely flexible and user definable. Any controllers utilizing factory programmed strategies that cannot be modified by field personnel on site, require factory assistance, or cannot be downloaded via remote communications are not acceptable. Changing strategies via firmware changes is also unacceptable.
3. Programming shall be object oriented using program blocks familiar to control specialists for all program strategies. Provide documentation in flow chart form for all programming. Include samples of flow chart documentation in submittals. All flow charts shall be generated with CAD system and automatically downloaded to controller. No re-entry of data base shall be necessary. As-Built documentation of all software shall be provided to end user in flow chart form at completion of project.

4. Program and program parameters such as set points shall be stored in EEPROM. Battery backed RAM shall not be accepted for this level of controller.
  5. All inputs shall be universal in that they accept analog and digital information. Inputs shall be capable of detecting a 0.1 second momentary closure. Analog inputs shall be capable of accepting thermistor inputs, 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA inputs. No external hardware shall need to be added for Terminal Unit Controller to accept these different types of inputs. All inputs shall utilize a minimum of 10 bit analog to digital conversion.
  6. Every digital output shall have local status indication. Outputs shall have minimum control resolution of 0.1 seconds On or Off.
  7. Each of the analog outputs shall be independently switch selectable to output 0 to 10 VDC or 4 to 20 mA. Unit shall be programmable to output a sub range of voltage or current to match the device controlled. Analog outputs shall use 8 bit digital to analog conversion.
  8. Terminal Unit Controller may be programmed to control what is displayed on zone sensor display. See section 2.4. Terminal Unit Controller may be programmed to show alpha numeric values on zone sensor display in response to program changes or button presses on the zone sensor.
  9. Each Terminal Unit Controller shall provide 24 VDC at 250 mA as a source of power for current transducer sensors in the field.
- C. Application Specific Terminal Unit Controllers:
1. Application Specific Terminal Unit Controllers shall be completely stand-alone controllers for unitary type controls such as VAV terminal boxes, heat pumps, AC units, unit ventilators, etc. All programs shall be resident in controller for complete stand-alone operation.
  2. EEPROM technology shall be used for storage of program parameters such as set points, limits, etc., controllers utilizing a battery for backup of program parameters shall not be allowed.
  3. All application specific Terminal Unit Controller units shall have capability to use Digital display zone sensor, or thermistor type zone sensor as listed in section 2.4.

## 2.05 TEMPERATURE SENSORS:

- A. General: All temperature sensors to be solid state electronic, factory calibrated to within one-half degree F, totally interchangeable. Wall sensors to be housed in enclosure appropriate for application. Duct and well sensors to be electronically identical with housing appropriate for application. Provide appropriate wells for installation by others.

- B. Zone Temperature Sensor:
  - 1. Sensor shall contain push-button bypass switch, electronic sensor, setpoint bias lever, setting adjustable wheel and jack for connection to Digital Display zone sensor for troubleshooting. The operator shall program the time of on after hours override operation from 0.0, no override, to 9.9 hours in 0. hour increments. Push buttons are to remain inactive until zone is in the afterhours mode.
  - 2. Setpoint bias shall be via labeled bias lever. Maximum bias shall be plus or minus 3 degrees F.

#### 2.06 OTHER CONTROL DEVICES:

- A. Dampers: shall be factory sizes nearest to duct size being used and shall have factory filler panels so damper assembly matches duct size. Bearings oil impregnated bronze. Provide parallel blades for positive or modulating mixing service and opposed blade for throttling service, or as specified in sequence. Maximum blade dimension 10 inches. Damper blades and damper frames galvanized. Provide blade edging and side seals for tight shutoff. Dampers shall be equal to Johnson D1200, D1300, or Ruskin CD35. Scribe end of damper drive shaft to indicate blade position.
- B. Damper actuators: Actuators to be pressure independent and sized to operate and shut valves and dampers properly against system pressures, differentials, velocities, and conditions. Damper actuators shall be sized for 80% of their published load rating including those with pilot positioners. Damper actuators shall be located to distribute operating force equally over full area of damper for uniform positioning of all blades. Quantity and size of actuators for each damper shall be listed on the shop drawings. Where damper operation and fan operation are interlocked, provide control to open damper sufficiently to prevent duct or equipment damage before fan is started. Where drawings indicate normal valve position for fail safe operation, valve actuator shall be spring return. Outside air and relief damper actuators shall also have spring return to closed position.

#### 2.07 SMOKE DETECTORS:

- A. Dual chamber ionization type with duct sampling tubes. UL approved with adjustable sensitivity. Arrange to stop associated fan on presence of smoke. Provide in return duct upstream of outside air connection and filters for all fan systems above 2000 CFM.

#### 2.08 CARBON DIOXIDE SENSORS:

- A. General: Duct-mounted carbon dioxide sensor. Infrared type.
- B. Range and Accuracy: 0 to 2,000 ppm plus or minus 100 ppm. Maximum drift plus or minus 100 ppm per year.
- C. Output Signal: 4 to 20 milliamps linearized.
- D. Calibration Interval: One year.
- E. Ambient Operating Conditions: 32°F to 122°F.

## 3 EXECUTION

## 3.01 EXAMINATION:

- A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.
- B. Notify the Owners Representative in writing of conditions detrimental to the proper and timely completion of the work.
- C. Do not begin work until all unsatisfactory conditions are resolved.

## 3.02 GENERAL INSTALLATION:

- A. Install in accordance with manufacturer's instructions.
- B. Provide all miscellaneous devices, hardware, software, interconnections installation and programming required to insure a complete operating system in accordance with the sequences of operation and point schedules.

## 3.03 LOCATION AND INSTALLATION OF COMPONENTS:

- A. Locate and install components for easy accessibility; in general, mount 60 inches above floor with minimum 3'-0" clear access space in front of units. Obtain Owner Representative's approval on locations prior to installation.
- B. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration and high temperatures.
- C. Identify all equipment and panels. Provide permanently mounted tags to all panels.
- D. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections; sized to suit pipe diameter without restricting flow.

## 3.04 INTERLOCKING AND CONTROL WIRING:

- A. Provide all interlock and control wiring. All wiring shall be installed in a neat and professional manner in accordance with all state and local electrical codes.
- B. Provide wiring as required by functions as specified and as recommended by equipment manufacturers, to serve specified control functions.
- C. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the Owner's Representative prior to rough-in.
- D. Provide auxiliary pilot duty relays on motor starters as required for control function.
- E. Provide power for all control components from nearest electrical control panel or as indicated on the electrical drawings, coordinate with electrical contractor.

- F. All control wiring in the mechanical, electrical, telephone and boiler rooms to be installed in raceways. All other wiring to be installed in a neat and inconspicuous manner per local code requirements.
- G. Where Class 2 wires are in concealed and accessible locations; including ceiling return air plenums, approved cables outside of electrical raceway can be used provided that the following conditions are met:
  - 1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
  - 2. All cables shall be UL listed for application (i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose).
- H. Do not install Class 2 wiring in conduits containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two via control relays and transformers.
- I. Where Class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 3 m [10 ft] intervals. Such bundled cable shall be fastened to the structure, using industry approved fasteners, at 1.5 m [5 ft] intervals or more often to achieve a neat and workmanlike result.
- J. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- K. Maximum allowable voltage for control wiring shall be 120Vac. If only higher voltages are available for use, the BAS manufacturer shall provide step-down transformers to achieve the desired control voltages.
- L. All control wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.
- M. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with Contract Documents and National and/or Local Codes.
- N. Conduit and wire sizing shall be determined by the BAS manufacturer in order to maintain manufacturer's recommendation and must meet National and Local Codes.
- O. Control and status relays are to be located in pre-fabricated enclosures that meet the application. These relays may also be located within packaged equipment control panel enclosures as coordinated. These relays shall not be located within Class 1 starter enclosures.
- P. Follow manufacturer's installation recommendations for all communication and network bus cabling. Network or communication cabling shall be run separately from all control power wiring.

- Q. BAS manufacturer shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- R. Flexible metal conduits and liquid-tight flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

### 3.05 DDC POINT SUMMARY:

- A. Provide all Data-base generation.
- B. Displays: System displays shall show all points in the system. They shall be logically laid out for ease of use by the owner. Provide outside air temperature indication on all system displays associated with economizer cycles.
- C. Run time Totalization: At a minimum, run time totalization shall be incorporated for each monitored supply fan, return fan, exhaust fan, hot water and chilled water pumps. Warning limits for each point shall be entered for alarm and or maintenance purposes.
- D. Trend Log: All binary and analog points shall have the capability to be trended.
- E. Alarm Points: All analog inputs (High/Low Limits) and selected digital input alarm points shall be prioritized and routed/auto-dial with alarm message per owner's requirements.
- F. Database Save: Provide back-up database for all stand-alone DDC panels on floppy disk.
- G. Provide all points required in above specification and in point schedule, included in this specification.

### 3.06 FIELD SERVICES:

- A. Prepare and start DDCS under provisions of this section.
- B. Start-up and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.
- C. Provide the capability for off-site monitoring at Control Contractor's local or main office. At a minimum, off-site facility shall be capable of system diagnostics and software download. Owner shall provide phone line for this service.
- D. Provide Owner's Representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.

### 3.07 TRAINING:

- A. Provide application engineer to instruct owner in operation of systems and equipment.

- B. Provide basic operator training for a minimum of 3 persons on data display, alarm, and status descriptors, requesting data, execution of commands and request of logs.
- C. Provide training above as required up to 40 hours as part of this contract.

#### 3.08 DEMONSTRATION:

- A. Provide systems demonstration under provisions of Section 15010.
- B. Demonstrate complete and operating system to Owner's Representative.
- C. Provide certificate stating that control system has been tested and adjusted for proper operation.

### 4 SEQUENCE OF OPERATION

#### 4.01 ROOFTOP AIR HANDLING UNITS:

- A. Run AHU system during occupied schedules, override, warm-up/cool down cycle, or night low limit modes of operation.
- B. When AHU system is off, supply fan off, outside air damper closed, return air damper full open, relief air damper closed.
- C. When AHU system is on during occupied mode, start AHU supply fan. In sequence modulate heating to maintain 90°F discharge supply temperature, modulate outside - return - relief air dampers to provide minimum ventilation amount as called for by CO2 sensor. Control outside - return - relief air dampers as required for free outside air economizer cooling. CO2 sensor shall reduce ventilation amounts below design levels as allowed by number of people in areas served. Design ventilation amount is upper level of ventilation allowed (except as called for by economizer cooling cycle). Ventilation minimum is the least allowed by Oregon Mechanical Code to still maintain area required ventilation amounts. When outside air temperature is greater than return air, discontinue economizer control and maintain minimum outside air. Limit discharge supply air temperature to a low limit of 50°F.
- D. Reset discharge supply air temperature as possible to just satisfy space heating requirements for maximum energy savings.
- E. Provide ionization type duct smoke detector(s) as required in the IMC for automatic fan shut down, and stop AHU when smoke is detected. Also stop AHU when fire alarm system initiates an alarm condition.
- F. During unoccupied schedules, stop AHU and reduce room temperature set point to a night low limit setting selected by Owner. If space temperature served by AHU drops below the night low limit temperature, start heating and run AHU only in a night low limit mode, providing heat only, with outside and relief dampers closed and return dampers full open until space temperature returns to the night low limit setting. When unoccupied mode changes to occupied, by time schedule or override, outside and relief dampers shall remain closed in a "warm up/cool down" cycle until space temperature reaches the occupied set point.

- G. Manual override of the unoccupied operating mode and night set back temperature is accomplished at room sensor. Override is for an adjustable, timed period of 1 hr, 2 hr, 3 hr, etc. as requested by Owner. During override operation AHU shall operate same as the occupied mode described above. Zone set point temperature shall be changed to occupied set point.
  - H. Space temperature, supply air temperature and supply air reset schedule, outside air temperature, damper positions, damper minimum positions, supply fan status, CO2 ppm, smoke detectors, heating stages and all setpoints for above items as applicable may be set and verified at operator terminal.
  - I. AHU shall have the ability to operate in night purge mode as required to lower space temperature prior to occupancy in morning.
- 4.02 EXHAUST/SUPPLY FANS:
- A. Start/stop exhaust and supply fans based on time schedule or space temperature as indicated in Drawings.
  - B. Fan start/stop, space temperature, time schedules and associated setpoints as applicable may be set and verified at operator terminal.

END OF SECTION

**1 GENERAL****1.01 WORK INCLUDED:**

- A. Provide air distribution equipment as specified herein and shown.
- B. Equipment capacity and size shall be as shown.

**1.02 QUALITY ASSURANCE:**

- A. Ductwork: Comply with requirements of the State Mechanical Specialty Code (latest edition).
- B. Field Wiring: Comply with requirements of Section 23 0000.
- C. Codes: Refer to Section 23 0000.

**1.03 SUBMITTALS:**

- A. Refer to Section 23 0000.
- B. Provide submittals for the following:
  - 1. Spiral ductwork.
  - 2. Flexible ductwork.
  - 3. Dampers.
  - 4. Grilles, Registers and Diffusers.
  - 5. Louvers.

**1.04 DELIVERY, STORAGE AND HANDLING:**

- A. Deliver product to site under provisions of Section 23 0000.
- B. Store and protect products under provisions of Section 23 0000.
- C. Store all ductwork, materials on pallets or above grade, protected from weather, dirt, mud and other construction dust.
- D. Remove all accumulated dust, dirt, etc. from each duct section as it is being installed.

**2 PRODUCTS****2.01 DUCTWORK:**

- A. Galvanized steel sheet metal: Metal gauges, joints, and reinforcement in accordance with mechanical Code, ASHRAE and SMACNA tables and recommendations.

- B. Spiral Seam Duct: Round and flat oval spiral seam duct shall be manufactured of galvanized steel sheet metal with spiral lock seam. Matching fittings shall be manufactured of galvanized steel with spot welded seams. United Sheet Metal, Semco, Rolock, Metco or accepted substitute.
- C. Flexible Ductwork: Insulated low pressure flexible duct, factory fabricated assembly consisting of a zinc coated spring steel helix, seamless inner liner, wrapped with a nominal one inch thick, one pound per cubic foot density fiberglass insulation. The assembly shall be sheathed in a vapor barrier jacket, factory sealed at both ends of each section assuring the vapor resistance of each section as well as the completed installation. The composite assembly, including insulation and vapor barrier, shall meet the Class I requirements of NFPA 90A and be labeled by UL with a flame spread rating of 25 or less and a smoke developed rating of 50 or under. The duct shall have factory sealed double air seal (interior and exterior), to assure an airtight installation. Genflex, Wiremold, Thermaflex or accepted substitute.

#### 2.02 ACOUSTICAL DUCT LINING:

- A. Line ducts with 1 inch thick, Johns Manville "Permacote Linacoustic" R-300, meeting NFPA 90A requirements for maximum flame spread and smoke developed. Gustin Bacon, Owens Corning or accepted substitute. Air side surface protected with acrylic coating, impervious to dust and dirt, will not support microbial growth, rated for 5,000 FPM air velocity. Mechanically attach lining to sheet metal duct with Johns Manville Grip Nails or Gramweld welding pins. Apply fire retardant type adhesive similar to Johns Manville No. 44 adhesive, Benjamin Foster 81-99, Insul-Coustic 22 or 3M equivalent on all leading edges, joints and seams.

#### 2.03 DUCT SEALING:

- A. Aluminum bonded to aluminized mylar reinforced with fiberglass mesh backing an elastomeric pressure sensitive adhesive specifically formulated for adhesion to galvanized metal. Hardcast "AFG-1402" with "HD-181" degreaser or accepted substitute.
- B. Two-part sealing system with woven fiber, mineral gypsum impregnated tape and non-flammable adhesive. Hardcast "DT-5300" tape and "RTA-50" adhesive or United "Uni-Cast" system or accepted substitute.
- C. Duct Joints for Sheet Metal Ducts: "Ductmate System" by Ductmate Industries, Inc., for making transverse rectangular and round duct joints. Ward Duct Connectors, Inc., MEZ, Lockformer TDC or accepted substitutes.

#### 2.04 ACCESSORIES:

- A. Manual Volume Dampers: Construct of material two gauges heavier than duct in which installed; single plate up to 12 inches wide; multiple over 12 inches wide. Hem both edges 1/2 inch and flange sides 1/2 inch. Provide regulator extension through sheet rock ceiling with concealed adjustable cover. Use Young, DuroDyne or accepted substitute damper accessories.

- B. Backdraft Dampers: Connected, felt-edged aluminum blades set in 14 gauge or heavier steel frame; brass, nylon or teflon bearings; equip with spring helper with tension adjustment feature or with adjustable counterweight and adjust to open when not more than 0.10 inch wg pressure is applied. Ruskin CBD-4, Pacific Air Products, Air Balance, Controlair or accepted substitute.
- C. Splitter Dampers: Same specification as manual volume dampers except blade dimension in direction of air flow to be minimum 12 inches in all cases. Location as shown. Splitter damper operators shall be as shown in SMACNA Low Velocity Duct Manual.
- D. Opposed Blade Damper: Install opposed blade dampers where shown. Young No. 817 or accepted substitute.
- E. Fire Dampers: Constructed and installed in accordance with NFPA, UMC and UL labeled. Provide dynamic fire dampers with 1-1/2 hour fire protective rating; locate fusible links for easy service or replacement; provide access panels of proper fire rating as required. Fusible links to be rated at 160°F. Fire damper assembly to be selected at a maximum pressure drop of 0.05 inches w.g. Provide dampers to maintain free area through damper same as unobstructed run of duct. American Warming, Dowco, Krueger, Ruskin, Phillips-Aire, Tuttle and Bailey, Prefco, Greenheck, Ultrasafe, Safe Air, National Controlled Air, Air Balance or accepted substitute.
- F. Combination Air-Smoke-Fire Dampers: Constructed and installed in accordance with NFPA, UMC and UL labeled. Fire damper functions to be as specified previously. Provide with factory mounted 120 volt operating motor where utilized as smoke damper. Smoke damper to be shaft operated. Prefco, Safe Air, National Controlled Air, Air Balance, Greenheck, Ruskin or accepted substitute.
- G. Access Doors: In sheet metal work, hollow core double construction of same or heavier gauge material as duct in which installed. Use no door smaller than 12 inches by 12 inches for simple manual access or smaller than 18 inches by 24 inches where personnel must pass through infrequently. Use 24 inches by 60 inches minimum for filters and more frequent maintenance. Use Ventlok or approved hinges and latches on all doors; 100 series hinges and latches on low pressure system doors up to 18 inches maximum dimension, 200 series on larger low pressure system doors and 333 series on high pressure systems. Construct doors up to 18 inches maximum dimension with one inch overlap fit and gasket with 3/4 inch by 1/8 inch sponge rubber; fit larger doors against 1-1/2 inches by 1/8 inch flat stock or angle frame and gasket with 3/4 inch by 1/8 inch sponge rubber or felt. Door swing to be opposite airflow.
- H. Fan and Air Handling Unit Flexible Connections: Install neoprene impregnated fiberglass connections in ductwork at all rotating equipment. Ventglass, Duro-Dyne or accepted substitute.
- I. Control Dampers: Provide automatic control dampers as indicated. Airfoil, multi-blade type with a maximum blade width of 48 inches. Blades to be interlocking, minimum 16 gauge. Continuous shafts to provide for "tracking" of all blades. Maximum air leakage of 4 CFM per sq. ft. at 1.0 inches water gauge. Provide damper actuator. Alerton, Honeywell, Johnson Control, Seimens, Trane or accepted substitute.

#### 2.05 GRILLES, REGISTERS AND DIFFUSERS:

- A. Description: Provide grilles, registers and diffusers as shown.
- B. Finish:
  - 1. Steel: Baked-on white enamel finish, or flat white prime coat, factory applied. Verify the exact finish type with architectural drawings.
  - 2. Aluminum: Clear anodized.
- C. Manufacturers: Air Devices, Anemostat, Carnes, Krueger, Tuttle & Bailey, Price Co., Metalaire are accepted substitutes where Titus model numbers only are listed.

#### 2.06 LOUVERS:

- A. Frame and sill styles compatible with adjacent substrate, specifically manufactured to fit into construction openings with accurate fit and adequate support for weatherproof installation. Construct of aluminum extrusions, ASTM B221. On inside face of exterior louvers, provide aluminum screen mounted in frames. Blades on 4-inch centers with rain stop design.
- B. Manufacturers: American Warming and Ventilating, Inc., Pottorff, United Metal Products, Carnes, Cesco, Industrial Louvers, Inc., Louvers & Dampers, Inc., Ruskin, Greenheck or accepted substitute.

#### 2.07 OPERABLE LOUVERS:

- A. Provide and install operable louver with rain stop design. Blades on 4-inch center. Furnish with aluminum screen on inside face in frame, duct collar and flanged frame. Provide all linkages required for one point motor operation.
- B. Manufacturers: American Warming and Ventilating, Inc., Pottorff, United Metal Products, Carnes, Cesco, Industrial Louvers, Inc., Louvers & Dampers, Inc., Ruskin, Greenheck or accepted substitute.

### 3 EXECUTION

#### 3.01 LAYOUT AND COORDINATION:

- A. Site Examination: Before starting work, carefully examine site and all contract drawings. Become thoroughly familiar with conditions governing work on this project.
- B. Utility Locations: The location of all utilities, wires, conduits, pipes, ducts, or other service facilities are shown in a general way only on the drawings.

#### 3.02 INSTALLATION:

- A. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube opening where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation materials inside a metal ring.

- B. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- C. Provide manual volume dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts for air balancing. Use splitter dampers only where shown. Location of all volume dampers are not necessarily shown on the drawings.
- D. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment.
- E. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where shown.
- F. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, and elsewhere as indicated. Provide minimum 12 inches x 12 inches size for hand access, 18 inches x 24 inches size for shoulder access and as indicated. Install necessary access openings and covers for cleaning, wiring or servicing motors, fire dampers, filters, fans, both entering and leaving air sides of coils, and to other equipment located within or blocked by ductwork.
- G. Support: Install ductwork with 1 inch wide 16 gauge cradle hangers not more than 8 feet c/c or as required by code. Support terminal units independent of adjacent ductwork. Attach to available building construction as per good practices for materials involved. Exposed ductwork shall be supported by closed cradle strap suspended from 3/8 inch threaded rod.
- H. Connection Fittings: Round connections to rectangular ducts manufactured sheet metal "spin-in" fittings. Genflex, Wiremold, Thermaflex, Glassflex, Clevepak, Manville, or accepted substitute.
- I. Elbows and Fittings: Construct elbows with throat radius equal to duct width in plane or turn or make them square and provide double wall, air foil turning vanes.
- J. Fittings: Make transitions and take-offs as shown. Provide volume dampers and splitter dampers as shown and as specified.
- K. Sleeves: Provide galvanized sheet metal plaster ring around ductwork penetrating exposed finished walls. Sleeve and flash all duct penetrations through exterior walls in an airtight and weatherproof manner.
- L. Plenums: Construct sheet metal plenums and partitions of not lighter than 18 gauge galvanized steel and reinforce with 1-1/2 inch by 1/2 inch by 1/8 inch angles as required to prevent drumming or breathing.
- M. Acoustical Duct Lining: Acoustically line all outside air ducts and plenums, all fan unit intake and discharge plenums, all ductwork indicated as lined on the Drawings.
- N. Manual Volume Dampers: Location of all volume dampers are not necessarily shown. Provide a minimum of one volume damper in each supply, return or exhaust branch.

- O. Duct Insulation: Insulate all ductwork per Section 23 0700 as requiring insulation. In addition, all ductwork indicated in Table No. 13-S of the Structural Specialty Code and Fire and Life Safety Regulations shall be insulated or lined.
- P. Flexible Ductwork: Support hanger or saddle material in contact with duct shall be of sufficient width to prevent any restriction of the internal diameter of the duct, and in no case less than 1 inch wide. Maximum sag to be 1/2 inch per foot of spacing between supports. Flexible ducts shall be installed in a fully extended condition free of kinks with no direction change to exceed 90 degrees, using only the minimum length required to make the connection with a maximum length of 24 inches. Sheet metal collars to which the duct is attached shall be a minimum of 2 inches long. Flexible duct shall be inserted into the collar a minimum of 1 inch and inner liner secured with a minimum 1/2 inch wide positive locking steel strap. In ducts larger than 12 inches diameter, steel strap must be secured by beading. Reshape insulation and vapor barrier over duct and collar and secure using drawband. Attachment of joints is similar using a minimum of 4 inches long collar.
- Q. Exposed ductwork joints shall be sealed with "Ductmate System".
- R. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

### 3.03 ADJUSTING AND CLEANING:

- A. Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

END OF SECTION

## 1 GENERAL

## 1.01 WORK INCLUDED:

- A. Provide equipment as specified herein and shown on the Drawings.
- B. Equipment capacity and size as indicated in the equipment lists on the Drawings.

## 1.02 QUALITY ASSURANCE:

- A. Air Handling Equipment: Rated in accordance with AMCA certified rating procedures and AMCA labeled.
- B. Air Conditioning and Refrigeration Equipment Rating: Rated in accordance with ARI certified rating procedures and AMCA labeled.
- C. Codes: Refer to Section 23 0000.

## 1.03 SUBMITTALS:

- A. Submit product data under provisions of Section 23 0000.
- B. Submit product data for manufactured products and assemblies required for this project.
- C. Indicate electrical service and duct connections on product data.
- D. Submit manufacturer's installation instructions under provisions of Section 23 0000.
- E. Provide Submittals for the following:
  - 1. Packaged Rooftop Air Conditioning Units.

## 1.04 DELIVERY, STORAGE AND HANDLING:

- A. Deliver product to site under provisions of Section 23 0000.
- B. Store and protect product under provisions of Section 23 0000.
- C. Store insulation in original shipping container with labeling in place. Do not install damaged insulation.

## 1.05 OPERATION AND MAINTENANCE DATA:

- A. Submit operation and maintenance data under provisions of Section 23 0500.
- B. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

## 2 PRODUCTS

## 2.01 PACKAGED ROOFTOP AIR CONDITIONING UNITS (3-20 TONS):

- A. Manufacturers: Trane, Carrier, McQuay, Luxaire, Lennox or approved substitution.
- B. Performance: Unit shall be selected within +/-5% of cooling and heating capacity scheduled. Unit shall be providing EER, IPLV, fan BHP efficiencies at or better than scheduled values.
- C. Unit: Single piece packaged rooftop combination heating and cooling unit. Unit factory assembled, piped, charged with refrigerant, wired and tested. Factory run tested to include the operation of all fans, compressors, heat exchangers, and control sequences. Factories adhere labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.
- D. Cabinet: Zinc coated galvanized steel to be finished with weather-resistant enamel finish. Unit surface shall withstand 600 hours in a salt spray test in compliance with ASTM B117. Unit to have downflow supply and return with duct connections made fully inside roof curb. The unit base shall have provisions for crane lifting lugs. Unit to include outside air intake hood. Roof panels shall be sloped to provide positive drainage of rainwater / melting snow away from the cabinet.
- E. Service Access: Access panels shall be hinged or quick lift out with no more than two screws and provide a water and airtight seal.
- F. Supply Fan: Forward curved, double width, double inlet, centrifugal type supply fan with self-aligning, grease lubricated ball or sleeve bearings with permanent lubrication fittings. Belt drive with fixed pitch sheaves on units 3 tons and larger, direct drive allowed only on units 2.5 tons and smaller. Provide one set of replacement sheaves if needed by air balancer. Provide thermal overload protection on motor.
- G. Gas Heating Section: Completely assembled and wired gas fired heating system with aluminized steel heat exchanger, electronic ignition, centrifugal combustion blower, continuous flame safety, automatic gas valve and manual gas shut-off valve. Designed and tested for use constant airflow with entering air down to 45 degrees. Two-stage natural gas heating when heating output is greater than 140 MBH.
- H. Refrigeration System: Direct drive hermetic scroll compressors with centrifugal type oil pumps. All compressors to include internal temperature and current-sensitive motor overloads. Crankcase heaters to be included on units 6-tons and above. Compressors shall be isolated from casing with suitable vibration isolation. Direct drive propeller condenser fans to include permanently lubricated bearings and built-in thermal overload protection. Aluminum fin DX cooling coil with moisture carryover management system. Condensate pan shall be sloped & pitched with not standing water. Condenser coil with plate type aluminum fin, maximum 16 fins per inch for cleanability. Refrigeration system suitable for ambient operation down to 0 degrees F in case of economizer failure. Refrigeration system suitable for ambient operation up to 125 deg F. Evaporator and condenser coils leak tested to 600psi.

- I. Economizer: Provide a fully integrated 100% modulating outside air economizer with return and outside air dampers. Damper operator shall be spring return and close outside air damper on power loss. Economizer controls shall utilize outdoor dry bulb temperature to enable economizer operation. Outside air shall be locked out during unoccupied and morning warmup conditions. Provide adjustable minimum position control.
- J. Electrical: Units shall be UL listed and label as a complete assembly. Provide single control panel with weatherproof control panel, single point electrical connection, suitable overload protection for each branch circuit, contactors for each motor & compressor, fused control power transformer. Provide wiring diagrams, affixed to access door. Provide factory thru-the-base electrical with power and control wiring requiring no outdoor or external wire and conduit. Include factory mounted and wired, externally accessible, disconnect. Provide factory unpowered convenience.
- K. Controls: Factory controls to include devices and wiring necessary for unit operation on a standalone basis for service checkout and operation before control installation is complete. This system shall consist of contactors, transformers, two minute supply fan anticycle timer, compressor min ON and OFF anticycle timers, condenser fan anticycle timers, heat anticycle timers, and refrigeration safeties factory wired and tested. Controls shall provide fully integrated, dry bulb initiated, economizer control that allows compressor operation to supplement free cooling. Unit control shall interface with controller specified under division 23 0923.
- L. Unit Options:
  - 1. Adaptor curb to attach to existing plenum curbs.

### 3 EXECUTION

#### 3.01 EXAMINATION:

- A. Verify that building is ready to receive work and opening dimensions are as illustrated by the manufacturer.
- B. Verify that proper power supply is available.

#### 3.02 INSTALLATION:

- A. Install in accordance with manufacturer's instructions and applicable code.
- B. Lubricate all moving and rotating parts in accordance with manufacturer's recommendation prior to start-up.
- C. All roof mounted mechanical equipment shall be supported and seismically anchored on leveled, flashed and counterflashed curbs anchored to resist seismic forces and suitable for the roof construction. Minimum curb height shall be 12 inches above the roof unless otherwise noted. Flashing into the roof is specified in another Section.

- D. Make all electrical and duct penetrations for each equipment within the curb unless shown otherwise on the Drawings. Piping and electrical conduit routed above and across the roof shall be supported on flashed and counterflashed curbs with pipe guides anchored to the curbs in "pitch pockets." Submit shop drawings on other arrangements for approval.

3.03 FILTERS:

- A. New filters shall be installed in units prior to air balancing and project acceptance.

END OF SECTION