

SECTION 23 00 00

BASIC MECHANICAL REQUIREMENTS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SECTION INCLUDES

- A. Basic mechanical requirements necessary to provide complete installation of all Division 23 work.

1.3 WORK INCLUDED

- A. This section of work comprises furnishing of all materials, equipment, tools, scaffolding, rigging, hoisting, labor and transportation necessary for the complete installation of the mechanical systems as shown on the plans and as specified herein.
- B. Bidders shall determine the contents of a complete set of drawings and specifications and be aware that they may be bidding from a partial set of drawings, applicable only to the various separate contracts, subcontracts, or trades as may be issued for bidding purposes only. The contract documents and the complete scope of work for the project are illustrated on the combined Architectural, Structural, Plumbing, Heating, Ventilating, Air Conditioning and Electrical, and each Bidder shall thoroughly acquaint himself with all the details of the complete set of drawings and specifications before submitting his bid. All drawings and specifications form a part of the contract documents for each separate contract and shall be considered as bound therewith in the event partial sets of plans and specifications are issued for bidding only. The submission of bids shall be deemed evidence of the review and examination of all drawings, specifications, and addenda issued for this project as no allowances will be made because of unfamiliarity with any portion of the complete set of documents.

1.4 CODES & REFERENCE STANDARDS

- A. General:
 - 1. Perform all Division 23 work in strict accordance with the requirements and recommendations stated in the codes and standards except when requirements are modified by the contract documents.
 - 2. Nothing in the Contract Documents shall be construed to permit work not conforming to these codes.
 - 3. When two or more codes or standards are applicable to the same work, then the stricter code or standard shall govern.
 - 4. The date of the code or standard that is in effect on the date of issue of the contract documents except when a particular publication date is specified.
 - 5. The Contractor shall be held responsible for verifying all local codes and ordinances that may alter any part of the plans or specifications. The Contractor shall bear all costs for correcting the deficiencies.
 - 6. Where local codes and ordinances are not in writing or on record but a local precedence has been set, the Owner shall pay for any additional cost incurred.
- B. Applicable Codes and Standards for All Division 23 Work:
 - 1. International Building Code

2. International Gas Code
3. International Plumbing Code
4. International Mechanical Code
5. International Energy Conservation Code
6. National Electrical Code
7. American Society of Heating, Refrigerating and Air Conditioning Engineers Standards.
8. Occupational Safety and Health Administration Standards:
 - a. OSHA Standard 2207 - Construction Industry Standards
 - b. OSHA 29 CFR Part 1926 – Regulation of Excavation
 - c. Texas Underground Facility Damage Prevention Act (H.B. 2295)
 - d. All other applicable standards
9. National Fire Protection Association:
 - a. NFPA No. 90A Installation of Air Conditioning and Ventilating Systems
10. Texas State Board of Insurance Standards
11. Clean Air Act and Clean Air Act Amendments
12. State Codes:
 - a. Texas Department of Labor Boiler Rules and Regulations
 - b. All other applicable codes
13. Local Municipal Codes and Ordinances

1.5 SCHEDULE OF ABBREVIATIONS

- A. Reference Standards are listed in Section 23 using abbreviations listed below:
- | | |
|--------|---|
| AABC | Associated Air Balance Council |
| AASHTO | American Association of State Highway and Transportation Officials |
| ADA | Americans with Disabilities Act |
| ADC | Air Diffusion Council |
| A/E | Architect/ Engineer |
| AGA | American Gas Association |
| AMCA | Air Moving and Conditioning Association |
| ANSI | American National Standards Institute |
| AHRI | Air-Conditioning and Refrigeration Institute |
| ASHRAE | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| ASME | American Society of Mechanical Engineers |
| ASPE | American Society of Plumbing Engineers |
| ASTM | American Society for Testing and Materials |
| AWE | American Welding Society |
| AWWA | American Water Works Association |
| CGA | Compressed Gas Association |
| CISPI | Cast Iron Soil Pipe Institute |
| CS | Commercial Standard |
| CSA | Canadian Standards Association |
| DIPRA | Ductile Iron Pipe Research Association |
| DOT | Department of Transportation |
| DOC | Department of Commerce |
| FCC | Federal Communications Commission |
| FM | Factory Mutual |
| FS | Federal Specification |
| GSHPA | Ground Source Heat Pump Association |
| IBC | International Building Code |
| ITL | Independent Testing Laboratories |
| NEC | National Electric Code |
| NFPA | National Fire Protection Association |
| NSF | National Sanitation Foundation |
| OSHA | Occupational Safety and Health Administration |

PDI	Plumbing and Drainage Institute
SMACNA	Sheet Metal and Air Conditioning National Association
TCEQ	Texas Commission on Environmental Quality
TDH	Texas Department of Health
TWC	Texas Water Commission
UBC	Uniform Building Code
UL	Underwriters Laboratories

1.6 QUALITY ASSURANCE

- A. Provide complete installations of all systems.
- B. Furnish all items of equipment, material, and labor to complete the Contract even though each and every item necessary is not specifically mentioned or shown.
- C. In case of any conflict between the specifications, plans and ordinances, the ordinances shall govern.
- D. All materials furnished under this Contract shall be new, free from defects of any kind, of the quality and design hereinafter specified, and shall conform to the standards of Underwriter's Laboratories Inc., except for equipment which U.L. does not list or provide label service.
- E. All mechanical equipment and fixtures shall be the same brand unless scheduled differently on plans.
- F. Contractor's Responsibility:
 - 1. Erect barricades, protective fencing, and signs to prevent injury to personnel on site.
 - 2. Make permanent connection to utilities or existing lines. Determine depth and location and bid accordingly.
 - 3. Relocate and repair any existing lines cut by general construction work.
 - 4. Pay all costs in connection with metering devices.
 - 5. Plans do not show exact location and elevations of lines, nor do they show all offsets required.
 - 6. Deviate from plans as required to conform to the general construction and provide proper grading.
 - 7. Maintain all utility services during construction to existing portions of job that remain.
 - 8. Procure and pay for all necessary permits or licenses to carry out the work.
 - 9. Obtain and pay for all the necessary certificates of approval which must be delivered to the A/E before final acceptance of the work.
 - 10. Periodically remove rubbish, clean or repair all surfaces marred by the work required under this contract.
 - 11. Protect work from damage by other trades.
 - 12. Make all tests required by law; pay all costs in connection with the testing.
 - 13. Where job conditions require changes in indicated locations and arrangement, make such changes without extra cost to Owner.
 - 14. Provide motor starters, controls, relays, all low-voltage wiring, conduit and wiring related to HVAC and other equipment and devices to form a complete working system. See Section 26 00 00.

1.7 DEFINITIONS

- A. Approval:
 - 1. It is understood that approval must be obtained from the A/E in writing before proceeding with the proposed work.

2. Approval by the A/E of any changes, submitted by the Contractor will be considered as general only to aid the Contractor in expediting his work.
- B. Contractor:
1. The Contractor engaged to execute the work included in a particular section only, even though he may be technically described as a Subcontractor to the General Contractor.
 2. If the Contractor engaged to execute said work employs Sub-Contractors to perform various portions of the work included under this Section, he shall be held responsible for the execution of same, in full conformity with Contract Document requirements.
 3. The Contractor shall cooperate at all times and shall be responsible for the satisfactory cooperation of his Subcontractors with the other Contractors on the job so that all of the various phases of the work may be properly coordinated without unnecessary delays or damage to any parts of the work of any Contractor.
- C. Provide:
1. Defined as requiring the furnishing and installing of the item or facility indicated, complete in all respects and ready for operation unless otherwise specifically noted.

1.8 WARRANTY

- A. The Contractor shall warranty his work against defective materials and workmanship for a period of one year from date of acceptance of the job.
- B. Neither the final payment nor any provisions in Contract Documents shall relieve the Contractor of the responsibility for faulty materials or workmanship.
- C. He shall remedy any defects due thereto and pay for any damage to other work resulting therefrom, which shall appear within a period of one year from date of substantial completion.
- D. The Owner shall give notice of observed defects with reasonable promptness.
- E. This Guarantee shall not be construed to include the normal maintenance of the various components of the system covered by these specifications.

1.9 SITE VISIT

- A. Before submitting his proposal, each bidder shall examine all plans and specifications relating to the work, shall visit the site of the project and become fully informed of the extent and character of the work required.
- B. No consideration will be granted for any alleged misunderstanding of the materials to be furnished or the amount of work to be done, it being fully understood that the tender of a proposal carries with it the agreement to all items and conditions referred to herein, or indicated on the accompanying plans or required by nature of the site of which may be fairly implied as essential to the execution and completion of any and all parts of the work.

1.10 SUBMITTALS

- A. Refer to Section 23 00 90 for submittal procedures.

1.11 PROJECT RECORD DOCUMENTS

- A. The Contractor shall keep a set of plans on the job, noting daily all changes made in connection with the final installation including exact dimensioned locations of all new and uncovered existing utility piping outside the building.

- B. Upon submitting his request for final payment, he shall turn over to the A/E, for subsequent transmittal to the Owner, a clean, neatly marked set of reproducible plans showing "as installed" work and an electronic file with changes of materials.
- C. In addition to the above, the Contractor shall accumulate during the job's progress the following data, in duplication (2 each), prepared in 3 ring binders of sufficient size, black in color, neat in appearance, and turned over to the A/E for checking and subsequent delivery to the Owner. Electronic copies of the following are also acceptable, but they must be saved to a single flash drive or external hard drive:
 - 1. All warranties, guarantees and manufacturer's directions on equipment and material covered by the Contract.
 - 2. Approved fixture brochures.
 - 3. Copies of approved shop drawings.
 - 4. Set of operating instructions. Operating instructions shall also include recommended maintenance and seasonal changeover procedures.
 - 5. Any and all other data and/or plans required during construction.
 - 6. Repair parts lists of all major items and equipment including name, address and telephone number of local supplier or agent.
- D. The first page, or pages, shall have the names, addresses, and telephone numbers of the following:
 - 1. General Contractor and all sub-contractors.
 - 2. Major Equipment Suppliers.

1.12 TRAINING

- A. Upon completion of the work and at a time designated by the Owner's representative, provide a formal training session for the Owner's operating personnel to include location, operation, and maintenance of all mechanical equipment and systems, some sections have further instructions.
- B. Before proceeding with instruction, prepare a typed outline in triplicate listing the subjects that will be covered. Submit the outline for review by the Owner's representative.
- C. At the conclusion of the instruction, obtain the signatures of the attendees on each copy of the outline to signify that they have a proper understanding of the operation and maintenance of the system. Submit the signed outlines to the Owner's representative and Engineer as a condition of final acceptance.

1.13 PLANS AND SPECIFICATIONS

- A. The plans show diagrammatically the locations of the various lines, ducts, conduits, fixtures, and equipment and the method of connecting and controlling them.
- B. It is not intended to show every connection in detail and all fittings required for a complete system.
- C. The systems shall include but are not limited to the items shown on the plans.
- D. Exact locations of these items shall be determined by reference to the general plans and measurements of the building and in cooperation with other contractors, and in all cases, shall be subject to the approval of the A/E.

- E. The A/E reserves the right to make any reasonable change in the location of any part of this work without additional cost to the Owner.
- F. Contractor, subcontractor, vendors and suppliers are required to waive subrogation against Owner and Engineer.

1.14 UTILITIES, LOCATIONS, AND ELEVATIONS

- A. Locations and elevations of the various utilities within the scope of this work have been obtained from the City and/or other substantially reliable sources and are offered separately from the Contract documents, as a general guide only, without guarantees as to accuracy.
- B. The Contractor shall examine the site, shall verify to his own satisfaction the locations, elevations and availability of all utilities and services required, and shall adequately inform himself as to their relation to the work; the submission of bids shall be deemed evidence thereof.
- C. The Contractor shall coordinate all services with the Utility Companies during construction, coordinate changes made by Utility Companies to the design of project, and coordinate with the Owner, A/E, and Utility the scheduling of any shutdowns or delays that may occur in providing service.
- D. The Contractor shall verify location, conduct all necessary tests, inspections, coordinate with Owner's representatives and utilities, and check for existing underground utilities and lines before ditching.
- E. The Contractor shall be responsible for repair of any cut or damaged lines or utilities he uncovers. There are lines and utilities not shown on any plans.

1.15 SUBSTITUTION OF PRODUCTS

- A. Substitution of products specified herein will be considered only when a complete list of proposed alternative equipment is submitted to the Engineer in writing, supported by adequate technical and cost data. This includes a complete description of the proposed substitution, drawings, catalog cuts, performance data, test data, or any other data or information necessary for evaluation.
- B. All proposed substitutions and data must be received by the Engineer no less than ten working days prior to the schedule date for opening of bids.
- C. The Engineer will consider all such submittals and the A/E will issue an addendum listing items which the Engineer considers acceptable. Only such items as specified or approved as acceptable will be installed on this project.
- D. Manufacturers' names are listed herein and on the plans to establish a standard of quality and design. Where a manufacturer's name is mentioned, products of other manufacturers will be acceptable, if in the opinion of the Engineer, the substitute material is of equivalent quality or better than that of the material specified.
- E. The Contractor's Bid represents that the bid price is based solely upon the materials and equipment described in the Bid Documents (including addenda, if any) and that he contemplates no substitutions or extras.

- F. Requests for substitution are understood to mean that the Contractor:
1. Has personally investigated the proposed substitution and determined that it is equal or superior in all respects to that specified.
 2. Will provide the same guarantee for the substitution that he would for that specified.
 3. Will, at no cost to the Owner, replace the substitute item with the specified product if the substitute item fails to perform satisfactorily.
 4. After Award of the Contract, substitutions will be considered only under one or more of the following circumstances:
 - a. The substitution is required for compliance with subsequent interpretations of code or insurance requirements.
 - b. The specified product is unavailable through no fault of the Contractor.
 - c. The manufacturer refuses to warranty the specified products as required.
 - d. Subsequent information that the specified product is unable to perform properly or to fit in the designated space.
 - e. In the Engineer's sole judgment, the substitution would be in the Owner's best interest.
 5. Revisions to the mechanical system shall be under the supervision of the Engineer at a standard hourly rate charged by the Engineer and shall be paid by the Contractor originating the changes.

1.16 PROTECTION OF EQUIPMENT AND MATERIALS

- A. The Contractor shall take such precautions as may be necessary to properly protect his apparatus from damage.
- B. This shall include the creation of all required temporary shelters to adequately protect any apparatus above the floor of the construction and the covering of apparatus in the completed building with tarpaulins or other protective covering.
- C. Failure to comply with the above to the satisfaction of the Owner's inspector will be sufficient cause for the rejection of the equipment in question and its complete replacement by this Contractor.
- D. All apparatus shall be cribbed up from the floor or ground by the Contractor and covered with tarpaulins or other protective covering where necessary or directed.

1.17 FINAL INSPECTION

- A. It shall be the duty of this Contractor to make a careful inspection trip of the entire project, assuring himself that the work on the project is ready for final acceptance before calling upon the A/E to make a final inspection.
- B. To avoid delay of final acceptance of the work, the Contractor shall have all necessary bonds, warranties, receipts, affidavits, etc., called for in the various articles of these specifications, prepared and signed in advance, together with a letter of transmittal, listing each paper included, and shall deliver the same to the A/E at or before the time of said final inspection. The Contractor is cautioned to check over each bond, receipt, etc., before preparing for submission to verify that the terms check with the requirements of the specifications.

1.18 ASBESTOS

- A. No asbestos or asbestos containing materials shall be permitted in this project.

1.19 CUTTING AND PATCHING

- A. All Subcontractors shall notify the General Contractor sufficiently ahead of construction of any floors, walls, ceiling, roof, etc., of any openings that will be required for his work.
- B. He shall see that all sleeves required for his work are set at proper times so as to avoid delay of the job.
- C. All necessary cutting of walls, floors, partitions, ceilings, etc., as required for the proper installation of the work under this Contract shall be done at the Subcontractor's expense in a neat and workmanlike manner, and as approved by the A/E.
- D. No joists, beams, girders or columns shall be cut by any Contractor without first obtaining written permission of the A/E.
- E. Patching of openings and/or alterations shall be provided by the General Contractor.
- F. All openings in firewalls and floors shall be completely sealed after installation for a completely airtight installation. Sealing material shall be non-combustible and UL approved. The installed sealing assembly shall not cause the fire rating of the penetrated structure to be decreased.
- G. All openings in exterior walls shall be sealed watertight.

1.20 IDENTIFICATION

- A. Refer to Section 23 05 53.

1.21 MANUFACTURER'S INSTRUCTIONS

- A. All equipment and devices shall be installed in accordance with these plans and specifications, manufacturer's instructions and applicable codes.
- B. Where specifications call for installation of a product to be in accordance with manufacturer's instructions and/or where manufacturer's instructions are required for installation of a product, it shall be the contractor's responsibility to obtain the necessary applicable manufacturer's instructions and install the product in accordance with the manufacturer's instructions.
- C. It shall be the Contractor's responsibility to install all equipment, materials, and devices shown on the plans and as called out in these specifications even if manufacturer's instructions are absolutely unattainable.

1.22 RELATED WORK

- A. Whether specifically identified or not, it is the responsibility of the Mechanical Contractor to coordinate all mechanical work with all related trades.

1.23 ELECTRICAL WIRING AND EQUIPMENT FOR MECHANICAL SYSTEMS

- A. All wiring, conduit, boxes, equipment (controls, thermostats, relays, contactors, motor starters, heaters, switches) and any other control devices or equipment required to form a complete and properly operating system, shall be the responsibility of the Mechanical Contractor.
- B. The Electrical Contractor shall only provide line voltage (including hook-up) to all mechanical equipment.

- C. All mechanical controls and devices shall be low voltage unless otherwise noted or shown on the plans. Where line voltage controls or devices are noted, the Contractor shall provide complete wiring diagrams (approved by the Engineer) to the Electrical Contractor prior to final hook-up.
- D. All electrical resistance heating elements which are scheduled to be served by three-phase electrical power shall impose an equal electrical load on all phases. Electrical resistance elements which are not balanced over all three phases are not acceptable.
- E. The Mechanical and Electrical plans are based on the equipment and devices scheduled as shown on the plans or as called for in the specifications. Should any mechanical equipment or device be changed or approved from those which are shown or noted, all electrical and/or mechanical changes shall be made at the expense of the trade or contractor initiating the change with no expense to the Owner, Architect, Engineer or their representatives.
- F. All wiring provided by this Contractor shall be installed in a workmanlike manner using tie wraps, labels, anchors and etc. Loose wiring is not acceptable.
- G. All conduit and boxes required in all walls for control purposes (thermostats, etc.) shall be provided by electrical contractor. All conduit required in attic, clear spaces, or on roof shall be by mechanical contractor.

1.24 OPERATION PRIOR TO COMPLETION

- A. When any piece of mechanical or electrical equipment is operable and the Contractor needs to operate the equipment, he may do so providing that he properly supervises the operation.
- B. The warranty period shall, however, not commence until such time as the equipment is operated for the beneficial use of the Owner.
- C. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, install clean filter media, properly adjust and complete all punch list items before final acceptance by the Owner.
- D. The date of acceptance and the start of the warranty may not be the same date.

1.25 SAFETY GUARDS

- A. Contractor shall furnish and install all safety guards required. All belt driven equipment, projecting shafts and other rotating parts shall be enclosed or adequately guarded.

1.26 FLAME SPREAD PROPERTIES OF MATERIALS

- A. All materials and adhesives used for air conditioning filters, acoustical lining and insulation shall conform to NFPA and UL life and flame spread properties of materials.
- B. The composite classifications shall not exceed the flame spread rating and the smoke development rating as outlined by NFPA 255/ ASTM E-84 for the basic material, the finishes, adhesives, etc., specified for each system, and shall be such when completely assembled.

1.27 FILTER ASSEMBLIES

- A. All filter housings and assemblies shall be factory built and supplied with the unit. A separate filter rack may be required and is the responsibility of the mechanical contractor to provide.

- B. Access doors (panels) which must be opened to change the air filters shall be labeled "Filter Access" and the number and size of required filters shall be identified.
- C. No piping conduit etc. shall be installed in front of this access door.
- D. Install clean filters prior to substantial completion.
- E. All air handlers shall have filters installed upstream of all coils.

1.28 LEAD MATERIALS

- A. No lead or lead containing materials shall be allowed in any domestic or potable water supply piping, valves, fixtures, components, equipment or any other item.

1.29 REFRIGERANTS

- A. Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs) shall not be allowed in any equipment on this project.
- B. Comply with ASHRAE Standards 15 and 34.

1.30 REFRIGERANT RECOVERY AND RECYCLE

- A. Refrigerants shall not be released to the environment.
- B. Contractor shall provide recovery and recycle equipment that has been certified by the Electrical Testing Laboratories or Underwriters Laboratories.
- C. Contractor shall also provide properly trained and certified (in accordance with EPA) personnel for refrigerant work during installation, demolition, start-up, servicing, etc.

1.31 ACCESS CLEARANCE

- A. Proper access to all installed equipment shall be provided. The Mechanical Contractor shall label all points of access immediately upon installation with a marker pen.
- B. A minimum of 3 feet shall be maintained in front of all access points.
- C. If another trade violates this space, the Mechanical Contractor shall immediately notify the General Contractor to correct this condition.
- D. When equipment is installed above lay-in ceiling the Mechanical Contractor shall coordinate with the Ceiling Contractor to provide access without removing part of T-bar ceiling.
- E. No speakers, lights, fire alarm equipment, etc. shall be installed in lay-in ceiling tiles where access is to be gained.

PART 2 PRODUCTS

- A. Not Applicable

PART 3 EXECUTION

3.1 TESTING

- A. After all mechanical systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequence and operation throughout the range of operation regardless of the season the contractor shall test all HVAC equipment in both heating and cooling modes.
- B. Each and every phase of the new air conditioning, heating and ventilating systems shall be operated separately, or in conjunction with the other, for a period of time, to demonstrate to the satisfaction of the A/E the ability of the equipment to meet the capacity and performance requirements while maintaining design conditions in accordance with the true intent and purpose of these specifications.
- C. Previous to such performance tests, the Contractor shall have set all valves, dampers, motors, controllers, thermostats, etc., and shall have the system operating and maintaining design temperatures, humidity and air circulation throughout all areas of the building.
- D. Make adjustments as required to ensure proper functioning of all systems.
- E. Special tests on individual systems are specified under individual sections.
- F. See Section 23 05 93 for Testing, Adjusting, and Balancing for HVAC.

END OF SECTION

SECTION 23 00 90

HVAC SUBMITTAL PROCEDURES

PART 1 GENERAL

1.1 SUMMARY

- A. This section supplements Division 01 Submittal Procedures and contains additional requirements applicable to Division 23 submittals.

1.2 SECTION INCLUDES

- A. This section includes, but is not limited to:
 1. HVAC submittal procedures
 2. List of required Division 23 submittals to the engineer
 3. This section applies only to the Division 23 specifications. Submittals required by other specification divisions are not included here, even though the same subcontractor may be providing work under other divisions.

1.3 RELATED SECTION

- A. Division 01 – Submittal Procedures

1.4 DEFINITIONS

- A. Product Data: Illustrations, standard schedules, performance charts, instructions, and brochures furnished by the contractor, subcontractor, manufacturer, or supplier to illustrate materials or equipment or to illustrate some portion of the work. Provide a summary of scheduled items with all data in schedules.
- B. Shop Drawings: Drawings, diagrams, schedules and other data specifically prepared for the work by the contractor, subcontractor, manufacturer, or supplier to illustrate some portion of the work.
- C. Equipment/Material Submittal Package: A compilation of the product data, shop drawings, and other items as required by the specifications, submitted near the start of the work. Typically, the specifications require the initial submittal package to be submitted within a certain number of days after the work starts.
- D. Quality Assurance Submittal: Items submitted before and during the execution of a particular portion of the work for the purpose of guarding against defects and deficiencies.
- E. Quality Control Submittal: Items submitted at the completion of a particular portion of the work for the purpose of evaluating completed activities and elements of the work for conformance with contract requirements (e.g. start-up reports).
- F. Closeout Submittals: Items submitted at or near the completion of the contract.

1.5 SUBMITTALS

- A. The materials, workmanship, design, and arrangement of all work installed under this contract shall be subject to the review of the architect, engineer and owner.

- B. Manufacturers: Manufacturers submitted shall be as per the acceptable manufacturers listed in each specification section or referenced schedule. For additional manufacturers requiring approval, reference the Substitution of Products article in Section 23 00 00.
- C. Required Submittals: Refer to the Submittals article of each individual Division 23 specification section for the required items to be submitted.
- D. Contractor's Coordination Submittals: The contractor may require his subcontractors to provide drawings, setting diagrams, and similar information to help coordinate the project, but such data shall remain between the contractor and his subcontractors and will not be reviewed by the engineer.
- E. Electronic Submittals: E-mail or other electronic forms of submittals from the contractor are required. The procedures described in this section shall be as follows:
 - 1. The contractor shall supply one electronic copy of the submittal.
 - 2. The electronic files will either be e-mailed to the architect or posted to a project management and information exchange web site, depending on the architect's requirements. The architect and contractor can distribute copies of the files as desired.
 - 3. The engineer will retain an electronic copy of the submittal and all responses.
- F. Coordination Correspondence: The contractor may desire to verify the acceptability of a particular item prior to assembling the initial submittal package. The contractor may send material directly to the engineer for comments and feedback. This communication will be treated as normal coordination correspondence and will not be tracked or documented as a formal submittal. The engineer may or may not respond to such correspondence. If the engineer agrees, in writing, to the use of a particular item, then that same material shall be included in the initial submittal package along with a copy of the correspondence.
- G. Unapproved Products: If materials or equipment are installed before being reviewed by the engineer, the contractor shall be liable for the removal and replacement of such unapproved materials and equipment, at no additional expense to the owner. Additionally, if the removal and replacement of rejected materials or equipment necessitates the removal and replacement of other related materials or equipment, then the contractor shall be liable for the removal and replacement of the related materials and equipment at no additional expense to the owner.
- H. Product Data: Where the content of manufacturer submittal literature includes data not pertinent to the submittal, clearly indicate which portions of the contents are being submitted for review. Catalogs, pamphlets, or other documents submitted to describe items on which review is being requested shall be specific and identifications in catalog, pamphlets, etc., of items submitted shall be clearly made in a contrasting ink or highlighting. Data of a general nature shall not be acceptable.
- I. Shop Drawings:
 - 1. Scale and measurements: Make shop drawings accurately to a scale sufficiently large to show all pertinent aspects of the item.
 - 2. Electronic shop drawing submittals are required.

PART 2 PRODUCTS

- A. Not applicable

PART 3 EXECUTION

3.1 SUBMITTALS

- A. Make submittals of product data, shop drawings, samples, quality assurance submittals, quality control submittals, and other items in accordance with the requirements of this section, applicable sections in Division 23, and additional requirements of each individual Division 23 specification section.
- B. Grouping of Submittals:
 - 1. The submittal package shall be coordinated and included in a single submission. Multiple submissions are not acceptable except where prior written approval has been obtained from the engineer. Partial submittals may be rejected, without being reviewed, as not complying with the provisions of the contract.
 - 2. In the case that multiple submissions are approved, it is the responsibility of the contractor to maintain and update a submittal check list. The contractor shall ensure that all applicable submittal sections are submitted to the Engineer. If a submittal section is not submitted, it will be considered rejected until reviewed by the Engineer.
 - 3. If submittal sections are submitted as individual submittal files, the submittal sections will be grouped and returned as one file with one set of submittal responses.
- C. Electronic Submittal Organization:
 - 1. Electronic submittals are to be submitted as a single PDF file. Within the PDF file, each section shall be bookmarked.
 - 2. Provide an electronic submittal cover sheet that lists at least the following:
 - a. Project name
 - b. Date
 - c. Name and address of architect
 - d. Name and address of engineer
 - e. Name, address and telephone number of prime contractor
 - f. Name, address and telephone number of HVAC contractor
 - g. Name, address and telephone number of HVAC supplier
 - 3. Provide an electronic index sheet listing all items submitted.
 - 4. The contractor shall call to the attention of the engineer, clouded in the submittal and noted after the index sheet, any instance in which the submittals are known to differ from the requirements of the contract documents.
 - 5. Organize all required items by specification section. The material for each specification section shall be organized as follows:
 - a. Provide an electronic section cover sheet that lists the same information as the submittal cover sheet, plus the specification number and title and the name, address and telephone number of the vendor or vendor's representative, if applicable.
 - b. Refer to the individual Division 23 specification sections for any required organization of the submittal material within each submittal section.
 - c. Bookmarked sections shall be arranged by specification section number in numerical order.
 - d. Submit in accordance with these procedures and procedures described in Division 01 Submittal Procedures.
 - e. Submittals not organized as described here may be rejected, without being reviewed, as not complying with the provisions of the contract.
- D. Response to engineer's review:
 - 1. Review comments: Review comments of the engineer will either be shown on the returned sets to the contractor or shown on a document attached to the sets. If the comments are on an attached document, then the engineer will place a note on the submittal referring to the attached comments. In such cases, the engineer's signature will appear only on the attached document. If the attached, signed document becomes

physically separated from the submittal, then the submittal will no longer be considered as being a reviewed submittal.

2. Complete rejection: If the submittal is not complete or does not meet the requirements of this specification section, then the engineer may reject the entire submittal and return the submittal without further review or comment. In such cases, the entire submittal shall be completely revised and resubmitted. The resubmittal shall be given a new submittal number and shall be documented and processed as a separate submittal from the original.
 3. Held for completion: If the submittal is not complete, but is only missing some minor item, the engineer may, at the engineer's sole discretion, hold the submittal rather than rejecting and returning the submittal. In such cases, the engineer will notify the architect and contractor that the submittal is being held for completion. The contractor will be given a predetermined amount of time to provide the missing item. Upon receipt of the missing item, the engineer will insert the missing item into the submittal package and proceed with the review process.
 4. Partial rejection: The engineer may reject only certain portions of the submittal. In such cases, only those rejected portions or items need to be revised and resubmitted.
 5. Provide as noted and corrected: The engineer may note a required change to a submitted item but may not consider the change serious enough to require a resubmittal. In such cases, the engineer will note that the item is to be provided as noted or corrected. In such cases, the contractor may proceed to provide the item. However, if subsequent observations reveal that the noted change was not made, then the contractor shall be liable for removal and replacement of the item at no additional cost to the owner.
 6. Reviewed without comment: The contractor may proceed to provide all materials and equipment as submitted.
- E. Close-out Submittals:
1. Provide close-out submittals in accordance with the requirements of Division 1.

Section	Submit on the following	1	2	3	4	Arch Sub #
23 05 29	Hangers and Supports for HVAC Piping and Equipment					
	Isolation Devices					
	Piping hangers and supports					
23 05 32	Roof Curbs					
	Roof curbs					
23 05 53	Identification for HVAC Piping and Equipment					
	Label material and attachment method (No adhesives)					
	Sample identification tag(s)					
23 05 93	Testing, Adjusting, and Balancing for HVAC					
	Test and Balance Company					
	Sample test and balance forms					
23 07 13	Duct and Grille Insulation					
	Insulation thickness and R-value					
23 07 21	Refrigerant Piping Insulation					
23 09 23	Energy Management Control System					
	Energy Management Controls company					
	Control Devices					
	System configuration drawings					
	Sequences of Operation					
23 23 00	Refrigerant Piping					
	Piping material					
23 31 13	Metal Ductwork					
	Ductwork material					
	Type of ductwork					
23 33 33	Access Doors					
	Access door material					
23 34 16	HVAC Fans					
	Fan manufacturer					
	Voltage/ phase					
	Fan CFM					
	Fan static pressure					
23 37 13	Diffusers, Registers, and Grilles					
	Grille manufacturer					
23 43 23	Bipolar Ionization Air Purification System					
	Bipolar ionization manufacturer					
	Bipolar ionization type					
23 81 23	Computer Room Air Conditioning Units					
	Unit manufacturer					
	Voltage/ phase					
	Unit capacity					
	Unit options and specifics					
23 81 26	Split System HVAC Units					
	Unit manufacturer					
	Voltage/ phase					
	Unit capacity					

Section	Submit on the following	1	2	3	4	Arch Sub #
	Unit options and specifics					
1 - Reviewed 2 - Furnish as corrected in comments, resubmit not required 3 - Revise and Resubmit based on comments 4 - Rejected based on comments						

END OF SECTION

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 1 Specifications and Section 23 00 00, apply to this Section.

1.2 SECTION INCLUDES

- A. Isolation pads
- B. Concrete bases
- C. Expansion joints
- D. Other supports

1.3 RELATED SECTIONS

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 09 23 – Energy Management Control System
- C. Section 23 31 13 – Metal Ductwork
- D. Section 23 34 16 – HVAC Fans
- E. Section 23 81 26 – Split System HVAC Units

1.4 SUBMITTALS

- A. Product Data:
 - 1. Provide submittal data on all items specified in this section in accordance with Section 23 00 90, General Conditions, and Division 1.
 - 2. Submit shop drawings and catalog data with locations of use.

1.5 REFERENCES

- A. Refer to Section 23 00 00 for complete names of references identified in this section.
- B. SMACNA Standards
- C. ASHRAE – American Society of Heating, Refrigeration and Air Conditioning Engineers

1.6 QUALITY ASSURANCE

- A. Isolation devices must be provided by a company whose sole business is to provide isolation equipment.

- B. All equipment and materials to be installed in workmanlike manner by experienced mechanics and as recommended by the manufacturers.
- C. Design Data: Complete design of isolation equipment including confirmation that no noise will be transmitted to structure of building.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide isolation and support devices as required for all mechanical equipment.

2.2 MANUFACTURERS

- A. Amber/Booth
- B. Anvil
- C. Kenetics
- D. Korfund Vibration Mountings
- E. Mason
- F. Peabody
- G. Vibro Acoustics

2.3 CONDENSING UNIT ISOLATION

- A. Provide isolation pad between unit and structure as shown on plans.

2.4 FLEXIBLE DUCT CONNECTIONS

- A. Use "Ventglas" fabric, fireproof, waterproof, and mildew resistant, approximately 30 ounces per square yard.
- B. Comply with SMACNA standards.

2.5 ISOLATION FOR AIR HANDLERS ABOVE 5 TONS

- A. Spring isolators:
 - 1. Type:
 - a. Open stable steel spring type with a minimum deflection of one inch.
- B. Concrete Pad:
 - 1. Type:
 - a. 5 inch housekeeping pad

2.6 HVAC PIPE SUPPORTS

- A. Hangers:
 - 1. All Copper Piping
 - a. Copper plated ferrous hangers.

2. 2" and smaller piping in walls:
 - a. May be split cast ring type with fastening device in walls and chases.
 3. All Other Above Ceiling Locations:
 - a. Adjustable clevis type. Hangers to accommodate circumference of pipe and saddles.
- B. Hanger Rods:
1. Type:
 - a. Minimum 3/8 inch diameter with machine threads.
- C. Minimum Steel Hanger Rod Diameter for Individually Suspended Horizontal Pipes:
1. 2" and smaller diameter pipe:
 - a. 3/8"
 2. 2-1/2" to 3-1/2" diameter pipe:
 - a. 1/2"
 3. 4" to 5" diameter pipe:
 - a. 5/8"
 4. 6" diameter pipe or larger:
 - a. 3/4"

2.7 SLEEVES

- A. Application:
1. Provide sleeves for all pipes and conduits which pass through a concrete slab, masonry wall/concrete wall, roof or other portion of the building structure.
- B. Above Grade and/or dry locations:
1. Material:
 - a. 20 or 22 gauge galvanized steel.
 2. Size:
 - a. As necessary to allow free passage of the insulated pipe.
- C. Passing through fire-rated enclosures:
1. Material:
 - a. Galvanized or black steel pipe.
 - b. Non-combustible.
 - c. PVC will not be allowed.

PART 3 - EXECUTION

3.1 ISOLATION DEVICES AND PAD INSTALLATION

- A. Install isolation pads between floor and equipment pads according to manufacturer's recommendations and approved shop drawings.
- B. Install flexible duct connections where ducts connect to fans or air handling units.
- C. All joints to be airtight.
- D. Provide a minimum of 1/2" slack in connections, and a minimum of 2½" distance between the edges of ducts.
- E. Comply with recommendations of ASHRAE for the selection and application of vibration materials and units.

3.2 SECURING AND SUPPORTING OF HVAC PIPING

- A. Support all pipe from the building structure by means of approved hangers and supports while maintaining required grade and pitch, preventing vibration and providing for expansion and contraction.
- B. Secure all hangers to approved inserts wherever possible.
- C. Set hanger inserts in place when the concrete is poured.
- D. If Joists Are Used for Attachment:
 - 1. 2" diameter or smaller:
 - a. May be attached to the bottom of joists.
 - 2. Greater than 2" diameter:
 - a. Must be attached to the top cord of the joists.
 - 3. Do not support any piping and trapeze hangers from joist bridging on roof and floor deck.
- E. If Structural Steel Framing Is Used for Attachment:
 - 1. Use approved beam clamps.
 - 2. Where required, install channels to span between framing members.
 - 3. Do not attach hangers to the roof deck or cross bracing.
- F. Hanger Spacing:
 - 1. Schedule 40 Black Steel Piping (Chilled water/ Hot water piping):
 - a. 1/2" diameter pipe → 6'-0" or less
 - b. 3/4" diameter pipe → 8'-0" or less
 - c. 1-1/4" diameter pipe → 10'-0" or less
 - d. Vertical:
 - (1) Every Floor Level Minimum
 - (2) Adequately support at their bases, either by a suitable hanger placed in the horizontal line near the riser, or by a base fitting set on a pedestal or foundation.
 - (3) Support from each floor slab by means of an approved clamp-type support which bears on the slab or beam.
 - 2. Copper Piping (Refrigerant Piping):
 - a. Smaller Than 1 1/4" → 6'-0" or less
 - b. 1 1/2" and Larger → 10'-0" or less
 - c. Vertical → 10'-0" or less
- G. Change of Direction:
 - 1. Install supports within two feet of change of direction.
 - 2. Brackets of approved type may be used along the walls.
 - 3. Install hangers within 2 feet of each change in vertical or horizontal direction, pipe tees and on each side of valves, strainers, etc.
 - 4. Multiple horizontal pipes, smaller than 12" diameter pipe, may be supported on trapeze hangers. Space trapeze hangers in accordance with the schedule for pipe spacing based upon the smallest size pipe.
 - 5. Properly size the trapeze members for the piping load they are to support. The number of pipes on the trapeze must be approved by the Engineer to prevent overloading of the building structure.
 - 6. Where pipes are insulated, oversize the hanger accordingly to accommodate the outside diameter of the insulation. Provide half-round 16 gauge galvanized steel shields, not less than 12" long and rolled to fit the insulation diameter, between the insulation and the hanger.

7. When pipe is guided at top and bottom, cover the entire pipe circumference with metal shields.
8. Adhere metal shield to the insulation so that the metal will not slide with respect to the insulation.
9. Wood struts shall not be used to support piping in walls.

3.3 SLEEVES

- A. Above Grade and/or Dry Locations:
 1. Walls:
 - a. Mount flush on both sides.
 2. Floors:
 - a. Mount 2 inches above finished floor in pipe chases.
- B. Passing Through Fire-Rated Enclosure:
 1. Fill the void space around the pipe in accordance with NFPA requirements.
 2. Do not allow the sleeve installation to lower the fire rating of the assembly.

END OF SECTION

SECTION 23 05 32

ROOF CURBS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 1 Specifications and Section 23 00 00, apply to this Section.

1.2 SECTION INCLUDES

- A. Roof curbs for rooftop packaged HVAC units, exhaust fans, and supply fans.

1.3 RELATED SECTIONS

- A. Section 23 00 00 - Basic Mechanical Requirements
- B. Section 23 34 16 - HVAC Fans

1.4 REFERENCES

- A. ASTM D4586 - Fibrated Asphalt Roof Cement

1.5 SUBMITTALS

- A. Product Data:
 - 1. Submit manufacturer's product data sheets, including installation instructions, in accordance with Section 23 00 90, General Conditions, and Division 01.
 - 2. Submit with equipment that curb is used with.
- B. Shop Drawings:
 - 1. Submit for prefabricated equipment supports in accordance with Section 23 00 90, General Conditions and Division 01.

PART 2 PRODUCTS

2.1 ROOF CURBS FOR EXHAUST FANS

- A. Insulated and Non-insulated Roof Decks:
 - 1. Type – Prefabricated insulated curb. No Hybrid curbs or assembled on site curbs permitted.
 - 2. Material – Minimum 18 gauge prime galvanized steel.
 - 3. Construction:
 - a. Designed to meet local wind zone load/rating
 - b. Designed to support weight of the exhaust fan.
 - c. Factory-welded corners.
 - d. Internally reinforced.
 - e. Factory-installed 1" x 4" treated wood nailers fastened from the underside with TEK screws.
 - f. Top of all curbs to be level with pitch built into the curb when deck slopes ¼ inch per foot or greater.

4. Fiberglass Insulation:
 - a. Thickness – 1 ½ inches
 - b. Density – 3 lbs.
 - c. Factory installed.
5. Height – 18 inches above the roof deck or as shown on plans.
6. Manufacturers:
 - a. TECO Metal Products
 - b. ThyCurb
 - c. Rooftop Systems
 - d. Fan Manufacturer

2.2 RELATED MATERIALS

- A. Nails:
 1. Type:
 - a. Stainless steel, flathead, wire, barbed, slating type.
 2. Washers:
 - a. Neoprene.
- B. Flashing Cement:
 1. ASTM D4586 - Type 1
 2. Asbestos free

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that substrates are smooth and clean to extent needed for work.

3.2 INSTALLATION

- A. General:
 1. Install prefabricated roof curbs beneath new exhaust fans, supply fans, and all other mechanical equipment on the roof.
 2. Install work watertight, without waves, warps, buckles, fastening stresses or distortion.
 3. Allow for expansion and contraction.
 4. Coat contact surfaces of dissimilar metals with zinc chromate paint.
 5. Set LEVEL and square on structural framing beneath roof deck.
 6. Securely fasten curb flanges with bolts through flanges.
 7. Seal bolt heads with flashing cement.
- B. Roof Curb Heights:
 1. Verify roofing insulation thickness where curbs are to be installed. Coordinate height above roof to meet roofing manufacturer's specifications.
 2. Minimum Height:
 - a. 12-inches above finished roof.

END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 01 Specifications and Section 23 00 00, apply to this Section.

1.2 SECTION INCLUDES

- A. Identification required for mechanical systems.
- B. Code required identification not shown on plans nor specified herein shall be provided.

1.3 RELATED SECTION

- A. Section 23 00 00 – Basic Mechanical Requirements

1.4 SUBMITTALS

- A. Provide submittal data on all items specified in this section in accordance with Specification Section 23 00 90, General Conditions, and Division 01.
- B. Submit wording of nameplates with submittals.
- C. Submit list of all products incorporated in this section.

1.5 REFERENCES

- A. Comply with ANSI A13.1
- B. USAS Code B31.8
- C. NTSB-PSS-73-1
- D. AGA

1.6 DESCRIPTION OF WORK

- A. Nameplates and tags are to be provided for all mechanical equipment and piping in the project. Identification is also required for the following, but is not limited to:
 - 1. Air Handlers
 - 2. Boilers/Water Heaters
 - 3. Condensing Units
 - 4. Duct Dampers
 - 5. Filter Sizes for Air Handlers
 - 6. Fire Dampers
 - 7. Heat Exchangers
 - 8. Outside Air Units
 - 9. Piping
 - 10. Pumps

11. Starters
12. Supply/Exhaust Fans
13. Valves

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Seton
- B. Brady
- C. MSI

2.2 EQUIPMENT LABELS

- A. Type: Engraving-Stock, melamine plastic laminate, 3 layer.
 1. Thickness:
 - a. Less than 25 square inches: 1/16 inch
 - b. 25 square inches or more: 1/8 inch
- B. Color:
 1. Black
- C. Conform to FS L-P-387A

2.3 LETTERING

- A. Style:
 1. Engraved standard print.
- B. Size:
 1. 3/16 inch to 1/4 inch
- C. Color:
 1. White letters, black background

2.4 NAMEPLATE/TAG INFORMATION

- A. HVAC Equipment:
 1. Unit mark from Drawings/Owner
 2. Voltage - Phase
 3. Manufacturer and Model Number
 4. Filter size

2.5 NAMEPLATE FASTENERS

- A. Securely attach nameplates to equipment with non-corroding stainless steel screws.
- B. Non-corroding pop rivets are acceptable.
- C. Stick-ons or adhesives will not be allowed.

2.6 PIPING AND CONTROL DIAGRAM SIGNS

- A. Material: 1/4 inch acrylic cover and backing screwed together with brass screw/bolts.
 - 1. Size:
 - a. Minimum: 12" x 17"
 - b. Maximum: 24" x 36"
- B. Provide a diagram in each mechanical room similar to the diagrams shown on the plans, and/or as required for the area served. This diagram to reflect as built conditions.

2.7 IDENTIFICATION OF PRODUCTS

- A. Provide pipe markers with the following features.
 - 1. Letters from 1/2" to 3-1/2"; size letters to afford readability from the appropriate viewing position.
 - 2. Repeated and reversed words for viewing from 360° around pipe.
 - 3. Self-clinging, coiled markers that snap into place around pipe and do not require any other securement.
 - 4. Integral directional arrows.
- B. Letters on Field:
 - 1. Identify the specific material conveyed. (i.e. "Domestic Cold Water", "Sprinkler", etc.)
- C. Model:
 - 1. Less than 3/4":
 - a. Tags: Piping System Devices, color codes for hazard.
 - 2. 3/4" up to 6"; snap-on.
 - 3. Over 6"; strap-on, with stainless steel spring straps.
 - 4. Use tags and/or nameplates that are scratch resistant and UV resistant for outdoor equipment and piping.
- D. Piping System Devices (Valves, Thermometers, Pressure Gages, etc., and Pipe Less Than 3/4"):
 - 1. Identify with the following:
 - a. Tags:
 - (1) Not less than 1-1/2 inch brass or aluminum tags, round, square, or octagonal.
 - b. Stamp tags with minimum 1/2" high descriptive characters, 1/2" high numbers with black enamel-filled indentations.
- E. Attachment:
 - 1. Stainless steel or solid brass jack chain, or stainless steel or brass "S" hooks
- F. Ductwork:
 - 1. Stenciled letters or self-adhesive labels, minimum 1" high characters.
 - 2. Red ribbon at each balancing damper.
- G. Underground Warning Tapes:
 - 1. Provide materials that meet the codes or have the approvals listed below:
 - a. Office of Pipeline Safety Regulation, USAS Code B31.8.
 - b. GSA Public Building Service Guide Specification.
 - c. National Transportation Safety Board Report NTSB-PSS-73-1.
 - d. AGA Report 72-D-56.
 - e. API Report API RP 1109.
 - 2. Material:
 - a. Plastic, continuous tape, color-coded, marked for hazard.

- b. For Non-metallic Piping System:
 - (1) Aluminum foil core encased in plastic.
 - c. Metallic Piping:
 - (1) Plastic tape.
 - 3. Color:
 - a. Colored (not printed color) plastic, coded for material conveyed by piping.
 - 4. Width:
 - a. As scheduled for piping system burial depth.
 - 5. Legend:
 - a. "Caution [System Name] Line Buried Below".
 - 6. Tape Colors:

Utility	Color
Natural Gas, Oil, Dangerous Materials	Hi Visibility Safety Yellow
Communications	Safety Alert Orange
 - 7. Model:
 - a. Metallic Piping System:
 - (1) Polyethylene Tape.
 - b. Non-Metallic Piping System:
 - (1) Metallic Detection Tape.
- H. Underground Gas Piping:
- 1. Attach No. 18 gauge copper tracer wire to the piping and terminate above grade at each end.
- I. Pipeline Markers for Pipe Beneath Pavement and Slabs:
- 1. Minimum 2" round, square, or octagonal, same as specified in Subparagraph: Piping System Devices.
- J. Attachment:
- 1. 1-1/2" screw, bolted to tag as anchor.
 - 2. Anchor Setting Compound:
 - a. Epoxy or epoxy grout, compatible with the pavement.

PART 3 EXECUTION

3.1 GENERAL

- A. Contractor shall verify room numbers with Owner/Engineer before nameplates are fabricated.
- B. The following shall be permanently and clearly identified:
 - 1. Each air handler, condensing unit, compressor, exhaust fan, and pump.
 - 2. Each zone duct, outside air duct, and return air duct whose duty is not immediately apparent.
 - 3. Each valve whose service and/or duty is not immediately apparent.

3.2 INSTALLATION

- A. Install signs on non-removable panels. Attach to equipment with pop rivets or stainless steel screws.
- B. Mount in an easily visible location.
- C. All labeling identification shall conform to final room numbers. Coordinate with General Contractor, A/E and Owner to secure construction room numbers.

- D. Provide all additional signage required by local authority at no cost to the Owner.
- E. Provide filter sizes and quantity on all air handlers.
- F. Complete installation in accordance with ANSI A13.1 and manufacturer's installation instructions and with the Drawings. Fasten each unit securely in place with stainless steel screws.
- G. Equipment Labeling:
 - 1. Install on scheduled items of equipment, including the following:
 - a. Air conditioning equipment
 - b. Pumps
 - c. Control panels and major control components
 - d. Include Mark Number and descriptive name from Drawing and Specification schedules
 - e. Attach with corrosion resistant, stainless steel screws or pop rivets
 - f. Install 1/2" diameter adhesive marker (color to be approved by A/E) and apply to T-bar below any mechanical equipment and fire dampers above lay-in ceiling.
- H. Piping System Color Coding:
 - 1. Designate for painter the following:
 - a. Types of piping services
 - b. Direction of flow
 - c. Other information required for proper identification.
- I. Surfaces to be Painted:
 - 1. Bare piping
 - 2. Insulation covering of insulated piping
- J. Paint according to the following schedule:

System	Pastel Color
Condenser Water	Green
Gas Piping on Roof	Black or as required by local authority having jurisdiction
- K. Piping System Devices (Valves, Thermometers, Pressure Gages, etc.):
 - 1. Identify with the following information:
 - a. System
 - b. Device number
 - c. Device Function
- L. Device Chart:
 - 1. Key devices to device chart
 - 2. Give complete description of device function and system.
- M. Key devices to drawings as follows:
 - 1. Floor plans
 - 2. Schematic drawings of piping systems

- N. Underground Warning Tapes:
1. Tape Widths:

Piping Burial	Depth Tape Width
10"	2"
20"	3"
27"	6"
30"	9"
40"	12"
50" or more	18"

- O. Recommended Tape Bury Depth:

1. Minimum Depth:
 - a. 6".
2. Distance Between Pipe and Tape:
 - a. Minimum 12".
 - b. Maximum Depth: 12".
3. Tie tape to pipe where pipe leaves the ground.

- P. Pipeline Markers for Pipe Beneath Pavement and Slabs.

1. Location:
 - a. Accuracy:
 - (1) Plus or minus 6" from piping centerline.
 - b. Flat Edge Pavement and Slabs:
 - (1) Set within 6" of pavement or slab edge.
 - c. Concrete Curbs:
 - (1) Set in top of curb.
 - d. Spacing:
 - (1) Each change in direction, each edge of pavement or slab, maximum spacing of 100'.
2. Legend:
 - a. Same as tags plus an engraved or stamped line; set marker with line parallel to buried line.
3. Attachment:
 - a. Drill hole for anchor bolt, full depth of bolt plus 1/2"; set full tag and bolt in epoxy, flush with pavement or slab.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC
(NOT IN CONTRACT, FOR REFERENCE ONLY)

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 1 Specifications and Section 23 00 00, apply to this Section.

1.2 SECTION INCLUDES

- A. Testing and balancing services for the heating, ventilating, and air conditioning (HVAC) systems of this project.
- B. The testing and balancing agency will be responsible for the satisfactory execution of testing and balancing of the HVAC systems.

1.3 RELATED SECTIONS

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 07 13 – Duct and Grille Insulation
- C. Section 23 09 23 – Energy Management Control System
- D. Section 23 31 13 – Metal Ductwork
- E. Section 23 34 16 – HVAC Fans
- F. Section 23 37 13 – Diffusers, Registers, and Grilles
- G. Section 23 81 26 – Split System HVAC Units

1.4 STANDARDS

- A. The balancing agency shall perform the services specified herein in accordance with the Associated Air Balance Council's National Standards, including revisions, to the date of the contract.
- B. All terms in this specification shall have their meaning defined as stated in the National Standards.
- C. If these specifications set forth more stringent requirements than the AABC National Standards, these specifications shall prevail.

1.5 QUALIFICATIONS OF THE BALANCING AGENCY

- A. The balancing agency shall be a member of the Associated Air Balance Council (AABC) and/or certified by the National Environmental Balancing Bureau (NEBB).

- B. To perform required professional services, the balancing agency shall have a minimum of one "Test and Balance Engineer" certified by the Associated Air Balance Council and/or the National Environmental Balancing Bureau (NEBB).
- C. This certified "Test and Balance Engineer" shall be responsible for supervision and certification for the total work herein specified.
- D. The balancing agency shall submit records of experience in the field of air and hydronic system balancing or any other data as requested by the Owner/Engineer. The supervisory personnel for the firm shall have at least five (5) years' experience and be a full time employee for a minimum of six (6) months prior to the project. All employees used in this project shall be qualified technicians in this specific field.
- E. The balancing agency shall furnish all necessary calibrated instrumentation to adequately perform the specified services. An inventory of all instruments and devices in possession of the balancing agency may be required by the Owner to determine the balancing agency's performance capability.
- F. The balancing agency shall have operated for a minimum of five (5) years under its current name.

1.6 DOCUMENTS

- A. The General Contractor will provide the balancing agency one copy of the following documents:
 - 1. Project drawings (mechanical sepias if requested) and specifications.
 - 2. Reviewed construction revisions pertaining to the HVAC systems.
 - 3. Reviewed submittal data on HVAC equipment and systems to be installed by the Mechanical Subcontractor.
 - 4. Reviewed HVAC shop drawings.
 - 5. Reviewed HVAC wiring diagrams, control diagrams, and equipment brochures, as appropriate.

1.7 COORDINATION

- A. It will be necessary for the balancing agency to perform its services in close coordination with the Mechanical Subcontractor.
- B. The plans and specifications indicate meters, valves, dampers, and other devices for the purpose of adjusting the system to obtain optimum operating conditions. It will be the responsibility of the Mechanical Subcontractor to install these devices in a manner that will leave them accessible, readily adjustable and complete. The balancing agency shall provide guidance if there is a questionable arrangement of a control or balancing device.
- C. The General Contractor, Mechanical Contractor, Temperature Controls Subcontractor, and the suppliers of the HVAC equipment shall all cooperate with the balancing agency to provide all necessary data on the design and proper application of the system components. In addition, they shall furnish all labor and materials required to eliminate any system deficiencies.

1.8 RESPONSIBILITIES OF THE MECHANICAL CONTRACTOR

- A. The Mechanical Contractor shall complete the installation and start all HVAC systems to ensure they are working properly and shall perform all other items as described hereinafter to assist the balancing agency in performing the testing and balancing of the HVAC systems.

- B. Air Distribution Systems:
1. Verify installation for conformity to design.
 2. Terminate all supply, return, and exhaust ducts, and pressure test them, for leakage, as required by specification.
 3. Ensure that all splitters, extractors, and volume and fire dampers are properly located and functional. Dampers serving requirements of minimum and maximum outside, return, relief, and exhaust air shall provide tight closure and full opening, with a smooth and free operation.
 4. Verify that all supply, return, exhaust, and transfer grilles; registers; diffusers; and high-pressure terminal units are installed and operational.
 5. Ensure that air-handling systems, units, and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., are blanked and/or sealed to eliminate excessive bypass or leakage of air.
 6. Ensure that all fans (supply, return, relief, and exhaust) are operating and free of vibration. All fans and drives shall be checked for proper fan rotation and belt tension. Overload protection shall be of proper size and rating. A record of motor current and voltage shall be made to verify that the motors do not exceed nameplate rating.
 7. Make any necessary changes to the sheaves, belts, and dampers, as required by the balancing agency, at no additional cost to the Owner.
 8. Install clean filters.
- C. Water Circulating Systems:
1. Verify installation for conformity to design.
 2. Check all pumps to verify pump alignment and rotation.
 3. Ensure that systems are clean, with the proper strainer screens installed for normal operation.
 4. Check all pump motors for current and voltage, to ensure that motors do not exceed nameplate rating.
 5. Verify electrical overload protection of proper size and rating.
 6. Ensure that all water circulating systems shall be full and free of air; that expansion tanks are set for proper water level; and that all air vents were installed at high points of systems and are operating.
 7. Check and set operating temperatures of heat exchangers to design requirements.

1.9 RESPONSIBILITIES OF THE TEMPERATURE CONTROLS CONTRACTOR

- A. The Temperature-Controls Contractor shall allow sufficient time in the project to provide assistance and instruction to the balancing agency in the proper use and setting of control components such as, but not limited to, computers, static pressure controllers, or any other device that may need set points changed so that the testing and balancing work can be performed.
- B. Furnish to the balancing agency any software and cables required to make adjustments to controls. Any unique micro-processor required to set controls shall be furnished by Temperature Controls Contractor.
- C. The Temperature Controls Contractor shall complete the installation of the temperature control system and operate and test all control systems to ensure they are functioning properly as designed. The Temperature Controls Contractor shall assist the balancing agency in testing and balancing the HVAC systems, as described hereinafter.
1. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset, and fire and freeze-stats.
 2. Verify that all controlling instruments are calibrated and set for design operating conditions.

3. Calibrate room thermostats/sensors after installation, and before the thermostat control verification tests are performed. The balancing agency shall prove the accuracy of final settings by taking temperature readings. The readings shall be in a typical conditioned space for each separately controlled zone.

1.10 PRE-BALANCING CONFERENCE

- A. Prior to beginning of the testing, adjusting and balancing procedures, schedule and conduct a conference with the Architect/Engineer, General Contractor, Mechanical Contractor, Electrical Contractor and Temperature Controls Contractor. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.

1.11 NOTIFICATION FOR TESTING AND BALANCING WORK TO BEGIN

- A. The general contractor shall notify the balancing agency in writing when all heating, ventilating, and air conditioning systems are complete and ready for testing and balancing. The Mechanical Contractor shall attest that he has completed all items as described in "RESPONSIBILITIES OF THE MECHANICAL CONTRACTOR" Section of these specifications.
- B. If, upon commencing the work, the balancing agency finds that the systems are not ready, or if a dispute occurs as to the readiness of the systems, the balancing agency shall request an inspection to be made by the Mechanical Engineer. This inspection shall establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for testing and balancing. Should the inspection reveal the notification to have been premature, the balancing agency shall be reimbursed for all costs for the inspection and work previously accomplished. Furthermore, such items that are not ready for testing and balancing shall be completed and placed in operational readiness before testing and balancing services shall again be requested.

PART 2 PRODUCTS

- A. Not Applicable

PART 3 EXECUTION

3.1 SCOPE

- A. In accordance with Project Drawings and Specifications and as specified herein, the balancing agency shall provide all supervision, personnel, instruments, calibration equipment, and all other materials and services necessary to perform all testing and balancing of the heating, ventilating, and air conditioning systems. All test data including all pertinent calculations shall be reported on appropriate forms.

3.2 GENERAL

- A. The testing and balancing of the heating, ventilating, and air conditioning systems shall be performed by an independent balancing agency approved by the Engineer. The balancing agency shall have a minimum of five years specialized experience in air and hydronic system balancing, possess calibrated instruments, certified "Test and Balance Engineers", and skilled technicians to perform all required tests. The balancing agency shall be a certified member of the Associated Air Balance Council and/or the National Environmental Balancing Bureau (NEBB).

- B. The tests shall demonstrate the specified capacities and operation of all equipment and materials comprising the systems. The balancing agency shall then make available to the Owner's representative such instruments and technicians as are required for spot checks of the system.
- C. The balancing agency shall not instruct or direct the Mechanical Contractor in any of the work. Any proposed changes or revision in the work shall be submitted to the Architect and General Contractor in writing.
- D. Document Review:
 - 1. The Test and Balance Firm shall be responsible for reviewing the HVAC plans and specifications relating to the test and balance services for proper arrangement and adequate provisions of devices for testing, adjusting and balancing.
 - 2. Test and Balance Firm shall review HVAC manufacturers' submittals data relative to balanceability.
 - 3. Test and Balance Firm shall review submitted HVAC automatic temperature control sequences for conformity to the specifications.

3.3 SERVICES

- A. During construction, the balancing agency shall inspect the installation of pipe systems, sheet metal work, temperature controls, and other component parts of the heating, ventilating, and air conditioning systems.
- B. The inspections shall be performed periodically as the work progresses. A minimum of two inspections are required as follows: (1) when 60 percent of the duct work is installed; (2) when 90 percent of the equipment is installed. The balancing agency shall submit a brief written report of each inspection to the General Contractor and Engineer.
- C. Upon completion of the installation and start-up of the mechanical equipment by the Mechanical Contractor, the balancing agency shall test and balance the system components to obtain optimum conditions in each conditioned space in the building.

3.4 DEFICIENCIES

- A. If in the process of performing the TAB work, any deficiencies encountered shall be brought to the attention of the contractor responsible through defined procedures and entered in the punch list of deficiencies on the next daily Status Report. If correction of the deficiency is urgent, the matter shall be brought to the attention of all involved parties for quick resolution. The General Contractor shall provide and coordinate services of qualified responsible subcontractors, suppliers and personnel as required to correct, repair or replace any and all deficient items or conditions during the testing, adjusting and balancing period.
- B. The notification may be for single or multiple deficiencies. The work necessary to correct items on the listing shall be performed and verified in writing by the affected trade.
- C. All deficiencies that prevent proper TAB work from being completed shall be corrected prior to submittal of the Final TAB Report, unless the correction of such deficiencies cannot be accomplished in a reasonable period of time, in which case the Mechanical Engineer may grant permission to submit the Final TAB Report with the deficiencies detailed in the report.

3.5 AIR SYSTEM PROCEDURES

- A. The balancing agency shall perform the following testing and balancing functions in accordance with the Associated Air Balance Council's National Standards:

1. Fan Speeds:
 - a. Test and adjust fan RPM to achieve design CFM requirements.
2. Current and Voltage:
 - a. Measure and record motor current and voltage.
3. Pitot-tube Traverse:
 - a. Perform a Pitot-tube traverse of main supply and return ducts to obtain total CFM. If a Pitot-tube traverse is not practical, the summation of the outlets or inlets may be used. An explanation why a traverse was not made must appear on the appropriate data sheet.
4. Outside Air:
 - a. Test and adjust system minimum outside air by Pitot-tube traverse. If a Pitot-tube traverse is not practical, the percentage of outside air may be determined by calculations from the return air, outside air, and mixed air temperatures. Make allowances for heat of compression and motor heat where applicable.
5. Static Pressure:
 - a. Test and record system static pressures, including suction and discharge static pressure of each fan.
6. Air Temperature:
 - a. Take wet-bulb and dry-bulb air temperatures on the entering and leaving side of each cooling coil. Dry-bulb temperature shall be taken on the entering and leaving side of each heating coil.
7. Zone Ducts:
 - a. Adjust zone ducts to within design CFM requirements. At least one zone balancing damper shall be completely open.
8. Main Ducts:
 - a. Adjust main ducts to within design CFM requirements and traverse for total CFM quantities.
9. Branch Ducts:
 - a. Adjust branch ducts to within design CFM requirements. Multi-diffuser branch ducts shall have at least one outlet or inlet volume damper completely open.
10. Tolerances:
 - a. Test and balance each diffuser, grille, and register to within 10 percent of design requirements.
11. Identification:
 - a. Identify the location and area of each grille, diffuser, register, and terminal box. This information shall be recorded on air outlet data sheets.
12. Description:
 - a. Record the size, type, and manufacturer of each diffuser, grille, and register on air outlet data sheets.
13. Terminal Boxes:
 - a. Set volume regulators on all terminal boxes to meet design maximum and minimum CFM requirements. All associated temperature controls shall be checked for proper operation and calibration. If the terminal boxes have separate settings for heating and cooling CFM, the CFM quantities for each shall be recorded on air outlet data sheets. All diffusers connected to the terminal box shall be read in the heating and cooling modes and their readings recorded on air outlet data sheets.
14. Minimizing Drafts:
 - a. Adjust all diffusers, grilles, and registers to minimize drafts in all areas.

3.6 VERIFICATION OF TEMPERATURE CONTROL

- A. The balancing agency shall be assisted by the Temperature Controls Contractor in verifying the operation and calibration of all temperature control systems. The following tests shall be conducted:
 1. Verify that all control components are installed in accordance with project requirements

- and are functional, including all electrical interlocks, damper sequences, air and water reset, and fire and freeze stats.
2. Verify that all controlling instruments are calibrated and set for design operating conditions.
 3. Verify the accuracy of the final settings by taking temperature readings. The readings shall be in a typical conditioned space for each separately controlled zone.
- B. In the process of performing the TAB work, the balancing agency firm shall:
1. Verify that all dampers, valves and other controlled devices are operated by the intended controller.
 2. Verify that all dampers and valves are in the position indicated by the controller (open, closed, or modulating).
 3. Verify the integrity of valves and dampers in terms of tightness of close-off and of full-open position. This includes dampers in VAV terminals.
 4. Check that all valves are properly installed in the piping system in relation to direction of flow and location.
 5. Verify the proper application of all normally open and normally closed valves.
 6. Check the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts, or cold/hot walls.
 7. Check the locations of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media.
 8. Check the sequence of operation for any control mode to ensure that it is in accordance with the Contract Documents.
- C. Verify that all controller set points meet the design intent. Record observations of systems under DDC control. Record all default set points if different from operating set points.
- D. Check all dampers for free and full operation, record any obstructions.
- E. Verify the operation of all interlock systems.
- F. Perform all system verifications to assure the safety of the system and its components.
- G. Verify that the changeover from heating to cooling mode occurs as specified.

3.7 TEST AND BALANCE REPORT

- A. The test and balance report shall be complete with logs, data, and records as required herein. All logs, data, and records shall be typed on white bond paper and bound and submitted in a single PDF file. The report shall be certified, accurate and complete by the balancing agency's certified Test and Balance Engineer.
- B. The report shall contain the following general data in a format selected by the balancing agency:
1. Project number
 2. Contract number
 3. Project title
 4. Project location
 5. Project Architect
 6. Project Mechanical Engineer
 7. Test & Balance agency
 8. Test & Balance Engineer
 9. General Contractor
 10. Mechanical Subcontractor
 11. Dates tests were performed

12. Certification

- C. The test and balance report shall be recorded on report forms conforming to the recommended forms in the AABC National Standards. At a minimum, the report shall include:
1. Preface
 - a. A general discussion of the system, any abnormalities and problems encountered.
 - b. A deficiency log detailing system abnormalities that do not meet these specifications.
 - c. The list of instruments including type, model, manufacturer, serial number, and calibration dates.
 2. Air System Data
 - a. All test and balance data indicating design conditions, and actual conditions of operation for each device and/or piece of HVAC equipment.
 - b. Outside Air Temperatures, dry bulb and wet bulb.
 - c. Entering Air Temperatures, dry bulb and wet bulb.
 - d. Discharge Air Temperatures, dry bulb and wet bulb.
 - e. Suction and discharge static pressures across each fan.
 3. System Identification
 - a. In each report, the zones, supply, return, and exhaust openings, and traverse points shall be numbered and/or lettered on mechanical drawings to correspond to the numbers and letters used on the report data sheets.
 4. Controls
 - a. Document verification of controls.
 5. Occupancy Inspection
 - a. Make a total of three (3) inspections within ninety (90) days after occupancy of the building, and make adjustments if required, to insure that satisfactory conditions are being maintained throughout. Inspections to be coordinated with Architect/Engineer and Owner and shall be documented with a supplemental report containing data and information as required.
 6. Instructions to Operating Personnel
 - a. Test and Balance Firm shall instruct the operating personnel regarding the following:
 - (1) Systems Operation
 - (2) Unusual Operating Conditions.
 - (3) System Troubleshooting Procedures.

3.8 REPORT SUBMITTAL

- A. The test and balance report are required and shall be submitted to the General Contractor for distribution to the Owner, Architect and Mechanical Engineer. The test and balance report shall be submitted in a single, fully bound PDF file.

3.9 FINAL ACCEPTANCE

- A. At the time of final inspection, the balancing agency shall recheck, in the presence of the Owner's representative, specific and random selections of data recorded in the certified test and balance report.
- B. Points and areas for recheck shall be selected by the Owner's representative.
- C. Measurements and test procedures shall be the same as the original test and balance.
- D. Selections for recheck, specific plus random, shall not normally exceed 15 percent of the total number tabulated in the report, except where special air systems require a complete recheck for safety reasons.

- E. If random tests demonstrate a measured flow deviation of 10 percent or more from that recorded in the certified test and balance report, the report shall automatically be rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, a new certified test and balance report submitted, and a new inspection test made, all at no additional cost to the Owner.

3.10 OPPOSITE SEASON TEST

- A. Opposite season test and balance work shall be required for systems that cannot be tested and balanced due to climate or seasonal conditions. An example would be Chiller operation in the winter season, or Boiler operation in the summer season. In such case, the balancing agency shall perform an inspection of the buildings HVAC system during the opposite season from that in which the initial adjustments were made. The balancing agency shall make any necessary modifications to the initial adjustments to produce optimum system operation in compliance with the contract documents. The TAB agency shall contact the Owner's Commissioning Agent, to coordinate such work, no less than 14 calendar days prior to any Opposite Season Testing.
- B. Opposite Season Testing is not required if the Owner's Commissioning Agent can simulate off season conditions via the building automated controls system.

END OF SECTION

SECTION 23 07 13

DUCT AND GRILLE INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 01 Specifications and Section 23 00 00, apply to this Section.

1.2 SECTION INCLUDES

- A. External duct insulation
- B. Internal duct liner

1.3 RELATED SECTIONS

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 31 13 – Metal Ductwork
- C. Section 23 37 13 – Diffusers, Registers, and Grilles

1.4 SUBMITTALS

- A. Product Data:
 - 1. Provide submittal data on all equipment specified in this section in accordance with Section 23 00 90, General Conditions, and Division 01.
 - 2. Submit product data indicating typical catalog of information.
 - 3. Submit product data sheets indicating dimensions, general assembly, and ratings.
 - 4. Submit manufacturer's installation instructions.
 - 5. Submit kitchen exhaust duct wrap to City for approval prior to submitting to Engineer.

1.5 REFERENCES

- A. Refer to Section 23 00 00 for complete names of references identified in this section.
 - ASTM E84 Standard test for surface burning characteristics of building materials.
 - NFPA 221 Fire walls and fire barrier walls.
 - NFPA 255 Surface burning characteristics of building materials.
 - NFPA 96 Ventilation control and fire protection of commercial cooking operations.
 - UL 723 Test for surface burning characteristics of building materials.
 - UL 1978 First Edition Standard for Grease Ducts
 - ASTM C553 Standard specification for mineral fiber blanket thermal insulation for commercial and industrial applications.
 - ASTM C1071 Fibrous glass duct lining insulation (thermal and sound).
 - IECC International Energy Conservation Code
 - ASTM C355 Water Vapor Permeance
 - ASTM C916-85(2001)e1 Standard Specification for Adhesives for Duct Thermal Insulation

ASTM C1136-02	Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM A635/A635M-02	Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Commercial Steel, Drawing Steel, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, Hot-Rolled, General Requirements
ASTM A924	Hot Dip Galvanized Coils & Sheets - Tolerances

1.6 QUALITY ASSURANCE

- A. Fire Hazard Rating:
 - 1. All insulation used on the project must have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50 as determined by test procedures ASTM E84, NFPA 255 and UL 723. Bear UL label. All insulation must meet ASTM C553.
 - 2. These ratings must be as tested on the composite of insulation, jacket or facing, and adhesive.
 - 3. Components such as adhesives, mastics and cements must meet the same individual ratings as minimum requirements.
 - 4. Install in accordance with SMACNA standards.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in original sealed containers or unopened packages, and clearly labeled with manufacturer's name, product identification, and lot numbers.
- B. Store materials out of weather and in an enclosed shelter.

PART 2 PRODUCTS

2.1 APPLICATIONS

- A. Supply ducts
- B. Return ducts
- C. Outside air ducts
- D. Supply and return diffusers
- E. Grilles
- F. General exhaust ducts do not receive insulation

2.2 MANUFACTURERS

- A. Owens Corning
- B. Knauf
- C. Johns Manville

2.3 EXTERNAL DUCT WRAP AND GRILLE INSULATION

- A. Minimum Density:
 - 1. 3/4 pound per cubic foot
- B. Material:
 - 1. Fiberglass blanket with type FRK foil reinforced Kraft vapor barrier jacket
- C. Thickness:
 - 1. 2.0 inch, Minimum Value R-6.0
- D. Comply with ASTM C553 standard
- E. Comply with ASTM C1136-02
- F. Comply with ASTM E84
- G. Comply with IECC

2.4 INTERNAL DUCT LINER

- A. Use only where specifically noted, or with written approval of Engineer.
- B. Install internal duct liner that extends no more than 2'-0" below roof deck at each rooftop unit.
- C. Thickness:
 - 1. 1½ inch thick, Minimum Value R-6.0
- D. Fasteners:
 - 1. Pronged straps.
- E. Comply With ASTM C916-85(2001)e1
- F. Comply with ASTM C1071 standard
- G. Comply with ASTM C553 standard
- H. Comply with ASTM C1136-02
- I. Comply with ASTM E84
- J. Comply with IECC

PART 3 EXECUTION

3.1 DUCT WRAP INSTALLATION

- A. Wrap insulation tightly on the ductwork with all circumferential joints butted and longitudinal joints overlapped a minimum of 3 inches.
- B. Adhere insulation to metal with 4 inch strips of insulation bonding, using adhesive at 8 inch centers.

- C. On circumferential joints, secure the 2-inch flange of the facing and tape with a minimum of 3 inch wide foil reinforced Kraft tape.
- D. On longitudinal joints, secure the overlap using 9/16 inch flared door staples applied 6 inches on centers and taped with minimum 3 inch wide foil reinforced Kraft tape.
- E. Tape all pin penetrations or punctures in facing.
- F. The duct wrap insulation on all rectangular/square ducts 24-inch or wider shall be additionally secured to the bottom of the duct with mechanical fasteners such as pins and speed clip washers. Spacing at 18-inch on center each direction to prevent sagging.
- G. Fasten insulation installed on diffusers, grilles, and registers using 3-inch minimum wide foil reinforced Kraft tape.
- H. Extend insulation 1 inch beyond each outer surface of diffuser, grille, and register.

3.2 INTERNAL DUCT LINER

- A. Provide internal duct liner as indicated on the plans.
- B. Install internal duct liner on rooftop unit supply and return ducts no more than 2'-0" below roof deck.
- C. Apply the liner to the inside of the duct with heavy density side to the air stream and secure to the duct with adhesive Insul-Coustic No. 225 completely coating the clean sheet metal.
- D. Do not use duct liner in kitchen or other areas that may have excess moisture present.
- E. Secure fasteners to the ducts with adhesive.
- F. Conform to SMACNA Standards for all duct construction standards.
- G. Accurately cut the liner and thoroughly coat the ends with adhesive to make a firmly butted and tightly sealed joint.
- H. Where ducts are lined, exterior insulation will not be needed except as otherwise specified.
- I. Install duct liner in accordance with SMACNA standards.

END OF SECTION

SECTION 23 07 21

REFRIGERANT PIPING INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 1 Specifications and Section 23 00 00, apply to this Section.

1.2 SECTION INCLUDES

- A. Elastomeric closed-cell structure insulation
- B. Applications – Refrigerant suction lines serving cooling units

1.3 RELATED SECTIONS

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 23 00 – Refrigerant Piping

1.4 SUBMITTALS

- A. Product Data:
 - 1. Provide submittal data on all equipment specified in this section in accordance with Section 23 00 90, General Conditions, and Division 1.
 - 2. Submit product data indicating typical catalog of information.
 - 3. Submit product data sheets indicating dimensions, general assembly, and ratings.
 - 4. Submit manufacturer's installation instructions.

1.5 SHOP DRAWINGS

- A. Submit 1/4" per foot shop drawing(s) showing all piping and equipment shown by plans and specifications. The drawings shall be coordinated with structural, electrical, and fire sprinkler drawings.

1.6 REFERENCES

- A. Refer to Section 23 00 00 for complete names of references identified in this section.
- B. ASTM E 84-03 - Standard Test Method for Surface Burning Characteristics of Building Materials
- C. ASTM C 355 - Water Vapor Permeability

1.7 QUALITY ASSURANCE

- A. Fire Endurance Rating: The composite classifications shall not exceed the flame spread rating and the smoke development rating as outlined by NFPA 255/ ASTM E-84 for the basic material, the finishes, adhesives, etc., specified for each system, and shall be such when completely assembled.

- B. Components such as adhesives, mastics and cement must meet the same requirement.

PART 2 PRODUCTS

2.1 PIPE INSULATION

- A. Type: Closed-cell polyethylene pipe insulation.
- B. Performance Criteria: Resistant to ultra-violet and biological degradation.
- C. Temperature Range: -90°F to 200°F
- D. Water Vapor Permeability (Dry Cup): Less than 0.03 per inch when measured by ASTM C355.
- E. Thermal Conductivity: 0.25 – 0.29 BTU-IN/HR-FT²-°F.
- F. Refrigerant Suction Lines Insulation thickness – 1½-inches
- G. Manufacturer/Model:
 - 1. Armacell
 - 2. Aeroflex

2.2 SEALANT & ADHESIVE

- A. Manufacturer/Model:
 - 1. Therma-Cel
 - 2. Armstrong
 - 3. Aeroflex

2.3 FINISHES

- A. Manufacturer:
 - 1. WB Armstrong Finish – White
 - 2. Aeroflex
 - 3. VentureClad

PART 3 EXECUTION

3.1 PIPE

- A. Where straps or hangers are used, provide insulation shield.
- B. Apply insulation to clean, dry pipes.
- C. Butt insulation joints firmly together.
- D. Seal butt seams with sealant. Duct tape or electrical tape will not be permitted.
- E. Install in accordance with manufacturer's instructions.
- F. Accomplish in a good workmanship manner and be neat in appearance.
- G. Insulation not neat in appearance will be rejected by the Engineer.

- H. Do not stretch insulation around elbows.
- I. Install insulation on piping prior to final connection.
- J. Longitudinal joints installed after pipe is assembled are not acceptable.
- K. Refer to plans for installation of shields around pipe hangers.
- L. Do not allow liquid lines to come in contact with any structural members or steel stubs. Use plastic ties to secure liquid lines to insulation on vapor line. Do not crush insulation.

3.2 FINISH

- A. All insulation to be painted with WB Armstrong Finish, or equivalent. Apply as recommended by the manufacturer, to protect the insulation on exterior of building. Apply above 50°F. Apply to dry insulation only.

3.3 VALVES, FLANGES & FITTINGS

- A. Insulate all valves, flanges, and fittings in a neat manner.

3.4 REPAIRS & REPLACEMENT

- A. Replace any insulation that has ever been wet.
- B. Repair any damage caused by condensation due to improper insulating.
- C. Replace any insulation which is cut or torn during construction.

END OF SECTION

SECTION 23 08 00

COMMISSIONING OF HEATING, VENTILATING AND AIR CONDITIONING (HVAC)

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.
- B. Division 01 section 'Building Systems Commissioning'.

1.2 SUMMARY

- A. This section includes commissioning process requirements for Mechanical systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "Building Systems Commissioning" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "Building Systems Commissioning" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "Building Systems Commissioning" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "Building Systems Commissioning" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
 - 1. Certificates of readiness
 - 2. Certificates of completion of installation, prestart, and startup activities.
 - 3. O&M manuals
 - 4. Test reports

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "Building Systems Commissioning" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the mechanical systems and controls systems in Division 23. A sufficient quantity of two-way radios shall be provided by each contractor.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.
- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 – EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Functional Testing Forms for all commissioned components, equipment, and systems.
- B. Red-lined Drawings:
 - 1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
 - 2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
 - 3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
 - 4. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. Operation and Maintenance Data:
 - 1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
 - 2. The CxA will review the O&M literature once for conformance to project requirements.

3. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.
- D. Systems manual requirements:
1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.
 2. The GC shall include final approved versions of the following information for the Systems Manual:
 - a. As-Built System Schematics
 - b. Verified Record Drawings
 - c. Test Results (not otherwise included in Cx Record)
 - d. Periodic Maintenance Information for computer maintenance management system
 - e. Recommendations for recalibration frequency of sensors and actuators
 - f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
 - g. Training Records, Information on training provided, attendees list, and any on-going training
 3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.
 4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning tests at the direction of the CxA.
- B. Attend construction phase controls coordination meetings.
- C. Participate in Mechanical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- D. Provide information requested by the CxA for final commissioning documentation.
- E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- F. Prepare preliminary schedule for Mechanical system orientations and inspections, operation and maintenance manual submissions, training sessions, equipment start-up and task completion for owner.
- G. Update schedule as required throughout the construction period.
- H. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.
- I. Assist the CxA in all verification and functional performance tests.
- J. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- K. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.

- L. Participate in, and schedule vendors and contractors to participate in the training sessions.
- M. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.

Cx Systems	Require Fx Testing	Items Tested
HVAC		
___ Chilled Water Plants	Yes	Controls, Sequence of Operations, Alarms
___ Hot Water Plants	Yes	Controls, Sequence of Operations, Alarms
___ Air Handling Units	Yes	Controls, Sequence of Operations, Alarms, Economizer
___ Packaged Units (RTU and HP)	Yes	Controls, Sequence of Operations, Alarms, Economizer
___ Terminal Units/VAV's	Yes	Controls, Sequence of Operations, Alarms, Economizer
___ Exhaust and Relief fans	Yes	Controls, Sequence of Operations, Alarms
___ DDC Control System (<i>Component installation and System Operation</i>)	Yes	System calibration and function

- N. The equipment supplier shall document the performance of his equipment.
- O. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- P. Provide training of the Owner's operating staff using expert qualified personnel, as specified.
- Q. Equipment Suppliers
 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 2. Assist in equipment testing per agreements with contractors.
 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- R. Refer to Division 01 Section "Building Systems Commissioning" for additional Contractor responsibilities.

3.3 OWNER'S RESPONSIBILITIES

- A. Refer to Division 01 Section "Building Systems Commissioning" for Owner's Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

- A. Refer to Division 01 Section "Building Systems Commissioning" for Design Professional's Responsibilities.

3.5 CXA'S RESPONSIBILITIES

- A. Refer to Division 01 Section "Building Systems Commissioning" for CxA's Responsibilities.

3.6 TESTING PREPARATION

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

3.7 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of Mechanical testing shall include sequence of operations for HVAC equipment, HVAC building automation control system, economizers; etc.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. Tests will be performed using design conditions whenever possible.
- E. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- F. The CxA may direct that set points be altered when simulating conditions is not practical.
- G. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- H. If tests cannot be completed because of a deficiency outside the scope of the Mechanical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

- I. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.8 MECHANICAL SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Functional Performance Tests: Sample functional performance testing procedures are included in Part 3.13. These procedures are representative of those that will be implemented in the Cx process. The CxA may modify these procedures during the Construction Phase once all systems are known and all required documentation has been provided.
- B. Mechanical Instrumentation and Control System Testing: Assist the CxA with preparation of testing plans.

3.9 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

- A. Refer to Division 01 Section “Building Systems Commissioning” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.10 APPROVAL

- A. Refer to Division 01 Section “Building Systems Commissioning” for approval procedures.

3.11 DEFERRED TESTING

- A. Refer to Division 01 Section “Building Systems Commissioning” for requirements pertaining to deferred testing.

3.12 OPERATION AND MAINTENANCE MANUALS

- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
- B. Refer to Division 01 Section “Building Systems Commissioning” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.13 SAMPLE FUNCTIONAL PERFORMANCE TESTING PROCEDURES

- A. These testing procedures are representative of those that will be implemented in the Cx process. The CxA may modify these procedures during the Construction Phase once all systems are known and all required documentation has been provided.

Example Systems

Electronic File Name

AHU

AHU-FT

Functional Test Record- _____		
Project Owner: _____		
Project Type: _____		
Project Address:		
List Building Systems to Test:		
CH-1 & CH-2	Cooling Only VAV Terminal	Generator Run Status
BL-1 & BL-2	Electrical Room Exhaust Fans	Lighting
AHU-A1, A2, B1, B2, C1, C2, D1, D2	Boiler Room Supply Fan	Fire Alarm Monitoring
AHU-B3, E1, E2	Packaged Computer Room Units (MDF/IDF)	Utility Monitoring
AHU-E3	Freezer/Cooler	Relief Dampers
OAHU-A1, B1, E1	Kitchen Exhaust/Supply Fans	Power Monitoring
FCU-1	Dishwasher Exhaust	Outside Air Conditions
Constant Volume Terminal Unit with Hot Water Reheat	Building Emergency Shutdown	
Constant Volume Terminal Unit with Electric Reheat	General Exhaust Fans	
Beginning O. A. Temp: _____ (F)	Ending O.A. Temp: _____ (F)	% RH: (HI) _____ (LO) _____

List Weather conditions at the project site: Mostly dry conditions with a short shower.			
List Controls and HVAC Testing Spec Sections:	_____, _____, _____, _____, _____		
Building Environmental Conditions:			
<input type="checkbox"/> Clean <input type="checkbox"/> Dirty <input type="checkbox"/> Dry <input type="checkbox"/> Wet <input type="checkbox"/> Other In Construction			
Verify the following conditions prior to testing	Yes	No	If <u>No</u> is checked, list reason
<input type="checkbox"/> AHU/O.A/CV Boxes have clean filters installed	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> Final Filters are as specified	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> Ductwork protective covers have been removed	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> TAB is Complete for systems being tested	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> Controls are complete and system is controlled from DDC control panel/laptop	<input type="checkbox"/>	<input type="checkbox"/>	

Verify the following documentation requirements have been met prior to testing	Yes	No
Checklists have been sampled for review by the CxA to determine the operational readiness for systems being tested	<input type="checkbox"/>	<input type="checkbox"/>
TAB <u>Draft Field Report</u> has been reviewed and all know TAB deficiencies are corrected or noted by the Cx Agent	<input type="checkbox"/>	<input type="checkbox"/>
Controls Contractor completed Pre-Commissioning Checklist has been reviewed by the CxA	<input type="checkbox"/>	<input type="checkbox"/>
General Contractor has been notified of the CxA scheduled testing dates and times. This is related to coordination with Life Safety Systems testing by the AHJ or Fire Marshal.	<input type="checkbox"/>	<input type="checkbox"/>
All issues identified and recorded on the Cx Issues Log or reported to the GC have been resolved	<input type="checkbox"/>	<input type="checkbox"/>
COMMISSIONING CHECKLISTS:		
<input type="checkbox"/> REVIEWED by CxA <input type="checkbox"/> COMPLETE <input type="checkbox"/> INCOMPLETE		
TAB FIELD REPORT:		
<input type="checkbox"/> SUBMITTED <input type="checkbox"/> NOT SUBMITTED		
<input type="checkbox"/> REVIEWED <input type="checkbox"/> NOT REVIEWED		
CEILING SYSTEMS/GRID INSTALLED IN ALL AREAS UNDER TEST		
<input type="checkbox"/> YES <input type="checkbox"/> NO		
LIGHTING SYSTEMS:		
<input type="checkbox"/> INDOOR <input type="checkbox"/> EXTERIOR <input type="checkbox"/> SITE <input type="checkbox"/> NOT TESTED		
<input type="checkbox"/> INSTALLED <input type="checkbox"/> FULLY OPERATIONAL <input type="checkbox"/> PRE-TESTED BY CONTROLS SUB		
<input type="checkbox"/> NOT INSTALLED <input type="checkbox"/> NOT FULLY OPERATIONAL <input type="checkbox"/> NOT PRE-TESTED		

COMMENTS:					
CxA Note: Items found noncompliant, incomplete, in variance to the contract documents or fail to perform as intended per the contract documents and engineer approved control sequences, will be documented in writing, and the GC, Owner's PM and Engineer of record will be notified of the discrepancy. The GC will be responsible for ensuring his sub-contractors resolve issues reported, in a timely manner and to notify the CxA that the system is made ready for Functional Retest.					
Building Occupied/Unoccupied Schedule:					
Day of Week	Area	System Enabled	Occ	Syst. Disabled	Un-Occ
Monday - Friday	Admin	6:00 AM	7:00 AM	3:30 PM	4:00 PM
	Classrooms				
	Gym				
	Cafeteria				
	General Spaces				
Weekend	Scheduled as requested per facility request				
Holidays	Scheduled as requested per facility request				
Note:					
Optimum Start Program:	Yes	No	Comments		
Required	<input type="checkbox"/>	<input type="checkbox"/>			
Programmed	<input type="checkbox"/>	<input type="checkbox"/>			

Designated Temperature Setpoints:						
Occupied:						
Cooling Setpoint °F	<u>74 +/- 1°</u>					
Heating Setpoint °F	<u>69 +/- 1°</u>					
Unoccupied:						
Cooling Setpoint °F	95					
Heating Setpoint °F	55					
Night Setback						
Setpoint °F	95/55					
CxA Note: Testing sequences may be conducted simultaneously where systems are connected or operate in conjunction with one another. This includes Chillers, Boilers, AHU's, TU's and Exhaust fans.						
Testing Sequence						
Variable Volume Air Handling Unit Sequence of Operation	Pass	Fail	Note			
Unit: VAV AHU #		-	-			
		-	-			
Fan Control		-	-			
When the air handling unit is requested to run, the BAS shall start the fan. A current switch shall prove status to the BAS and shall alarm at the central site if the switch is not made within 40 seconds (adjustable).		-	-			
		-	-			

Cold Deck Temperature Control		-	-
When the air handling unit is in occupied mode and cooling is required, the BAS shall send a request for cooling to the chiller plant and shall modulate the chilled water control valve to maintain leaving air temperature set point (55 °F, adjustable).		-	-
			-
Air Volume Control		-	-
While the air handling unit is active, the BAS shall maintain the duct static pressure set point at 1.5" w.g. (adjustable) by modulating the speed of the supply fan through a variable speed drive (VSD). A static pressure sensor, mounted two-thirds down the longest duct run, shall monitor the duct static pressure. A manual-reset static pressure high limit switch, shall monitor the static pressure of the supply ducts. If the duct static pressure rises above 3.0" w.g. (locally adjustable) the air handling unit shall be de-energized via hard-wire interlock to the VFD safety circuit. The BAS shall monitor the high static limit switch and shall display an alarm at the central site. The static pressure high limit switch must be manually reset.		-	-
			-
Demand Control Ventilation		-	-
When the air handler is running in the occupied mode, the OA damper control shall be enabled. CO2 sensors mounted as indicated on drawings, shall monitor the CO2 levels. Where multiple sensors are provided for a particular AHU, the BAS shall select the highest level for control. The BAS shall modulate the outdoor air damper from its minimum position to its maximum position as required to maintain the CO2 level between 850 ppm and 1000 ppm (all adjustable). The OA dampers minimum and maximum positions shall be determined by the T.A.B. contractor to be the positions that allow the scheduled minimum and maximum OA CFM. The system shall have the ability to perform a "Purge Mode" at a scheduled time for a scheduled duration. The BAS will monitor Outside Airflow via the Airflow Monitoring Station.		-	-
			-

Humidity Control		-	-
The BAS shall monitor humidity in 2 representative zones for each AHU. If either humidity transmitter senses humidity above 55% (adjustable), the BAS shall command 40% of the associated terminal units to 100% cooling (adjustable), and the terminal unit controller shall utilize the terminal unit reheat to maintain space setpoint.		-	-
		-	-
Auxiliary DX Cooling Coil (If Available)		-	-
The air handling unit serving the administration area shall be provided with an auxiliary DX cooling coil in addition to the hydronic coil. When the system is operating after hours, the BAS shall utilize the DX cooling for supply air temperature control and shall not send a request to the chiller plant.		-	-
		-	-
Reversed valve, DX coil not started up			-
Associated Equipment		-	-
During the occupied time period, any associated exhaust fans shall be energized.		-	-
		-	-
<i>End of Testing</i>			

END OF SECTION

SECTION 23 09 23

ENERGY MANAGEMENT CONTROL SYSTEM (BACNET)

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 1 Specifications and Section 23 00 00, apply to this Section.

1.2 SUMMARY

- A. It is the intent of this specification to describe the basic architecture and performance requirements of the Energy Management Control System (EMCS). The turn-key EMCS shall include Control Units, Distributed Controllers, Unitary Controllers, Local Area Networks (LANs), sensors, modems, wiring, connectors, control devices, actuators, installation and calibration, supervision, adjustments and fine tuning necessary for a complete and fully operational system.
- B. A distributed logic control system complete with all software and hardware functions shall be provided and installed. System shall be completely based on ANSI/ASHRAE Standard 135-2001, BACnet. This system is to control all mechanical equipment, including all unitary equipment such as VAV boxes, heat pumps, fan-coils, AC units, etc. and all air handlers, boilers, chillers, and any other listed equipment using Native BACnet-compliant components.
- C. All systems shall be complete true stand-alone systems.
- D. LonWorks or proprietary protocol software is not allowed.
- E. Everything shall be reprogrammed through software without change of any hardware. The owner shall have all the tools necessary to reprogram without any additional costs.
- F. A PC computer (Remote Workstation) is required at every school. A central work station (CPU) shall be installed in the Energy Manager's office and provided by the owner.
- G. EMCS shall have backward and forward compatibility.
- H. Systems shall be furnished and installed complete in all respects, including any and all equipment, controls, wiring, instrumentation, enclosures, labor, engineering, training, commissioning, programming, supervision, calibration, coordination with other trades, etc. No information given in (or omitted from) these specifications shall relieve the contractor of this absolute requirement. Include all associated electrical work except as noted. Work includes furnishing of all labor, superintendence, materials, tools, equipment and sources necessary for the complete installation or modification of the following systems as herein specified. It is the intent of these specifications that the Contractor shall furnish and install the systems complete in every respect and ready to operate. All equipment, miscellaneous items and accessories required for such installation and for the correct and convenient operation of the entire installation whether or not each such item or accessory is shown on the plans or mentioned in these specifications shall be furnished and installed.
- I. Should discrepancies or ambiguities arise within these specifications, the most stringent condition with regard to cost shall govern the bid. Obtain clarification from the Engineer prior to purchasing equipment and proceeding with the work.

- J. Where drawings are provided as part of or supplement to these specifications, such drawings are inherently schematic only and not intended to convey all controls, wiring, installation, details, etc. It shall be the responsibility of the EMCS contractor to verify that control approaches presented are appropriate for the HVAC systems involved, and that bids include all work described, specified, or otherwise necessary for a complete and functioning system.
- K. Schedule: Contractor acknowledges that submission of bid constitutes agreement with and conformance to the completion dates.
- L. Codes, Permits, and Fees: This contractor shall comply with all local, state and national codes, and shall secure and pay or all applicable costs, fees, permits, and licenses. No additional costs shall be allowed for these items.
- M. Other Conditions:
 - 1. Safety: Execute all work with the highest regard to safety. Comply with all laws governing safety, including the "Occupational Safety and Health Standards" and the "Safety and Health Regulations for Construction", State and federal. All applicable power tools used during construction shall have current approval under an approved Equipment Grounding Program and shall bear the tag relating such. Contractor is solely responsible for all means and methods.
 - 2. Coordination and Supervision: Each bid shall include the necessary detail and interconnection work to coordinate his work with the work of other trades. Contractor shall keep competent supervisory personnel on the job whenever work is being performed which affects his trade.
 - 3. Storage of Materials: Each Contractor shall provide temporary storage facilities suitable for equipment stored at the job site. Storage facilities shall be weatherproof and lockable as required.
 - 4. Protection of Building and Materials: Each Contractor shall take necessary precautions to prevent damage to existing buildings and to work of other trades.
 - 5. Observations: Site observation by Owner or Engineer is for express purpose of verifying compliance by Contractor with Contract Documents and shall not be construed as construction supervision nor indication of approval of manner or location in which work is being performed as being safe practice or place.
 - 6. Contractor is reminded that he shall also comply with all respects to the Invitation to Bid, General Conditions, Supplementary Conditions, Notice of Bidders, Instructions to Bidders, and all other governing parts of these specifications and the contract documents. These sections are included as part of the contract.
 - 7. Where the term "Contractor" is used within these specifications, it shall be understood to mean an approved controls manufacturer/contractor, and facility management systems contractor.
- N. The entire system shall be approved and listed by Underwriters Laboratories, Inc., under UL916 for energy management systems and FCC-Part 15 Subparagraph J Class A Emissions Requirements.
- O. Equipment and Software Updates/Upgrades:
 - 1. Equipment: All equipment, components, parts, materials, etc. provided throughout the period of Work (as governed in the Agreement) shall be fully compatible with all other equipment, etc. provided at any other time throughout the period of Work. Should updated versions of equipment be provided which are not fully compatible with earlier equipment provided, Contractor shall replace earlier equipment with the later version at no cost to Owner.

2. Software: All software upgrades applicable to system and offered by the manufacturer/contractor for this system shall be provided at no cost to the Owner throughout the period of work. This no cost upgrade shall include installation, programming, modifications to field equipment, data base revisions, training, etc. as appropriate.
- P. The Engineer shall reserve all authority regarding approval, conditional approval, or rejection of systems not fully complying with these specifications.

1.3 WORK INCLUDED

- A. The EMCS shall be a totally Native BACnet-based system, including a Microsoft Windows operator's workstation, based on a distributed control system in accordance with this specification. The operator's workstation, all building controllers, application controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135–2001, BACnet. In other words, all workstations and controllers, including unitary controllers, shall be Native BACnet devices. No gateways shall be used for communication to controllers installed under this section. Gateways may be used for communication to existing systems or to systems installed under other sections.
- B. The installing contractor shall provide the new web-based software and software updates required for this project. Additionally, the installing contractor shall provide all computer related components (BAS Web server) for the new software platform to function in a peer-to-peer environment.
- C. The owner will provide reserved DHCP addresses and any other network configuration information necessary to each control contractor for the purpose of configuring each building controller and/or server on the owner's network. The controls contractor shall coordinate the IP address for each building controller and/or server. It shall be the responsibility of each control contractor to coordinate with the owner for network connectivity.
- D. The Energy Management and Control System (EMCS) application program shall be written to communicate specifically utilizing BACnet protocols. Software shall include password protection, alarming, logging of historical data, full graphics including animation, full suite of field engineering tools including graphical programming and applications. Systems using operating systems other than that described above are strictly prohibited.
- E. Building controllers shall include complete energy management software, including scheduling building control strategies and logging routines. All energy management software and firmware shall be resident in field hardware and shall not be dependent on the operator's terminal. Operator's terminal software is to be used for access to field-based energy management functions only. Provide zone-by-zone direct digital logic control of space temperature, scheduling, runtime accumulation, equipment alarm reporting, and override timers for after-hours usage.
- F. All application controllers for every terminal unit (VAV, HP, UV, etc.) air handler, all central plant equipment, and any other piece of controlled equipment shall be fully programmable. Application controllers shall be mounted next to controlled equipment and communicate with building controller via BACnet LAN.
- G. Provide all necessary BACnet-compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.

- H. Prepare individual hardware layouts, interconnection drawings, and software configuration from project design data.
- I. Implement the detailed design for all analog and binary objects, system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.
- J. Design, provide, and install all equipment cabinets, panels, data communication network cables needed, and all associated hardware.
- K. Provide and install all interconnecting cables between supplied cabinets, application controllers, and input/output devices.
- L. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this section.
- M. Provide complete manufacturer's specifications for all items that are supplied. Include vendor name of every item supplied.
- N. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, startup, and commissioning.
- O. Provide a comprehensive operator and technician training program as described herein.
- P. Provide as-built documentation, operator's terminal software, diagrams, and all other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.
- Q. Provide new sensors, dampers, valves, and install only new electronic actuators. No used components shall be used as any part or piece of installed system.
- R. Unless otherwise specified, all products shall be of single manufacturer where possible with substitutions approved by Engineer/Owner.
- S. Provide all indicating devices, interface equipment, and other apparatus required to operate mechanical system and to perform functions specified and to operate other items specified.
- T. Provide protective devices to prevent damage to the EMCS as a result of lightning.
- U. The Energy Management Control system shall allow full user operation with minimum of training. It shall have an English language display, with both user prompts and a "help" user tutorial. It shall contain management reports for the monitoring of both current and historical energy usage, heating and cooling degree day, building status and after hours occupancy information.
- V. All applications programs shall be pre-engineered and pretested. Program entries shall utilize graphical templates.

W. Workmanship:

1. Contractor shall use only thoroughly trained and experienced workmen completely familiar with the items required and with the manufacturers recommended methods of installation. In all respects, the workmanship shall be of the highest grade, and all construction shall be done according to the best practice of the trade. Unless otherwise noted, conduit shall be concealed and installed square to the building lines. Any work not meeting these requirements shall be replaced or rebuilt without extra expense to the Owner

1.4 RELATED SECTIONS

- A. Section 23 00 00 - Basic Mechanical Requirements
- B. Section 23 81 23 – Computer Room Air Conditioning Unit
- C. Section 23 81 26 – Split System HVAC Units
- D. Section 26 00 00 – Basic Electrical Requirements

1.5 DEFINITIONS

- A. Energy Management Control System, Facility Management System, Control System are to be considered the same.

1.6 REFERENCES

- A. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
 1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
 2. ANSI/ASHRAE Standard 135-2001, BACnet.
 3. Uniform Building Code (UBC), including local amendments.
 4. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
 5. National Electrical Code (NEC).
 6. FCC Part 15, Subpart J, Class A.
 7. EMC Directive 89/336/EEC (European CE Mark).
 8. City, county, state, and federal regulations and codes in effect as of contract date.
 9. Except as otherwise indicated the system supplier shall secure and pay for all permits, inspections, and certifications required for his work and arrange for necessary approvals by the governing authorities.

1.7 SPECIFICATION NOMENCLATURE

EMCS	Energy Management and Control System
WAN	Wide Area Network
RWS	Remote Work Station
HHI	Hand Held Interface
LAN	Local Area Network

1.8 QUALITY ASSURANCE

- A. Responsibility:
 1. The supplier of the EMCS shall be responsible for inspection and Quality Assurance (QA) for all materials and workmanship furnished.

- B. Component Testing:
 - 1. 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:
 - 1. The EMCS supplier shall provide all tools, testing, and calibration equipment necessary to ensure reliability and accuracy of the system.

1.9 SUBMITTALS

- A. Drawings
 - 1. The system supplier shall submit detailed complete, engineered drawings, control sequence, and bill of materials for approval.
 - 2. The contractor shall supply one electronic copy of the submittal.
 - 3. The electronic files will either be e-mailed to the architect or posted to a project management and information exchange web site, depending on the architect's requirements. The architect and contractor can distribute copies of the files as desired.
 - 4. The engineer will retain an electronic copy of the submittal and all responses.
- B. System Documentation
 - 1. Include the following in submittal package:
 - a. Data sheets for all pieces of equipment.
 - b. System configuration diagrams in simplified block format.
 - c. All input/output object listings and an alarm point summary listing.
 - d. Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.
 - e. Complete bill of materials, valve schedule and damper schedule.
 - f. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
 - g. Overall system operation and maintenance instructions including preventive maintenance and troubleshooting instructions.
- C. For all system elements - operator's workstation(s), building controller(s), application controllers, routers, and repeaters, provide BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2001.
- D. Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.
- E. A list of all functions available and a sample of function block programming that shall be part of delivered system.
 - 1. Scheduling
 - a. The vendor shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases. Schedule shall show all the target dates for transmission of project information and documents and shall indicate timing and dates for system installation, debugging, and commissioning.
 - 2. Drawings and Manuals:
 - a. Upon completion of the work, the Contractor shall provide the Owner with "record" layouts for the system. Layouts shall indicate all equipment and the function of each item shall be indicated.
 - 3. Operating instructions and as-built system flow diagrams and drawings shall be prepared, bound and delivered to the Owner. Each sensor, relay, switch, motor, controller, indicator

(when inside panel), and item of equipment, etc., shall be identified with a number or mark identical to one which shall be tagged on each item. Large items of equipment may be identified by a suitable symbol listed in a legend on the control diagram.

1.10 EMCS CONTRACTOR QUALIFICATION REQUIREMENTS

- A. The Energy Management Control System Manufacturer/Contractor, to be acceptable to this project, must have had an established engineering and service office serving the Owner's area for a minimum of five years prior to bid date of this project and be the authorized installing contractor for the manufacturer of the BACnet components. This office shall have a staff of factory trained technicians fully capable of rendering training, instruction, calibration procedures and routine and emergency maintenance service on all system components furnished.
- B. Installers shall have not less than five years' experience with electronic and pneumatic controls.
- C. The entire system shall be provided by a qualified and approved Controls Manufacturer/Contractor. It shall be designed by engineers and installed by competent technicians, all of which are regularly employed by the manufacturer of the control equipment. The Manufacturer/Contractor shall maintain permanent local facilities for engineering, installation, and 24 hour maintenance and service. Submit required Qualifications Form as specified. The manufacturer shall provide evidence of the ability to support and service the work in the Owner's facilities.
- D. The Bidder/Contractor shall be certified by the manufacturer of the equipment and have factory trained installers
- E. Equipment and performance are intended as a standard of quality, but not as a means of excluding other approved Manufacturers/Control Contractors.

1.11 WARRANTY

- A. The temperature control contractor shall guarantee all workmanship and material in the installed temperature regulation system for a period of one (1) year, such guarantee dating from the date of final acceptance of the entire air conditioning system by the Architect/Engineer.
- B. This warranty shall cover the repair or replacement without additional costs to the Owner of any defective materials, parts, etc. of facility workmanship.
- C. During the warranty period, the temperature controls contractor shall respond to calls for warranty service within eight (8) working hours. Emergency service shall be obtainable within four (4) hours of notification by the Owner. Emergency service shall be obtainable on a 24 hour basis, seven (7) days per week.
- D. The temperature control contractor's office shall be within a 150-mile radius of the job site.
- E. Warranty Access:
 - 1. The Owner shall grant to the Contractor, reasonable access to the EMCS system during the warranty period. The owner shall provide, at no cost to the contractor, remote software access to an on-site computer or VPN access for the following functions:
 - a. Access to the entire facility control system by the contractor to provide service and diagnostic support.

- F. Service:
 - 1. All service of the system shall be furnished by the Contractor, at no cost to the Owner, for a period of one (1) year, concurrent with the warranty period specified above.

PART 2 PRODUCTS

2.1 ACCEPTABLE EMCS VENDORS

- A. Alerton - Climatec
- B. Reliable Controls – Enviromatic Systems
- C. The Engineer and Owner shall reserve all authority regarding approval, conditional approval, or rejection of systems not fully complying with these specifications

2.2 MATERIALS

- A. General: All materials and equipment used shall be standard components, of regular manufacture for this application. All systems and components shall have been thoroughly tested and proven in actual use.
- B. Exceptions to the specification will qualify bid as unacceptable.

2.3 OPERATOR'S WORKSTATION

- A. Software:
 - 1. EMS software shall be provided as an all-inclusive package. Software package shall allow the owner to have all the software modules/software tools that the controls contractor has for installation. The district shall have the software tools to be 100% self-sufficient when it comes to programming the systems, modifying DDC and graphics, creating reports and trends, etc. Provisions to provide software at each school campus at no additional charge in the future must be included as a part of this bid.
- B. Software shall include the following, but not be limited to:
 - 1. DDC Programming tool
 - 2. All points binding and interoperability software to make the system truly open
 - 3. Graphic editing tools
 - 4. Energy management tools
 - 5. Trending tools
- C. Graphics:
 - 1. Graphics pages shall consist of the following graphics at a minimum:
 - 2. District Map
 - 3. Floor plans (typical of every school for both space temperature and humidity)
 - 4. Animated Unit Summary Pages (one per piece of HVAC equipment)
 - 5. Text Summary Pages (one per piece HVAC equipment)
 - 6. Time Schedule Pages
 - 7. Run times Page
 - 8. Graphics Editing Mode
 - 9. Trendlog Page
- D. General structure of workstation interaction shall be a standard client/server relationship. Server shall be used to archive data and store system database. Clients shall access server for all archived data. Each client shall include flexibility to access graphics from server or local

drive. Server shall support a minimum of 50 clients simultaneously. Provide software licenses for server and 20 clients.

E. BACnet Conformance:

1. Operator's workstation shall as a minimum support Point-to-Point (PTP) and Ethernet BACnet LAN types. It shall communicate directly via these BACnet LANs as a Native BACnet device. Operator's terminal shall comply with the requirements of a BACnet conformance class 3 device and support all BACnet services necessary to provide the following BACnet functional groups:
 - a. Clock Functional Group
 - b. Event Response Functional Group
 - c. Time Master Functional Group
 - d. Device Communications
2. Refer to section 22.2, BACnet Functional Groups, in the BACnet standard for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types accessed by the workstation shall include as a minimum: Analog Value, Analog Input, Analog Output, Binary Value, Binary Input, Binary Output, Calendar, Device, Event Enrollment, File, Notification Class, Program and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
4. The Operator Workstation shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs). Workstation shall support Foreign Device Registration to allow temporary workstation connection to IP network.

F. Displays:

1. Operator's workstation shall display all data associated with project as called out on drawings and/or object type list supplied. Graphic files shall be created using digital, full color photographs of system installation, AutoCAD or Visio drawing files of field installation drawings and wiring diagrams from as-built drawings. Operator's workstation shall display all data using three-dimensional graphic representations of all mechanical equipment. System shall be capable of displaying graphic file, text, and dynamic object data together on each display and shall include animation. Information shall be labeled with descriptors and shall be shown with the appropriate engineering units. All information on any display shall be dynamically updated without any action by the user. Workstation shall allow user to change all field-resident EMCS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc. from any screen no matter if that screen shows all text or a complete graphic display. This shall be done without any reference to object addresses or other numeric/mnemonic indications.
2. All displays and programming shall be generated and customized by the local EMCS supplier and installer. Systems requiring factory programming for graphics or DDC logic are specifically prohibited.
3. Binary objects shall be displayed as ACTIVE/INACTIVE/NULL or with customized text. Text shall be justified left, right or center as selected by the user. Also, allow binary objects to be displayed as individual change-of-state graphic objects on the display screen such that they overlay the system graphic. Each binary object displayed in this manner shall be assigned up to three graphic files for display when the point is ON, OFF or in alarm. For binary outputs, toggle the object's commanded status when the graphic item is selected with the system mouse. Similarly, allow the workstation operator to toggle

the binary object's status by selecting with the mouse a graphic of a switch or light, for example, which then displays a different graphic (such as an "ON" switch or lighted lamp). Additionally, allow binary objects to be displayed as an animated graphic. Animated graphic objects shall be displayed as a sequence of multiple graphics to simulate motion. For example, when a pump is in the OFF condition, display a stationary graphic of the pump. When the operator selects the pump graphic with the mouse, the represented object's status is toggled and the graphic of the pump's impeller rotates in a time-based animation. The operator shall be able to click on an animated graphical object or switch it from the OFF position to ON, or ON to OFF. Allow operator to change graphic file assignment and also create new and original graphics online. System shall be supplied with a library of standard graphics, which may be used unaltered or modified by the operator. Systems that do not allow customization or creation of new graphic objects by the operator (or with third-party software) shall not be allowed.

4. Analog objects shall be displayed with operator modifiable units. Analog input objects may also be displayed as individual graphic items on the display screen as an overlay to the system graphic. Each analog input object may be assigned to a minimum of five graphic files, each with high/low limits for automatic selection and display of these graphics. 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 objects, when selected with the mouse, shall be displayed as a prompted dialog (text only) box. Selection for display type shall be individual for each object. Analog object values may be changed by selecting either the "increase" or "decrease" arrow in the analog object spinner box without using the keypad. Pressing the button on the right side of the analog object spinner box allows direct entry of an analog value and accesses various menus where the analog value may be used, such as trendlogs.
 5. Analog objects may also be assigned to an area of a system graphic, where the color of the defined area changes based on the analog object's value. For example, an area of a floor-plan graphic served by a single control zone would change color with respect to the temperature of the zone or its deviation from setpoint. All editing and area assignment shall be created or modified online using simple icon tools.
 6. A customized menu label (push-button) 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 label push buttons 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 security level may be assigned to each display and system object. The menu label shall not appear on the graphic if the operator does not have the appropriate security level.
 7. A mouse shall be used to move the pointer arrow to the desired item for selection of new display or to allow the operator to make changes to object data.
- G. Password Protection:
1. Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator's assigned functions when user is logged on. This includes displays as outlined above.
 2. Each operator's terminal shall provide security for 200 users minimum. Each user shall have an individual User ID, User Name and Password. Entries are alphanumeric characters only and are case sensitive (except for User ID). User ID shall be 0–8 characters, User Name shall be 0–29 characters, and Password shall be 4–8 characters long. Each system user shall be allowed individual assignment of only those control functions and menu items to which that user requires access. All passwords, user names, and access assignments shall be adjustable online at the operator's terminal. Each user shall also have a set security level, which defines access to displays and individual objects the user may control. System shall include 10 separate and distinct security levels for assignment to users.

- H. Operator Activity Log:
1. Operator Activity Log shall be included with system that tracks all operator changes and activities. System shall track what is changed in the system, who performed this change, date and time of system activity and value of the change before and after operator activity. Operator shall be able to display all activity, sort the changes by user and also by operation.
 2. Log shall be gathered and archived to hard drive on operator workstation as needed. Operator shall be able to export data for display and sorting in a spreadsheet.
 3. Any displayed data, that is changeable by the operator, may be selected using the right mouse button and the operator activity log shall then be selectable on the screen. Selection of the operator activity log using this method shall show all operator changes of just that displayed data.
- I. Scheduling:
1. Operator's workstation shall show all information in easy-to-read daily format including calendar of this month and next. All schedules shall show actual ON/OFF times for day based on scheduling priority. Priority for scheduling shall be events, holidays and daily with events being the highest.
 2. Scheduling tool shall allow scheduling of events up to 2 calendar years in advance.
 3. Holiday and special event schedules shall display data in calendar format. Operator shall be able to schedule holidays and special events directly from these calendars.
 4. Operator shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.
 5. System shall include a Schedule Wizard for set up of schedules. Wizard shall walk user through all steps necessary for schedule generation. Wizard shall have its own pull-down selection for startup or may be started by right clicking on value displayed on graphic and then selecting Schedule.
- J. Alarm Indication and Handling:
1. Operator's workstation 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), currently running. Printout of alarms shall be sent to the assigned terminal and port.
 2. System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator's terminal. Each entry shall include a description of the event-initiating object generating the alarm. Description shall be an alarm message of at least 256 characters in length. Entry shall include time and date of alarm occurrence, time and date of object state return to normal, time and date of alarm acknowledgment and identification of operator acknowledging alarm.
 3. Alarm messages shall be in user-definable text (English or other specified language) and shall be entered either at the operator's terminal or via remote communication.
 4. System shall include an Alarm Wizard for set up of alarms. Wizard shall walk user through all steps necessary for alarm generation. Wizard shall have its own pull-down selection for startup or may be started by right clicking on value displayed on graphic and then selecting alarm setup.
- K. Trendlog Information:
1. System server shall periodically gather historically recorded data stored in the building controllers and field controllers and archive the information. Archived files shall be appended with new sample data, allowing samples to be accumulated. Systems that write over archived data shall not be allowed, unless limited file size is specified. Samples may be viewed at the operator's workstation. Operator shall be able to scroll through all trended data. All trendlog information shall be displayed in standard engineering units.
 2. Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x, y) graphs that display up to ten object

types at the same time in different colors. Graphs shall show object values relative to time.

3. Operator shall be able to change trend log setup information. This includes the information to be logged as well as the interval at which it is to be logged. All input, output, and value object types in the system may be logged. All operations shall be password protected. Setup and viewing may be accessed directly from any and all graphics on which object is displayed.
4. System shall include a trend Wizard for setup of logs. Wizard shall walk user through all necessary steps. Wizard shall have its own pull-down selection for startup or may be started by right clicking on value displayed on graphic, and then selecting Trendlogs from the displayed menu.

L. Energy Log Information:

1. System server shall be capable of periodically gathering energy log data stored in the field equipment and archive the information. Archive files shall be appended with new data, allowing data to be accumulated. Systems that write over archived data shall not be allowed unless limited file size is specified. Display all energy log information in standard engineering units.
2. All data shall be stored in data base file format for direct use by third-party programs. Operation of system shall stay completely online during all graphing operations.
3. Operator shall be able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All meters monitored by the system may be logged. System shall support using flow and temperature sensors for BTU monitoring.
4. System shall display archived data in tabular format form for both consumption and peak values. Data shall be shown in hourly, daily, weekly, monthly and yearly formats. In each format the user shall be able to select a specific period of data to view.

M. Configuration/Setup:

1. 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 daylight savings set forward/set back, printer termination, port addresses, modem port and speed, etc. Items shall be modified using understandable terminology with simple mouse/cursor key movements.

N. Field Engineering Tools:

1. Operator's workstation software shall include field-engineering tools for programming all controllers supplied. All controllers shall be programmed using graphical tools that allow the user to connect function blocks on screen that provide sequencing of all control logic. Function blocks shall be represented by graphical displays that are easily identified and distinct from other types of blocks. Graphical programming that uses simple rectangles and squares is not acceptable.
2. User shall be able to pick graphical function block from menu and place on screen. Provide zoom in and zoom out capabilities. Function blocks shall be downloaded to controller without any reentry of data.
3. Programming tools shall include a real time operation mode. Function blocks shall display real time data and be animated to show status of data inputs and outputs when in real time operation. Animation shall show change of status on logic devices and countdown of timer devices in graphical format.
4. Field engineering tools shall also include a database manager of applications that include logic files for controllers and associated graphics. Operator shall be able to select unit type, input/output configuration and other items that define unit to be controlled. Supply minimum of 250 applications as part of workstation software.
5. Field engineering tool shall include Device Manager for automatic detection of devices connected anywhere on the BACnet network by scanning of the entire network. This

function shall display device instance, network identification, model number and description of connected devices. It shall record and display software file loaded into each controller. A copy of each file shall be stored on the computer's hard drive. If needed, this file shall be downloaded to the appropriate controller by selection using the mouse.

O. Software:

1. At the conclusion of project, contractor shall leave with owner a CD ROM or flash drive that includes the complete software operation system and project graphics, setpoints, system parameters, etc. This backup shall allow the owner to completely restore the system in the case of a computer malfunction.

2.4 BUILDING CONTROLLER

A. General:

1. All communication with operator workstation and all application controllers shall be via BACnet. Building controller shall incorporate as a minimum, the functions of a 3-way BACnet router. Controller shall route BACnet messages between the high-speed LAN (Ethernet 10/100MHz), at least 4 master slave token passing (MS/TP) LANs, a point-to-point (PTP – RS-232) connection and an on-board modem.
 - a. Each MS/TP LAN must be software configurable from 9.6 to 76.8Kbps.
 - b. The RJ-45 Ethernet connection must accept either 10Base-T or 100Base-TX BACnet over twisted pair cable (UTP).
 - c. The direct access port must be a female DB-9 connector supporting BACnet temporary PTP connection of a portable BACnet operator terminal at 9.6 to 115.2 Kbps over RS-232 null modem cable.
2. Building controller shall be capable of providing global control strategies for the system based on information from any objects in the system regardless if the object is directly monitored by the controller or by another controller. The program that implements these strategies shall be completely flexible and user definable. Any systems 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.
3. Programming shall be object-oriented using control function blocks, supporting DDC functions, 1000 Analog Values and 1000 Binary Values. All flowcharts shall be generated and automatically downloaded to controller. Programming tool shall be resident on workstation and the same tool used for all controllers.
4. Provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function may be performed via the operator's workstation or field computer.
5. Building controller shall provide battery-backed real-time (hardware) clock functions.
6. Controller shall have a memory needed to ensure high performance and data reliability. Battery shall retain static RAM memory and real-time clock functions for a minimum of 1.5 years (cumulative).
7. Global control algorithms and automated control functions should execute via 32-bit processor.
8. Controller installation shall include memory-free gel-cell battery providing ongoing power conditioning and noise filtering for operation data integrity. It shall provide up to 5 minutes of powerless operation for orderly shutdown and data backup.
9. BACnet Conformance:
 - a. Building Controller shall as a minimum support Point-to-Point (PTP), MS/TP and Ethernet BACnet LAN types. It shall communicate directly via these BACnet LANs as a Native BACnet device and shall support simultaneous routing functions between all supported LAN types. Global controller shall be a BACnet conformance class 3 device and support all BACnet services necessary to provide the following BACnet functional groups:

- b. Clock Functional Group
 - (1) Files Functional Group
 - (2) Reinitialize Functional Group
 - (3) Device Communications Functional Group
 - (4) Event Initiation Functional Group
 - 10. Refer to section 22.2, BACnet Functional Groups, in the BACnet standard for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
 - 11. Standard BACnet object types supported shall include as a minimum: Analog Value, Binary Value, Calendar, Device, File, Group, Notification Class, Program and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
 - 12. The Building Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs) and function as a BACnet Broadcast Management Device (BBMD).
- B. Schedules:
- 1. Each building controller shall support a minimum of 250 BACnet Schedule Objects and 250 BACnet Calendar Objects.
- C. Logging Capabilities:
- 1. Each building controller shall log as minimum 1000 trendlogs. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
 - 2. Logs may be viewed both on-site or off-site via remote communication.
 - 3. Building controller shall periodically upload trended data to networked operator's workstation for long term archiving if desired.
 - 4. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.
 - 5. Alarm Generation:
 - a. Alarms may be generated within the system for any object change of value or state either real or calculated. This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
 - b. Each alarm may be dialed out as noted in paragraph 2 above.
 - c. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site via remote communications.
 - d. Controller must be able to handle up to 1500 alarm setups stored as BACnet event enrollment objects – system destination and actions individually configurable.

2.5 WEB BROWSER CLIENTS

- A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ or Mozilla Firefox™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.
- B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., to allow the Web browser to function with the EMCS shall not be acceptable.

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

2.6 TERMINAL UNIT APPLICATION CONTROLLERS (ROOFTOPS, HEAT PUMPS, AC UNITS, FAN COILS)

- A. General:
 - 1. Provide one Native BACnet application controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.
- B. BACnet Conformance:
 - 1. Application controllers shall as a minimum support MS/TP BACnet LAN types. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a Native

BACnet device. Application controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:

- a. Files Functional Group
 - b. Reinitialize Functional Group
 - c. Device Communications Functional Group
2. Refer to section 22.2, BACnet Functional Groups in the BACnet standard for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
 3. Standard BACnet object types supported shall include as a minimum—Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
 4. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC, 4–20 mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.
 5. All program sequences shall be stored on board controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.
 6. Application controller shall include support for intelligent room sensor (see Section 2.9.B.). Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

C. Smoke Detectors:

1. Smoke detectors (duct and area type) shall be provided, installed, and wired into the Fire Alarm System by the Electrical Contractor. The Controls Contractor shall be responsible for interlock wiring between duct smoke detectors and control relays, and starter safety circuits.

2.7 ELECTRONIC ACTUATORS

A. General:

1. Shall be Electric unless otherwise specified. Shall be manufactured by Belimo. Five-year manufacturer's warranty. Two-year unconditional and three-year product defect from date of installation.
2. Furnish a Freeze-stat and install "Hard Wire" interlock to disconnect the mechanical spring return actuator power circuit for fail-safe operation. Use of the control signal to drive the actuators closed is not acceptable.
3. VAV box damper actuation shall be Floating type or Analog (2-10vdc, 4-20ma) and provide to VAV box manufactured for factory installation.
4. Booster-heat valve actuation shall be Floating type or Analog (2-10vdc, 4-20ma).
5. Primary valve control shall be Analog (2-10vdc, 4-20ma).

6. UL Listed Standard 873 and Canadian Standards Association Class 481302 shall certify Actuators.
 7. Mechanical spring shall be provided when specified. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
 8. Position indicator device shall be installed and made visible to the exposed side of the Actuator. For damper short shaft mounting, a separate indicator shall be provided to the exposed side of the Actuator.
 9. Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for Butterfly Valve actuators.
 10. A push button gearbox release shall be provided for all non-spring actuators.
 11. Modulating actuators shall be 24VAC and consume 10VA power or less.
 12. Conduit connectors are required when specified and when code requires it.
- B. Damper Actuators:
1. Electronic damper actuators shall be direct-coupled rotary type, suitable for mounting directly on the damper end shaft. Electronic damper actuators shall be properly sized to provide sufficient torque to position the damper throughout its operating range. Damper actuators used on economizer and/or outside air dampers shall be spring return.
 2. Terminal unit damper actuators shall be electric, low voltage, utilizing floating control.
 3. Outside Air and Exhaust Air Damper Actuators shall be Mechanical Spring Return. Capacitors or other non-mechanical forms of fail-safe are not acceptable. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.
 4. Economizer Actuators shall be provided and installed by EMCS contractor. Actuators shall utilize Analog control 2-10 VDC and shall give position feedback for FDD monitoring. Floating control is not acceptable. Actuators shall be Mechanical Spring Return. Equal to Belimo LF-24-SR.
 5. Electric damper actuators (including VAV box actuators) shall be direct shaft mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or setscrew type fasteners are not acceptable.
 6. One electronic actuator shall be direct shaft mounted per damper section. No connecting rods or jackshafts shall be needed. Small outside air and return air economizer dampers may be mechanically linked together if one actuator has sufficient torque to drive both and damper drive shafts are both horizontal installed.
 7. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per damper section. (See below execution section for more installation details.)

2.8 DAMPERS AND VALVES

- A. Control Dampers:
1. The sheet metal contractor shall furnish and size all automatic control dampers unless provided with packaged equipment.
 2. The sheet metal contractor shall install all dampers unless provided with packaged equipment.
 3. Control air dampers shall be parallel blade for two-position control and opposed blade for modulating control applications. Dampers shall be galvanized with nylon bearings. Blade edge and tip seals shall be included for all dampers. Leakage through the damper shall not exceed **4 CFM per square foot at 1" w.c.** Blades shall be 16-gauge minimum and 10" wide maximum and frame shall be of welded channel iron. Dampers over 48" wide shall be equipped with a jackshaft to provide sufficient force throughout the intended

- operating range.
4. All dampers used for modulating service shall be opposed blade type arrange for normally open or normally closed operation as required. The damper is to be sized so that when wide open the pressure drop is a sufficient amount of its close-off pressure drop for effective throttling.
 5. All dampers used for two-position or open-close control shall be parallel blade type arranged for normally open or closed operation as required.
 6. Damper linkage hardware shall be constructed of aluminum or corrosion resistant zinc & nickel-plated steel and furnished as follows:
 - a. Bearing support bracket and drive blade pin extension shall be provided for each damper section. Sheet metal contractor shall install bearing support bracket and drive blade pin extension. Sheet metal contractor shall provide permanent indication of blade position by scratching or marking the visible end of the drive blade pin extension.
 - b. Drive pin may be round only if V-bolt and toothed V-clamp is used to cause a cold weld effect for positive gripping. For single bolt or set-screw type actuator fasteners, round damper pin shafts must be milled with at least one side flat to avoid slippage.
- B. Multiple Section Dampers:
1. Size damper sections based on actuator manufacturers specific recommendations for face velocity, differential pressure and damper type. In general:
 - a. Damper section shall not exceed 24 ft-sq. with face velocity £ 1500 FPM.
 - b. Damper section shall not exceed 18 ft-sq. with face velocity £ 2500 FPM.
 - c. Damper section shall not exceed 13 ft-sq. with face velocity £ 3000 FPM.
 2. Damper manufacturer shall supply alignment plates for all multi-section dampers.
 3. Multiple section dampers of two or more shall be arranged to allow actuators to be direct shaft mounted on the outside of the duct.
 4. Multiple section dampers of three or more sections wide shall be arranged with a 3-sided vertical channel (8" wide by 6" deep) within the duct or fan housing and between adjacent damper sections. Vertical channel shall be anchored at the top and bottom to the fan housing or building structure for support. The sides of each damper frame shall be connected to the channels. Holes in the channel shall allow damper drive blade shafts to pass through channel for direct shaft mounting of actuators. Open side of channel shall be faced down stream of the airflow, except for exhaust air dampers.
 5. Multiple section dampers to be mounted flush within a wall or housing opening shall receive either vertical channel supports as described above or sheet metal stand out collars. Sheet metal collars (12" minimum) shall bring each damper section out of the wall to allow direct shaft mounting of the actuator on the side of the collar.

2.9 ENCLOSURES

- A. NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.
- B. All controllers, power supplies and relays shall be mounted in enclosures.
- C. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment. Indoor enclosures shall be NEMA 12 when installed in other than a clean environment.
- D. Enclosures shall have hinged, locking doors.
- E. Provide laminated plastic nameplates for all enclosures in any mechanical room or electrical room. Include location and unit served on nameplate. Laminated plastic shall be 1/8" thick sized appropriately to make label easy to read.

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

2.10 SENSORS, SWITCHES, CONTROLLERS, TRANSDUCERS, AND MISCELLANEOUS DEVICES

- A. Temperature Sensors:
 - 1. All temperature sensors to be solid state electronic, factory-calibrated to within 0.5°F, totally interchangeable with housing appropriate for application. Wall sensors to be installed as indicated on drawings. Mount 48 inches above finished floor. Duct sensors to be installed such that the sensing element is in the main air stream. Immersion sensors to be installed in wells provided by control contractor, but installed by mechanical contractor. Immersion wells shall be filled with thermal compound before installation of immersion sensors. Outside air sensors shall be installed away from exhaust or relief vents, not in an outside air intake and in a location that is in the shade most of the day.
- B. Wall Sensor
 - 1. Standard wall sensor shall use solid-state sensor identical to intelligent room sensor and shall be packaged in aesthetically pleasing enclosure. Sensor shall provide override function, warmer/cooler lever for set point adjustment and port for plug-in of Field Service Tool for field adjustments. Override time shall be stored in controller and be adjustable on a zone-by-zone basis. Adjustment range for warmer/cooler lever shall also be stored in EEPROM on controller. All programmable variables shall be available to Field Service Tool through wall sensor port. Sensor shall be equal to Reliable SMART Sensor EPD or Alerton Microtel II.
- C. Field Service Tool:
 - 1. Field service tool shall allow technician to view and modify all setpoints and tuning parameters stored in application controller. In addition, technician shall be able to view status of all inputs and outputs on digital readout. Each piece of data shall have a data code associated with it that is customizable.
 - 2. Field service tool shall plug into wall sensor and provide all the functionality specified. Operator workstation shall include the capability to disable operation of the field service tool.
 - 3. Provide Field Service Tool(s) for this project.
- D. Network Connection Tool:
 - 1. Network connection tool shall allow technician to connect a laptop to any MS/TP network or at any MS/TP device and view and modify all information throughout the entire BACnet network. Laptop connection to tool shall be via Ethernet or PTP.
 - 2. Provide quick connect to MS/TP LAN at each controller. Tool shall be able to adjust to all MS/TP baud rates specified in the BACnet standard.
 - 3. Provide 1 Network Connection Tool for this project.
- E. Differential Pressure Switches (Air):
 - 1. Provide differential pressure switches across fans and filters for status indication. Differential pressure switches shall have an adjustable setpoint from 0.05" w.c. to 2" w.c. with a switch differential that progressively increases from 0.02" w.c. at minimum to 0.8" w.c. at maximum. Switch shall be SPDT rated for 15A (non-inductive) at 277VAC.
- F. Float Switches:
 - 1. Provide float switches in condensate drain pans as required by code. Float switches shall

utilize a magnetically actuated dry reed switch. Float shall be constructed of seamless polypropylene. Switch shall be SPDT rated for 16A (non-inductive) at 120VAC.

- G. Mixed Air Low Limit Controllers (Freezestats):
 - 1. Mixed air low limit controllers shall be manual reset, adjustable setpoint with 20-foot element serpentine across the entering air face of center cooling coil. Control shall be responsive only to the lowest temperature along the element.
- H. Static High Limit Controllers:
 - 1. Discharge static high limit controllers shall be provided on all VAV AHU systems. When discharge static pressure exceeds setpoint, the supply fan shall be de-energized. Manual reset shall be required.
- I. Static Pressure Transducers (Air):
 - 1. Provide static pressure transducers for monitoring supply duct static pressure. Static pressure transducers shall be 100% solid state and shall include glass on silicon, ultra stable capacitance sensors. Each static pressure transducer shall incorporate short circuit and reverse polarity protection. Transmitter output shall be either 0-10VDC or 4-20mA. Static pressure transducers are to be provided in an enclosure that is suitable for duct mounting. The desired setpoint is to be in the top 50% of the transmitter's operating range.
- J. Differential Pressure Transducers (Air):
 - 1. Provide differential pressure transducers for monitoring air system and airflow measuring station differential pressures. Differential pressure transducers shall be 100% solid state and shall include glass on silicon, ultra stable capacitance sensors. Each differential pressure transducer shall incorporate short circuit and reverse polarity protection. Transducer output shall be either 0-10VDC or 4-20mA. Differential pressure transducers are to be provided in an enclosure that is suitable for duct mounting. The desired setpoint is to be in the top 50% of the transducer's operating range.
- K. Current Sensing Relays:
 - 1. Provide current switches for indication of equipment status. Amperage ratings shall be adjustable with the desired setpoint to be in the top 50% of the current relay's operating range. Current sensing relays shall incorporate trip indication LED's and shall be sized for proper operation with the equipment served.
- L. Relative Humidity Sensors:
 - 1. Relative humidity sensors shall have an accuracy of +/- 2% from 5 to 95% RH. Output signal shall be either be 0-10VDC or 4-20mA. Humidity transmitters shall be factory calibrated and require no field setting.
- M. Duct/Well Sensors:
 - 1. Sensors for duct and water temperature sensing shall incorporate either RTD or Thermistor sensing devices. Sensing element accuracy shall be 0.1% over the sensor span or better. Where the element is being used for sensing mixed air or coil discharge temperatures and/or the duct cross sectional area is in excess of 14 square feet, the element shall be of the averaging type. Averaging duct sensors shall utilize a 6, 12 or 24 foot sensing element. Immersion sensors shall use matched 316 stainless steel bulb wells. All duct and immersion sensors shall be provided with conduit connection housings. Sensors shall be provided with adequate standoffs for insulation installation.
- N. Selector Switches:
 - 1. Selector switches shall be 2 or 3-position, knob or key type as required by the sequence of operation. Selector switches shall feature oil tight construction and be fitted with snap-

fit contact blocks rated for 10A, 600VAC/DC operation. Labels shall be provided indicating switch position.

- O. Pushbutton Switches:
 - 1. Pushbutton switches shall be either maintained or momentary as required by the sequence of operation. Pushbutton switches shall feature oil tight construction and be fitted with snap-fit contact blocks rated for 10A, 600VAC/DC operation. Labels shall be provided indicating switch function.

PART 3 EXECUTION

3.1 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.
- D. Each bid must include all costs associated with providing wiring, conduit, concrete trenching, and earth trenching.

3.2 OPERATION

- A. BACnet Object List:
 - 1. The following points as defined for each piece of equipment are designated as follows:
 - a. Binary Out (BO) - Defined as any two-state output (start/stop) (enable/disable), etc.
 - b. Binary In (BI) - Defined as any two-state input (alarm, status), etc.
 - c. Analog In (AI) - Defined as any variable input (temperature) (position), etc.
 - d. Analog Out (AO) - Defined as any electrical variable output. 0–20mA, 4–20mA and 0–10VDC are the only acceptable analog outputs. The driver for analog outputs must come from both hardware and software resident in the controllers. Transducers will not be acceptable under any circumstance.
 - 2. Each and every point will be checked out by the Contractor and the Owner's Representative will inspect each point with the bidder prior to acceptance. Provide complete written documented inspections, test and checkout report. Calibrate all equipment.
- B. DDC Object Type Summary:
 - 1. Provide all database generation.
 - 2. Displays:
 - a. System displays shall show all analog and binary object types within the system. They shall be logically laid out for easy use by the owner. Provide outside air temperature indication on all system displays associated with economizer cycles.
 - 3. Run Time Totalization:
 - a. 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.
 - 4. Trendlog:
 - a. All binary and analog object types (including zones) shall have the capability to be automatically trended.

5. Alarm:
 - a. All analog inputs (High/Low Limits) and selected binary input alarm points shall be prioritized and routed (locally or remotely) with alarm message per owner's requirements.
6. Database Save:
 - a. Provide back-up database for all stand-alone application controllers on disk.

3.3 INSTALLATION

- A. General:
 1. Install in accordance with manufacturer's instructions.
 2. Provide all miscellaneous devices, hardware, software, interconnections installation and programming required to ensure a complete operating system in accordance with the sequences of operation and point schedules.
 3. Provide a complete and operational temperature control and building automation system based on the following points and sequence of operation. The system shall be complete as to sequences and standard control practices. The determined point list is the minimum amount of points that are to be provided. If additional points are required to meet the sequence of operation, they will be provided.
- B. Location and Installation of Components:
 1. Locate and install components for easy accessibility; in general, mount 48 inches above floor with minimum 3'-0" clear access space in front of units. Obtain approval on locations from owner's representative prior to installation.
 2. Enclosures and hardware or wiring shall not block or limit accessibility to service compartments of any other equipment.
 3. The work shall be coordinated fully, as it pertains to the fire protection system, fire alarm system, and electrical power system. All items shall be terminated in the DDC controllers in a predetermined order as indicated in the submittal drawings.
 4. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture and high or low temperatures.
 5. Identify all equipment and panels. Provide permanently mounted tags for all panels.
 6. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections - sized to suit pipe diameter without restricting flow.
- C. Interlocking and Control Wiring:
 1. Provide all interlock and control wiring. All wiring shall be installed neatly and professionally, in accordance with Specification Division 26 and all national, state and local electrical codes.
 2. Provide wiring as required by functions as specified and as recommended by equipment manufacturers, to serve specified control functions. Provide shielded low capacitance wire for all communications trunks.
 3. 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.
 4. Provide auxiliary pilot duty relays on motor starters as required for control function.
 5. Provide power for all control components from nearest electrical control panel or as indicated on the electrical drawings. Coordinate with electrical contractor.
 6. All control wiring in the mechanical, electrical, telephone and boiler rooms to be installed in conduit. All other wiring to be installed neatly and inconspicuously per local code requirements. If local code allows, control wiring above accessible ceiling spaces may be run with plenum rated cable (without conduit).

- D. Installation Requirements:
1. Any panels associated with the control system shall be furnished and installed under this section of the work. Panel wiring shall be terminated by connecting to numbered terminals strips. Wire nut connections shall not be allowed. All wiring shall be color coded and shall be tagged for future identification.
 2. Unless otherwise specified, all devices, panels, etc., furnished and/or installed by the Contractor shall be located where they can be calibrated and maintained from the floor without use of a ladder. These items shall be identified by means of plates made of plastic suitably engraved, embossed or punched, plastic tape will not be acceptable. At completion of job, the Contractor shall submit record drawings of any changes made during construction. This submittal shall be a condition of final payment.
 3. Any conduit on roof shall be absolute minimum and shall have prior written approval.
 4. All conduit used indoor and outdoor shall be metal and shall be of type and fittings to minimize corrosion and moisture entry.
- E. Cable Installation and Attachments:
1. Control System wiring and equipment installation shall be in accordance with good engineering practices as established by the TIA/EIA and the NEC. Wiring shall meet all state and local electrical codes. All wiring shall test free from all grounds and shorts. All cable shall be supported from the building structure and bundled.
 2. The support system shall provide a protective pathway to eliminate stress that could damage the cabling. The cable shall not be crushed, deformed, skinned, crimped, twisted, or formed into tight radius bends that could compromise the integrity of the cabling. Controls cables shall not be run loose on ceiling grid or ceiling tiles. Support shall be provided by mounting appropriate fasteners which may be loaded with multiple cables. Provided that the weight load is carried by the support rod or wire, the support assembly may attach to the ceiling grid for lateral stabilization. The required support wires for the ceiling grid or light fixtures shall not be utilized. Any fastener attached to the ceiling grid shall not interfere with inserting or removing ceiling tiles. All cabling and supports must be positioned at least 12 inches above the ceiling grid.
 3. Controls cables shall be run in bundles above accessible ceilings and supported from building structure. Cabling shall be loosely bundled with wire wraps randomly spaced at 30 to 48 inches on center, wire wraps shall not be tight enough to deform cabling and shall not be used to support the cabling.
 4. Attachments for cabling support shall be spaced at 48 to 60 inches on center. The cable bundle shall not be allowed to sag more than 12 inches mid-span between attachments. Attachments shall be sized as follows:

Bundles up to 1/2" dia. (Ten 1/4" cables)	2" bridle ring, Caddy #4BRT32 or equivalent
Bundles up to 3/4" dia. (Sixteen 1/4" cables)	3/4" J-Hook, Caddy #CAT12 or equivalent
Bundles up to 1-5/16" dia. (Fifty 1/4" cables)	1-5/16" J-Hook, Caddy #CAT21 or equivalent
Bundles up to 2" dia. (Eighty 1/4" cables)	2" J-Hook, Caddy #CAT21 or equivalent

Split bundles greater than 2" dia. or provide cable tray.
 5. Do not mix different signal strength cables on the same J-Hook (i.e. fire alarm, 25 volt speaker cable). Multiple J-Hooks can be on the same attachment point up to the rated weight of the attachment device.
 6. Controls cables shall be run in conduit stubs, where stubs are provided, from wall mounted devices to above accessible ceilings. Conduit shall be required only within walls and concealed spaces to provide access. Provide a plastic snap bushing or sleeve on the end of each conduit stub such as Thomas & Betts Catalog no. 443 - 3/4", 424 - 1", 425 - 1 1/4", 427 - 2" or equivalent.
 7. Conduit, duct or track shall be used for controls cable in exposed areas.
 8. All conduit, ducts, track and raceways shall be supported from the structure at industry standard intervals for the size specified, utilizing proper anchoring devices and techniques for each type of cable used.

9. All penetrations through fire rated walls or floors shall feature a short length of metal conduit. The hole shall be neatly cut, not oversize or irregular. Seal the interior of the conduit sleeve around the cables and around the outside of the sleeve on each side of the penetration with fire-stop caulk or putty, such as Minnesota Mining & Mfg. Co. (3M) - CP 25WB+ caulk, MPS-2+ putty, or equivalent. Install according to the manufacturers' instructions.
 10. All cable shall have a label on both ends utilizing self-laminating, flexible vinyl film and non-smear nylon marking pens. Utilize Tyton Corporation Part No. RO175 Rite-On labels and Part No. FTP1 nylon marking pens or equivalent.
 11. Each cable run shall include a three foot service loop with wire tie located in the ceiling above the control unit panel. This is to allow for future re-termination or repair.
 12. No terminations or splices shall be installed in or above ceilings. Cable shall be continuous from one device termination to the next.
 13. Mount all equipment firmly in place. Route cable in a professional, neat and orderly installation.
 14. All cabling shall be placed with regard to the environment, EMI/RFI (interference) and its effect on communication signal transmission.
 15. Do not route any controls cable within two feet of any light fixture, HVAC unit service access area, electric panel, or any device containing a motor or transformer.
 16. Low voltage controls cable will not be installed in the same conduit, duct or track with line voltage electrical cable.
 17. Maximum pulling tension should not exceed 25 lb/ft. or manufactures recommendation, whichever is less.
 18. Any pulling compounds utilized must be approved by the cable manufacturer and shall not degrade the strength or electrical characteristics of the cable.
 19. Cable bends shall not exceed the manufacturers' suggested bend radius.
 20. Provide for adequate ventilation in all equipment panels.
 21. Provide wiremold where wiring must run exposed. Obtain advance approval from Architect and Owner before running exposed. Coordinate with Owner and Architect.
 22. For all wiring, provide numbering on all terminations (both ends).
 23. Label all panels, cans, enclosures, controllers and correlate with air conditioning units served. Labeling shall relate to shop drawings and equipment served. Provide wiring diagram inside each enclosure.
 24. Provide a rain-tight enclosure for each rooftop unit controller.
 25. Locate outdoor air sensors shielded and on northern exposure.
- F. Termination practices:
1. Strip back only as much cable jacket as required to terminate.
 2. Preserve wire twists as closely as possible to point of termination (0.5" maximum) to keep signal impairment to a minimum.
 3. Avoid twisting cable during installation.
 4. Electrical Interlocks:
 - a. All electrical interlocks shall be provided as specified. All electrical interlocks shall be made by means of motor starters or shall be accomplished by separate relays. No motor power lead shall be utilized in an interlock circuit.

3.4 SERVICES

- A. Field Services:
1. Prepare and start logic control system under provisions of this section.
 2. Start-up and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.
 3. 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 for 1 year or as specified.

4. Provide Owner's Representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.
- B. HVAC Training:
1. Provide application engineer to instruct owner in operation of systems and equipment.
 2. Provide system operator's training to include (but not limited to) such items as the following: modification of data displays, alarm and status descriptors, requesting data, execution of commands and request of logs. Provide this training to a minimum of 3 persons.
 3. Provide on-site training above as required, up to 40 hours as part of this contract.
- C. Demonstration:
1. Provide systems demonstration under provisions of Section 23 00 00.
 2. Demonstrate complete operating system to owner's representative.
 3. Provide certificate stating that control system has been tested and adjusted for proper operation.
- D. Programming:
1. Prior to completion of the control installation, schedule time with Owner's designated representatives to evaluate and select programming options and requirements. Contractor shall provide engineer for such meetings and consultations on an as-needed basis. Preparation time for the conference shall be in addition to the "in conference" time and shall be provided on an as-needed basis without additional cost to the Owner.
 2. The Contractor shall also provide additional coordination as needed with the Owner's representative and Engineer to formulate and determine functions, reports, graphics, and alarms most desirable and suitable for the school district and writing the software capability. Programming of these items shall be provided. The Contractor shall program the system using coordinated Owner provided schedules for time of day and holidays.
 3. No hardware change shall be required for program changes.
- E. Documentation:
1. The Contractor shall provide a complete documentation package to the owner which shall include floor plans indicating location of EMCS equipment, wiring diagrams, bill of materials, data base information, and sequences of operation. The sequences of operation shall be submitted and approved by the owner in writing prior to installation and programming.
- F. Coordination:
1. For construction project installations where electrical and mechanical contractors are responsible for their respective trade, the electrical contractor is to provide line voltage to required equipment and the mechanical contractor is to install any devices that are to be included in systems. It is the controls contractor's responsibility to provide all devices with diagrams for location and coordinate with mechanical contractor prior to mechanical contractor starting installations. Controls contractor shall coordinate and provide all required work and wiring for duct mounted smoke detectors, control relays for unit shutdown, and interface with any fire alarm system. For installations where controls only work is provided, all necessary work shall be performed by the controls contractor.

PART 4 SEQUENCE OF OPERATION

4.1 SEQUENCE OF OPERATION

- A. The following are sequences of operations which will be accomplished by the EMCS. Coordinate with Owner in operating equipment to maximize comfort and economy. All points required to accomplish the sequences will be provided and connected to the EMCS.

- B. DDC Control - Rooftop Units, Split Systems and DX Units, and Heat Pumps: Each unit shall be started and stopped by the EMCS. Automatic override during low or high ambient temperatures shall be provided. Provide one outdoor air sensor per school. Provide an indoor air space sensor for every unit to monitor space temperature and be capable of remote resetting space temperature by Owner.
- C. Provide one outside air relative humidity sensor and temperature sensor per campus. It is also acceptable to obtain outside air ambient conditions from a nearby weather station.
- D. ACRONYMS:
- | | |
|-----------------|---|
| EMCS | Energy Management Control System. The EMCS controls all of the HVAC functions as well as lighting schedules and lawn sprinkler schedules. |
| TCS | Temperature Control Sensor. This is the device that controls the temperature in the space. |
| VFD | Variable Frequency Drive. |
| DDC | Direct Digital Control. |
| OAU | Outside Air Unit. |
| CO ₂ | Carbon Dioxide. |
| CFM | Cubic Feet per Minute |
| GPM | Gallons Per Minute |
| A/H | Air Handler |
| F/C | Fan Coil Unit |
| CHW | Chilled Water |
| HW | Hot Water |
| VAV | Variable Air Volume |
| UCP | Unit Control Panel |
| ppm | Parts Per Million – A measurement of the concentration of one substance within another. In this case, it is the number of CO ₂ particles in a sample of one million air particles. |
| Adj | Adjustable – All set points are assumed to be adjustable whether specified or not. The set points specified are values that should be programmed initially but can be changed if necessary. |
- E. DEFINITIONS:
- Occupancy Period:
 - The period of the day that the owner wants the environmental conditions acceptable for occupancy. Outside air ventilation may not be enabled at all times during the occupancy period. This schedule will be defined for each component of the HVAC system and will not be the same for all components.
 - Outside Air Schedule:
 - The period of the day that outside air ventilation is enabled. This schedule will be defined for each component of the HVAC system.
 - Warm-up Mode:
 - The time between the end of the unoccupied and start of the occupied period during which the space temperature is increased (night setback) to the normal occupancy temperature.
 - Cool-down Mode:
 - The time between the end of the unoccupied and start of the occupied period during which the space temperature is lowered (night setup) to the normal occupied temperature.
 - Unoccupied Period:
 - The period of the day that the temperature control setting is lowered (heating) or raised (cooling) to conserve on the amount of energy required to condition the building. The fans are also turned “OFF” to conserve energy.

F. DOCUMENTATION

1. The Contractor shall provide a complete documentation package to the owner which shall include floor plans indicating location of EMCS equipment, wiring diagrams, bill of materials, data base information, and sequences of operation. The sequences of operation shall be submitted and approved by the owner in writing prior to installation and programming.

G. MONITORING

1. Domestic Water Supply Monitoring
 - a. The EMCS shall monitor low flow from the primary domestic water supply to each building during unoccupied schedules for leaks. When the amount of flow is greater than programmed (adj.) for more than 5 minutes (adj.), the EMCS shall send an alarm. The alarm shall be sent both as a text and email message stating the time & date. Provide all flow meters using floating ball technology (Omni Compound C2 water flow meter or equivalent) and controls points for a complete system. Meter shall be provided by controls contractor and installed by plumbing contractor.
2. Electric Meter Monitoring :
 - a. The EMCS shall monitor the electrical energy consumption at the buildings main electric feed. Pulse generator shall be furnished by the utility company and paid for by the owner. The temperature control contractor shall be responsible for coordinating requirements with utility company. The EMCS shall monitor pulse counts and broadcast signal to HMI operator workstation. The Division 26 contractor shall provide a dedicated 1" buried conduit from building to main electrical service for use by the temperature controls contractor. Pulse meters may be located on the MSB, coordinate with electrical contractor.

H. CONTROL

1. Domestic Hot Water:
 - a. The domestic water heater(s) and associated circulating pump(s) shall be disabled/enabled by the EMCS based on a time schedule. The domestic hot water supply from the water heater shall be monitored and shall generate an alarm upon exceeding above or dropping below its assigned alarm limits (adj.). The circulating pump(s) shall be started by the EMCS based on a demand for hot water within the occupancy. The EMCS shall turn off the circulating pump(s) when there is no demand for hot water, and the water in the circulation loop is at the desired temperature.
 - b. A pressure sensor shall be provided by the controls contractor and installed by the plumbing contractor in the domestic water loop to maintain a constant pressure. Any time the pressure drops below setpoint (demand in the system), the pump shall turn on to maintain a constant pressure in the system. When the pressure rises (no demand in the system), the reverse shall occur. The pressure sensor shall be installed downstream of the most remote fixture.
 - c. A temperature sensor shall be provided by the controls contractor and installed by the plumbing contractor in the domestic water loop to maintain a minimum temperature of 110°F (adj.). The temperature sensor shall be installed downstream of the most remote fixture.
 - d. The points required to accomplish this sequence shall be connected to the nearest available EMCS controller. The price for this sequence shall not include a controller.
2. Freeze Protection:
 - a. Upon the outside air temperature dropping below an adjustable setpoint, all pumps in the building shall be started by the EMCS, all outside air dampers shall be closed, and all valves shall be opened to full flow through the water coil (s). Each building shall be provided with a temperature sensor located outside (northern exposure) to monitor outside air temperature.

3. Outside Lighting:
 - a. Provide auxiliary contactor(s) to control lighting. Include all hardware and software required and connect to nearest EMCS controller. Coordinate with electrical contractor.
4. Battery Room Exhaust Fans
 - a. Fans to be disabled/enabled by the EMCS based on a time schedule. The points required to accomplish this sequence shall be connected to the nearest available EMCS controller.
5. IDF/MDF/Electrical Room Split Systems:
 - a. Mini split DX units are to operate continuously regardless of occupancy schedule to maintain space temperature. EMCS shall monitor space temperature and shall alert owner anytime space temperature exceeds 90° F (adj.).
6. Unit Ionization Device:
 - a. Each unit provided with an ionization device (see mechanical schedules for listing) shall be enabled/disabled via interlocking with the supply fan control. After a 1-minute delay on a call for supply fan operation, the EMCS shall enable the ionization device. EMCS shall monitor the device for faults via dry contacts provided on the device. The EMCS shall generate an alarm if a fault is observed. The points required to accomplish this sequence shall be connected to the nearest available EMCS controller.

4.2 SINGLE ZONE SPLIT SYSTEM WITH 2 STAGE COMPRESSOR (COOLING ONLY)

A. GENERAL:

1. Each unit shall be provided with a cooling section, supply fan section, and a microprocessor control board. The controls contractor shall provide an outside air/return air damper section, and a 0-100% motorized, modulating outside air damper with spring return. The mechanical contractor shall install the damper section. The space temperature sensor shall be provided with a local override button. The temperature control system contractor shall provide a dedicated stand-alone DDC controller for each unit. The occupied/unoccupied mode of operation shall be defined by the EMCS optimum start/stop schedule.

B. FAN CONTROL:

1. Fan speed shall be controlled by the air handler, based on its internal controls. The fan shall run in low speed during first stage cooling and high speed during second stage cooling.

C. TEMPERATURE CONTROL:

1. Cool-down: The EMCS shall determine the required cool-down period based on the optimized start algorithm. In this mode, the outside air damper shall be fully closed and the EMCS will control the unit to reach occupied cooling setpoint temperature of 74°F (adjustable). Once the occupied cooling setpoint temperature has been reached, the EMCS shall switch the unit to the occupied mode.
2. Unoccupied Mode: The DDC controller shall enable the cooling as required to maintain the unoccupied cooling setpoint (initially 82°F adj.) as sensed by the space temperature sensor. Upon a rise in space temperature above the unoccupied cooling setpoint, the DDC controller shall enable the mechanical cooling.
3. The space temperature sensor shall have an override pushbutton. Whenever the override pushbutton is depressed, the unit shall be indexed to the occupied mode for an adjustable period of time (initially 1 hour). After the override time period has expired, the unit shall revert back to the unoccupied mode.

4. Occupied Mode: In the occupied mode of operation, the unit supply fan shall cycle with a call for cooling. The DDC controller shall energize the cooling as required to maintain the occupied cooling setpoints (initially 74°F adj.) as sensed by a space temperature sensor with digital display and pushbutton override. Space set point shall be user adjustable within $\pm 2^\circ\text{F}$ (adj.). On a rise in space temperature above the occupied cooling setpoint, the DDC controller shall energize the first stage of mechanical cooling. Upon a further rise in space temperature of 2°F (adj.) above the occupied cooling setpoint, the DDC controller shall energize the second stage of mechanical cooling. On a drop in space temperature below the occupied cooling setpoint, the reverse shall occur.

4.3 SINGLE ZONE HEAT PUMP SPLIT SYSTEM WITH 2 STAGE COMPRESSOR AND BIPOLAR IONIZATION

A. GENERAL:

1. Each unit shall be provided with a cooling section, heating section, supply fan section, microprocessor control board. The controls contractor shall provide an outside air/ return air damper section, and a 0-100% motorized, modulating outside air damper with spring return. The mechanical contractor shall install the damper section. The space temperature sensor shall be provided with a local override button. The temperature control system contractor shall provide a dedicated stand-alone DDC controller for each unit. The occupied/unoccupied mode of operation shall be defined by the EMCS optimum start/stop schedule.

B. FAN CONTROL:

1. Fan speed shall be controlled by the air handler, based on its internal controls. The fan shall run in low speed during first stage cooling and high speed during second stage cooling.

C. OUTSIDE AIR CONTROL:

1. During unoccupied operation, the outside air damper shall be fully closed.
2. During occupied mode, the outside air damper shall be closed when the outside air temperature is below 20°F (adj.).
3. During occupied operation, the outside air damper shall be set to its minimum position (reference scheduled CFM).
4. Bipolar Ionization Unit shall be enabled any time the air handler fan is enabled.

D. TEMPERATURE CONTROL:

1. Warm-up: The EMCS shall determine the required warm-up period based on the optimized start algorithm. In this mode, the outside air damper shall be fully closed and the EMCS will control the unit to reach occupied heating setpoint of 70°F (adjustable). Once the occupied heating setpoint temperature has been reached, the EMCS shall switch the unit to the occupied mode.
2. Cool-down: The EMCS shall determine the required cool-down period based on the optimized start algorithm. In this mode, the outside air damper shall be fully closed and the EMCS will control the unit to reach occupied cooling setpoint temperature of 74°F (adjustable). Once the occupied cooling setpoint temperature has been reached, the EMCS shall switch the unit to the occupied mode.
3. Unoccupied Mode: In the unoccupied mode of operation, the unit outside air damper shall be fully closed and the supply fan shall cycle with the unit's heating and cooling modes. The DDC controller shall enable the heating or cooling as required to maintain the unoccupied heating and cooling setpoints (initially 55°F heating and 82°F cooling) as sensed by the space temperature sensor. Upon a rise in space temperature above the unoccupied cooling setpoint, the DDC controller shall enable the mechanical cooling. On a drop in space temperature below the unoccupied heating setpoint, the DDC controller shall enable the heating. First stage of heating shall be to activate the reversing valve

- and operate in heat pump mode. Upon a further drop in space temperature, the electric heat shall be energized.
4. The space temperature sensor shall have an override pushbutton. Whenever the override pushbutton is depressed, the unit shall be indexed to the occupied mode for an adjustable period of time (initially 1 hour). After the override time period has expired, the unit shall revert back to the unoccupied mode.
 5. Occupied Mode: In the occupied mode of operation, the unit supply fan shall cycle with a call for heating or cooling. The DDC controller shall energize the heating and cooling as required to maintain the occupied heating and cooling setpoints (initially 70°F heating, 74°F cooling) as sensed by a space temperature sensor with digital display and pushbutton override. Space set point shall be user adjustable within $\pm 2^\circ\text{F}$ (adj.). On a rise in space temperature above the occupied cooling setpoint, the DDC controller shall energize the first stage of mechanical cooling. Upon a further rise in space temperature of 2°F (adj.) above the occupied cooling setpoint, the DDC controller shall energize the second stage of mechanical cooling. On a drop in space temperature below the occupied cooling setpoint, the reverse shall occur. On a further drop in space temperature below the occupied heating setpoint, the DDC controller shall operate the reversing valve and operate in heat pump mode. Upon a further drop in space temperature below the occupied heating setpoint, the DDC controller shall energize the electric heat. On a rise in space temperature above the heating setpoint, the reverse shall occur.
 6. Economizer Mode: In unoccupied or occupied mode, anytime there is a call for cooling in the space, and the outside air temperature is 55°F (adj.) or below, the motorized outside air damper is to open to provide half of the total cooling CFM, and provide free cooling to the space until the space is satisfied.

END OF SECTION

SECTION 23 23 00

REFRIGERANT PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 01 Specifications and Section 23 00 00, apply to this Section.

1.2 SECTION INCLUDES

- A. Refrigerant piping for split system (including heat pumps) cooling/heating units.

1.3 RELATED SECTIONS

- A. Section 22 05 24 – Valves - General
- B. Section 22 05 30 – Pipe and Pipe Fittings - General
- C. Section 23 00 00 – Basic Mechanical Requirements
- D. Section 23 07 21 – Refrigerant Piping Insulation
- E. Section 23 33 33 – Access Doors

1.4 REFERENCES

- A. ASTM B280 - Seamless Copper Tube for Air Conditioning & Refrigeration Service

1.5 SUBMITTALS

- A. Provide submittal data on all items specified in this section in accordance with Specification Section 23 00 90, General Conditions, and Division 1.

1.6 COORDINATION

- A. Coordinate the refrigerant line sizing, lengths, traps, and all other aspects of the refrigerant systems with the air conditioning unit manufacturer to ensure a completely working and reliable system.
- B. Submit product data on piping materials and fittings.
- C. Provide letter stating air conditioning manufacturer has reviewed refrigerant line design. Provide drawings on any lines that are longer than 80 feet.
- D. If units have to be moved due to line lengths, then all associated costs will be at the Contractor's expense.

PART 2 PRODUCTS

2.1 PIPING

- A. ACR hard drawn copper tubing, conform to ASTM B280.
- B. ACR soft drawn copper tubing is allowed in concealed locations, such as behind walls. Above ceiling is not considered a concealed location.

2.2 FITTINGS

- A. Wrought copper fittings
- B. Use silver solder at connections

2.3 VALVES

- A. Manufacturers:
 - 1. Alco Controls
 - 2. Sporlan Valve Company

PART 3 EXECUTION

3.1 MATERIAL PREPARATION

- A. Cut tubing with a sharp pipe cutter.
- B. Ream and thoroughly clean to remove all burrs, filings, dirt and grease before assembly and soldering.
- C. Remove oxide and discoloration prior to assembly.

3.2 SLEEVES

- A. Sleeve piping as required in accordance with Section 23 05 29 – Pipe and Pipe Fittings.
- B. All refrigerant piping passing under slab shall be sleeved.
- C. Sleeves shall be of an adequate size to permit removal of the piping at a later date.

3.3 HANGER SUPPORTS

- A. Support as required in accordance with Section 23 05 29 – Pipe and Pipe Fittings.
- B. Do not fasten liquid and suction lines together unless there is insulation between them. Use wire ties. Duct tape not allowed.
- C. Insulate all refrigerant lines from structure.

3.4 INSTALLATION

- A. Route with building lines, vertical lines to be plumb, grade horizontal suction lines to compressor.
- B. All brazing shall be done with 2-8 psig dry nitrogen purge.

- C. Protect all valves and paint from excessive heat.
- D. Keep refrigerant lines sealed from atmosphere during construction.
- E. All suction lines to receive insulation.
- F. No welded or mechanical joints in concealed areas, such as walls. Soft drawn copper is acceptable.
- G. Follow A/C manufacturer's instructions.

END OF SECTION

SECTION 23 31 13

METAL DUCTWORK

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 01 Specifications and Section 23 00 00, apply to this Section.

1.2 SECTION INCLUDES

- A. Furnishing and installation of all ductwork as shown on the construction documents. Acoustical and thermal linings and wrappings; flexible ductwork and connections; combination smoke and fire dampers, smoke dampers, and fire dampers; duct access doors; air diffusers, grilles and registers; air volume control devices; hangers and supports; plenums and casings; turning vanes; air filters; installation of temperature control dampers, and other appurtenances necessary for a complete and operational system.
- B. All work shall be preceded by taking measurements at the job site, fully coordinating all work with other disciplines, verifying available spaces for ductwork, and developing shop drawings.

1.3 RELATED SECTIONS

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 07 13 – Duct and Grille Insulation
- C. Section 23 33 33 – Access Doors
- D. Section 23 34 16 – HVAC Fans
- E. Section 23 37 13 – Diffusers, Registers, and Grilles
- F. Section 23 81 26 – Split System HVAC Units

1.4 REFERENCES

- A. AMCA 500 - Test Methods for Louvers, Dampers and Shutters
- B. AMCA 511 - Certified Ratings Program for Air Control Devices
- C. ASTM 653 - Sheet Metal, Zinc Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvanized) by the Hot-Dipped Process
- D. ASTM A924 - Hot Dip Galvanized Coils & Sheets – Tolerances
- E. ASTM A463 - Steel Sheet Aluminum Coated by the Hot Dip Process
- F. NFPA 90A - National Fire Protection Association – Installation of Air Conditioning and Ventilation Systems
- G. NFPA 92A - Smoke-Control Systems

- H. SMACNA - Sheet Metal and Air Conditioning Contractors Association
- I. SMACNA HVAC Duct Construction Standards, Third Edition 2005, for Metal and Flexible Ducts
- J. U.L. - Underwriter's Laboratories
- K. UL 555 - Standard for Safety; Fire Dampers
- L. UL 555S - Standard for Safety; Leakage Rated Dampers for Use in Smoke Control Systems

1.5 SYSTEM DESCRIPTION

- A. Design static pressure:
 - 1. 1 inch w.g. minimum for all low pressure ductwork applications.

1.6 SUBMITTALS

- A. Product Data:
 - 1. Provide submittal data on all equipment specified in this section in accordance with Section 23 00 90, General Conditions, and Division 01.
 - 2. Submit product data indicating typical catalog of information including arrangements.
 - 3. Submit product data sheets indicating dimensions, general assembly, and materials used in fabrication.
 - 4. Indicate mechanical and electrical service locations and requirements of equipment.
 - 5. Submit manufacturer's installation instructions.
- B. Shop Drawings:
 - 1. Submit 1/4" per foot shop drawing(s) showing all ducts, piping and equipment shown by plans and specifications. Submit drawings on all mechanical rooms. The drawings shall be coordinated with structural and electrical. Provide sections for all congested areas and mechanical rooms. Submit prior to construction of ductwork.

1.7 QUALITY ASSURANCE

- A. All equipment and materials shall be new and of the quality as specified herein. All work shall comply with the Local Building Code, Mechanical Code, Fire Code, and all other applicable State and Local Codes or ordinances.
- B. All equipment and materials shall be installed in a workmanlike manner by trained and experienced sheet metal technicians and mechanics as recommended by the manufacturers of the products installed.
- C. All ductwork to be manufactured in accordance with SMACNA standards.
- D. Where the standards and requirements of this specification exceed those of SMACNA, the requirements herein shall govern.
- E. Except where specified otherwise, all sheet metal used shall be constructed from prime galvanized steel sheets or coils up to 60 inches in width. Each sheet shall be stenciled with manufacturer's name and gauge. Coils of sheet steel shall be stenciled throughout on 10 foot centers with manufacturer's name and gauge tolerances in inches.

- F. Spiral pipe:
 - 1. All pipe and fittings must be from a single manufacturer.
- G. Flexible:
 - 1. The composite assembly including insulation, vapor barrier, and glass scrim shall meet the Class 1 requirements of the latest NFPA Bulletin #90A and be labeled for a spread rating of 25 or less and a smoke development rating of 50 or under.

1.8 WARRANTY

- A. Warranty all ductwork and dampers for 1 year from the date of final acceptance. The warranty will cover workmanship, noise, chatter, whistling, and vibration. Ductwork must be free from pulsation under all conditions of operation.

PART 2 PRODUCTS

2.1 RECTANGULAR AND ROUND RIGID DUCTS:

- A. Material:
 - 1. New, prime grade sheet or coil steel
- B. Gauge:
 - 1. Select gauge in accordance with SMACNA Duct Construction Standards Tables 1-3 to 1-9 and Appendix- page 2.
- C. Auditorium and stages:
 - 1. Increase two gauges (heavier) for the first 20 feet of supply and return duct.
- D. Coating:
 - 1. Type:
 - a. Continuous, hot-dip, galvanized coating
- E. Application:
 - 1. 1-1/4 ounces per 1 square foot, two-sided sheet
 - 2. Comply with ASTM A 653.
- F. Identification:
 - 1. Sheet steel:
 - a. Stencil each sheet with manufacturer's name and gauge.
- G. Coil steel:
 - 1. Stencil coils on 10 foot centers with manufacturer's name and gauge.
- H. Construction:
 - 1. Manufacture in accordance with SMACNA Round Duct Standards, Tables 3-2A, 3-2B, and 3-3, Figures 3-1, 3-2, 3-3, 3-4, and 3-5.
 - 2. Pre-manufactured round duct may be used if approved by the Architect/Engineer.

2.2 ACCESS DOORS

- A. Install access doors to facilitate cleaning as required by code.
- B. Install access doors as required for access to fire protection devices.

2.3 FLEXIBLE DUCTS

- A. Material: In accordance with SMACNA Metal and Flexible Duct Standards, Latest Edition.
- B. Construction:
 - 1. Factory insulate with high density fiberglass to a minimum R value of 5.79.
 - 2. Provide a positive interior air seal permanently bonded to a carbon steel spring helix.
 - 3. Sheath seal in a Class 1 vapor barrier and factory seal at both ends.
 - 4. Conform to U.L. 181, NFPA 90A
- C. Manufacturer/Model:
 - 1. ATCO 30 Series

2.4 VOLUME CONTROL DAMPERS

- A. Manufacturer:
 - 1. Nailor Industries Series 1020, 1021 or equal.
- B. Type:
 - 1. Manually operated single blade or multi-blade
 - 2. Conform to SMACNA Duct Standards (Metal & Flexible), Figures 2-12 & 2-13.
- C. Application:
 - 1. Provide in all branches, splits and taps whether indicated on plans or not.
- D. Construction:
 - 1. Provide an indicating device with lock to hold damper in proper position.
 - 2. All manual dampers installed above hard ceilings or at other inaccessible areas shall be supplied with a cable operated damper equal to Young Regulator Model 830A-CC. Damper(s) to be opposed blade type constructed of .050 minimum heavy duty extruded aluminum frames and blades. All necessary hardware to ensure compatibility with remote cable control system shall be included. Damper blades to include individual blade bushings for smooth and quiet operation. Damper blades shall rotate between a matched pair of formed and punched 306 stainless steel connecting slide rails which facilitate smooth blade movement and ensure alignment.

2.5 TURNING VANES

- A. Provide in all rectangular supply elbows. Turning vanes in return air ductwork is not necessary.
- B. Conform to SMACNA Duct Standards, Figures 2-3 and 2-4.

2.6 DUCT SEALANT

- A. Equal to Glenkote "Seal-Flex" duct sealer, Hardcast "Irongrip 601", Foster 32-19" or "Childers CP-146"

2.7 FIRE DAMPERS

- A. Manufacturer/Model:
 - 1. Fire Dampers – Pottorff, Ruskin, Greenheck, National Controlled Air or Nailor
 - 2. Ceiling Fire Dampers/Thermal Blankets - CK-2000-1 thermal blanket and Model CFSR-2 ceiling damper for supply outlets (round or square) and CFSR-2 for return outlets (square).

- B. Type:
 - 1. 212°F fusible link fire damper.
 - 2. Fire protection rating: 1.5 hours
 - 3. Conform to UL Standard 555 and be UL labeled
 - 4. Tested in accordance with AMCA 500.
- C. Application:
 - 1. Provide at locations shown on plans and where required by Local and State ordinances.
- D. Features:
 - 1. Maximum leakage 8 cfm at 4-inch S.P.
 - 2. Vertical or horizontal installation
 - 3. Interface with fire alarm
 - 4. Radiation blanket
 - 5. Blades 16 gauge galvanized, maximum 6-inch width.
 - 6. 5 year warranty.
- E. Manufacturer/Model:
 - 1. Ceiling Fire Dampers:
 - a. Pottorff Ceiling Fire Dampers/Thermal Blankets – Series CFD
 - b. Equals by Nailor Industries, NCA, United Air, Ruskin, Greenheck

2.8 FIRE SAFETY FUNCTIONS - DUCT MOUNTED SMOKE DETECTORS, CONTROL RELAYS, AND SMOKE FIRE DAMPER CONTROL

- A. The Fire Alarm Contractor shall provide the Duct Mounted Smoke Detectors, Control Modules, Power Relays, and Control Relay devices and perform the final low-voltage hook-up to the fire alarm system.
- B. Duct mounted smoke detector housings and sample tubes shall be furnished by the Fire Alarm Contractor and mounted by the Mechanical Contractor.
- C. Line voltage hook-up shall be by the Electrical Contractor.
- D. Fire Alarm Safety Control Functions, which may include the operation of fire alarm Control Relays [CR] associated with duct mounted smoke detector [D]/air handler shut down, high volume low speed (HVLS) fan shut down, fire door hold-back and release, smoke fire damper motor control, et cetera, shall be initiated via Control Relays which shall be de-energized under fire alarm conditions. These Control Relays shall be provided and mounted by the Fire Alarm Contractor and located within three feet of the unit. These Control Relays shall be controlled by a fail-safe Fire Safety Control Function circuit. For each controlled device the contractor providing the device shall wire it internally for fail-safe shut-down and provide a labeled 3' coil of cable outside the unit to allow the fire alarm contractor to make final connection to the Common and N.O. or N.C. dry contacts on the fire alarm SPDT Control Relay. Each Fire Safety Control Function circuit controlled device shall be configured such that when the fire alarm system safety control circuit is re-energized, by the fire alarm control panel, the device shall return to normal operation (e.g. be ready to re-start) without a need for manual or environmental control system intervention.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Erect all ductwork in the general locations shown.
- B. Conform to all structural and finish conditions of the building.
- C. Ductwork shall not be allowed to pass through or over designated electrical rooms.
- D. Before fabricating any ductwork, check the physical conditions at the job site and make all necessary changes in cross sections, offsets, and similar items, whether they are specifically indicated or not.
- E. Where ductwork is shown to be lined on the inside with duct liner, the sizes shown on the plans are the inside dimensions. Therefore, sheet metal dimensions shall be increased accordingly.
- F. Seal all joints both transverse and longitudinal seams, with duct sealant in accordance to Table 1-2 Class B.
- G. Install 1" roll type filter media on all return duct openings prior to starting blowers. Leave in place and change as necessary during construction.
- H. Before installing grilles, operate air conditioning unit fans and remove all debris or foreign matter.
- I. Rectangular ductwork:
 - 1. Construct in accordance with SMACNA, Duct Construction Standards for the specific duct pressure classification involved (see pressure classification). Do not use radius ells with square throats.
- J. Round ductwork:
 - 1. Connect with slip type joints using a minimum of three sheet metal screws per joint and in accordance with SMACNA Duct Construction Standards.
- K. Flexible ductwork:
 - 1. All flexible ducts shall be demountable and individual lengths shall not be in excess of seven feet. Flexible ducts are not allowed to substitute rectangular return air ductwork, unless approved by engineer.
 - 2. Use only factory-made connectors.
 - 3. Flexible ducts should be installed fully extended, free of sags and kinks.
- L. Reinforcement:
 - 1. Reinforce all ducts to prevent buckling, breathing, vibration, or unnecessary noise.
 - 2. Reinforcing shall be in accordance with SMACNA Duct Construction Standards (Metal and Flexible), Tables 1-3, 1-4, 1-5, 1-6, 1-7, 1-8, and 1-9 plus any additional reinforcing to meet job conditions.
 - 3. All ducts shall be supported in accordance with SMACNA Duct Construction Standards (Metal and Flexible), Tables 4-1, 4-2, 4-3.
- M. Flexible Connections:
 - 1. Where ducts connect to fans or air handling units, make flexible airtight connections using "Ventglas" fabric.
 - 2. The fabric must be fire-resistant, waterproof and mildew resistant with a weight of approximately 30 ounces per square yard.

3. Provide a minimum of 1/2 inch slack in the connections, and a minimum of 2-1/2 inches distance between the edges of the ducts.
 4. Provide a minimum of 1 inch slack for each inch of static pressure on the fan system.
 5. Securely fasten fabric to apparatus and to adjacent ductwork by means of galvanized flats or draw bands.
 6. Do not install outdoors, except where detailed on plans.
 7. Where connections are made in outdoor locations, seal fabric to metal with mastic.
- N. Access Doors:
1. Install ductwork access doors in structural angle frames and provide with sash locks and hinges arranged for convenient access.
 2. Construct doors which occur in insulated ducts with an insulation filler.
 3. All access doors shall be appropriately labeled.
- O. Flashing and Opening Sealing:
1. Ducts passing through roofs or exterior walls:
 - a. Provide suitable flashing to prevent rain or air currents from entering the building as detailed on plans.
 - b. The flashing shall be minimum No. 24 gauge galvanized steel.
- P. Duct Leakage:
1. Seal ductwork in accordance with Table 1-2 of the SMACNA HVAC Duct Construction Standards - Metal and Flexible.
 2. Minimal leakage is expected for ductwork constructed to these standards but in no case shall the total leakage exceed 5% of designed CFM.
 3. All joints to be sealed with duct sealant.
- Q. Fire and Smoke Dampers:
1. Install fire and smoke dampers at locations shown on plans, and where required by local and state ordinances.
 2. Do not compress or stretch SFD, FD frame into duct or opening.
 3. Install dampers square and free from racking with blade running horizontally.
 4. Handle damper suing sleeve or frame. Do not lift damper using blades actuator, or jackshaft.
 5. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.
 6. Provide access doors in attached ductwork for inspection.
 7. Stencil each door "Fire Damper Access" per U. L. 555 standard.
 8. Install fire dampers in openings utilizing steel angles, sleeves, and other materials, and practices required to provide an installation equivalent that used by manufacturer when dampers were tested at UL.
 9. Install in accordance with damper manufacturer's published recommendations and instructions and NFPA Standard 90A.

3.2 BALANCING DAMPERS

- A. Volume Control Dampers:
1. Install manually operated volume control dampers in all branch ducts, splits or taps whether indicated on the drawings or not. Install a minimum of 5'-0" from grille/diffuser.
 2. Provide indicating device with lock to hold damper in position.
- B. Cable Operated Dampers:
1. Install a minimum of 5'-0" from grille/diffuser.
 2. Install to facilitate smooth blade movement and ensure alignment.

- C. Back Draft Dampers:
 - 1. Install back draft dampers as shown on plans.
 - 2. Manufacturer: Nailor Industries Series 1300 or equal.
- D. Air Intake Ducts:
 - 1. Insulate all outside air intake ducts.

3.3 DAMPER IDENTIFICATION

- A. Provide a securely attached red band and a label reading "Damper Location" at the location of all concealed manual dampers.
- B. All manual dampers which are not readily visible after duct insulation installation shall be identified in this manner.

3.4 DUCTWORK SUPPORT

- A. All ducting must be supported from building structure.
- B. Duct straps are not allowed to be screwed to roof decks, support from cross bridging or supported from bottom chord of joists.
- C. Do not support from roof or floor deck joist bridging.
- D. Support sizes and spacing shall conform to SMACNA Standards.

END OF SECTION

SECTION 23 33 33

ACCESS DOORS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 01 Specifications and Section 23 00 00, apply to this Section.

1.2 SECTION INCLUDES

- A. Access doors and their installation requirements.

1.3 RELATED SECTIONS

- A. Division 28 – Fire Alarm System
- B. Section 22 05 24 – Valves - General
- C. Section 22 11 17 – Domestic Water Piping and Appurtenances
- D. Section 22 13 17 – Soil, Waste, and Sanitary Drain Piping, Vent Piping, and Appurtenances
- E. Section 22 13 18 – Condensate Piping
- F. Section 22 40 01 – Plumbing Fixtures and Fixture Carriers
- G. Section 22 66 54 – Chemical Waste and Vent Piping
- H. Section 23 00 00 – Basic Mechanical Requirements
- I. Section 23 09 23 – Energy Management Control System
- J. Section 23 31 13 – Metal Ductwork

1.4 SUBMITTALS

- A. Provide submittal data on all items specified in this section in accordance with Specification Section 23 00 90, General Conditions, and Division 01.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Acudor
- B. Elmdor
- C. Mifab

2.2 ACCESS DOORS:

- A. Locations requiring access doors:
 - 1. Concealed valves
 - 2. Traps
 - 3. Trap primers
 - 4. Controls
 - 5. Cleanouts
 - 6. Dampers
 - 7. Ducts adjacent to fire doors, fire dampers, and smoke detectors.
 - 8. Equipment above hard ceilings.
 - 9. Other equipment requiring accessibility for operation and maintenance.
- B. Type:
 - 1. Hinged flush-type steel framed door with straps and exposed narrow border.
- C. Minimum size:
 - 1. 18" x 18" unless otherwise indicated.
 - 2. 24" x 24" for equipment above hard ceilings.
 - 3. Conform to architectural panel pattern for acoustical ceilings.
 - 4. Confirm size with Building Inspector and Engineer.
- D. Construction:
 - 1. Hinges: Concealed continuous type.
 - 2. Locking Device: Flush cam type, screw driver operated.
- E. Fire Rating:
 - 1. Same or better fire rating than the surrounding area.
- F. Access doors located in kitchens, restrooms or areas where water is present shall be stainless steel.

2.3 FACTORY PAINTING

- A. Apply prime coat of rust inhibiting paint, unless located in wet area.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions and recommendations.
- B. In suspended acoustical ceilings, provide a beaded pin or other approved means for identification and easy removal where necessary.
- C. Access doors shall only be installed in areas/locations that are readily accessible.
- D. Doors shall be installed in such a manner that door will open 180 degrees.

END OF SECTION

SECTION 23 34 16

HVAC FANS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 01 Specifications and Section 23 00 00, apply to this Section.

1.2 SECTION INCLUDES

- A. Centrifugal fans

1.3 RELATED SECTIONS

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 31 13 – Metal Ductwork
- C. Section 23 37 13 – Diffusers, Registers and Grilles

1.4 REFERENCES

- A. AMCA – Air Moving and Conditioning Association, Inc.
- B. UL – Underwriter’s Laboratory

1.5 QUALITY ASSURANCE

- A. UL Listed and Bear Label
- B. Tested in accordance with AMCA standards

1.6 SUBMITTALS

- A. Provide submittal data on all items specified in this section in accordance with Specification Section 23 00 90, General Conditions, and Division 01.
- B. Submit product data indicating typical catalog data, including arrangements, dimensions, general assembly, and materials used in fabrication.
- C. Provide in table form a schedule similar to drawings with data listing all fans, information, accessories, etc.
- D. Indicate mechanical and electrical service locations and requirements.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Acme

- B. Cook
- C. Greenheck
- D. PennBarry
- E. Twin City Fans

2.2 GENERAL

- A. Provide fan type, arrangement, capacity, size, motor horsepower, and motor voltage as shown on the drawings.
- B. Rate fans according to appropriate Air Moving and Conditioning Association, Inc. (AMCA) approved test codes and procedures. Seal to be attached.
- C. Supply fans with sound ratings below the maximums permitted by AMCA standards.
- D. All fans provided must bear the UL Label.
- E. Sound levels shall be as listed or quieter. Fans with excessive noise will be replaced at Contractor's expense.
- F. Fans are to be supplied with engraved aluminum nameplates indicating CFM, static pressure, manufacturer, serial number, and model number.

2.3 ROOF MOUNTED EXHAUST FANS

- A. Type:
 - 1. Roof mounted, direct driven centrifugal exhaust ventilator. Fan shall be spun aluminum and mounted on vibration isolators.
- B. Motors:
 - 1. NEMA design B with a minimum of Class B insulation rated for continuous duty and furnished at the scheduled voltage.
 - 2. Motor shall be electronically commutated motor rated for continuous duty and furnished either with internally mounted potentiometer speed controller, or with leads for connection to 0-10 VDC external controller.
 - 3. Exhaust fan motor to be located outside of the exhaust airstream and enclosed in a weather-tight compartment.
- C. Mounting:
 - 1. Resilient mounts outside the air stream.
- D. Cooling:
 - 1. Forced air cooling.
- E. Bearing Rating:
 - 1. Heavy duty regreasable ball type in a cast iron pillowblock housing selected for a minimum L50 life in excess of 200,000 hours at maximum catalogued operating speed.
- F. Construction:
 - 1. Fan shall be bolted and welded construction utilizing corrosion resistant fasteners.

2. Spun aluminum structural components shall be constructed of minimum 18 gauge marine alloy aluminum and bolted to a rigid aluminum support structure.
 3. Aluminum base shall have continuously welded curb cap corners for maximum leak protection.
 4. Fan wheel shall be backward inclined, constructed of 100% aluminum, and provided with an aerodynamic aluminum inlet cone.
 5. Integral conduit chase shall be provided through the curb cap and into the motor compartment to facilitate wiring connections.
 6. Provide 1/2 inch galvanized mesh bird screen over openings
- G. Features:
1. Disconnect switch: Factory wire the switch and motor to the junction box
 2. Automatic dampers with curb flanges
 3. Insulated, prefabricated curb with cant strips and with resilient gasket on top flange.
 4. Minimum 18 gauge galvanized steel or aluminum.
 5. Factory installed variable speed controller.
 6. Minimum 18 inch curb height.
 7. Lifting lugs.
- H. Verify roof slope so that fans are installed in a level condition.
- I. Coordinate and furnish curbs that are compatible with roof being installed.

2.4 CEILING MOUNTED EXHAUST FANS

- A. Type:
1. Centrifugal, direct driven exhaust fans
- B. Motors:
1. Motor shall be totally enclosed type with permanently lubricated bearings and built-in thermal overload protection.
- C. Construction:
1. Fan housing shall be minimum 20 gauge galvanized steel and acoustically insulated.
 2. Blower and motor assembly shall be mounted to a minimum 14 gauge reinforcing channel.
 3. Fan wheels shall be twin DWDI centrifugal forward curved type, constructed of galvanized steel.
 4. Integral aluminum backdraft damper.
- D. Features:
1. Disconnect switch: Internal wiring box with switch.
 2. Blower assembly to be easily removed without disconnecting the ductwork.
 3. Factory tested prior to shipment.
 4. Powder painted white steel grille.
 5. Factory installed variable speed controller.
 6. Provide 277 volt to 120 volt transformer.

2.5 SUPPLEMENTAL EQUIPMENT

- A. Weatherproof motor covers for outdoor installations:
1. Apply the same finish as used on the fan.

- B. Belt driven fans:
 - 1. Equip the fan motors with variable pitch sheaves. Select the sheave size for the approximate midpoint of adjustment and to provide not less than 20 percent speed variation from full open to full closed.
- C. Nonadjustable motor sheaves:
 - 1. Use for motor sizes over 15 horsepower.
- D. Factory wired, safety disconnect switch on each unit.
- E. Heaters with starters.
- F. Internal overload protection circuit.

2.6 PROTECTIVE COATINGS

- A. Apply manufacturer's standard prime coat and finish to all fans, motors and accessories, except on aluminum surfaces or where special coatings are required.
- B. Galvanizing:
 - 1. Hot dip coat all surfaces which require galvanizing.
 - 2. Where galvanizing is specified, a zinc coating may be used.
 - 3. After fabrication, apply the zinc coating and air dry the coating to 95 percent pure zinc.
 - a. Zinc Coatings:
 - (1) Amercoat
 - (2) Diametcoat
 - (3) Sealube
 - (4) Zincilate
- C. All exhaust fans which will operate in a corrosive environment (Science Labs, etc.) shall have a factory applied acid resistant coating.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install fans according to the manufacturer's instructions and in the locations shown on the drawings.
- B. All roof mounted fans shall have electrical wiring and conduit internal to roof curb and fan housing. No external wiring or conduit will be allowed on roof.**
- C. Verify compliance of "in Situ" vibration readings with AMCA Standard 204-05.
- D. All fans shall be air balanced in accordance with Section 23 05 93.
- E. Top of level curb to have minimum 11" from finished roof to top of curb.
- F. Screw fans to curbs with gasketed screws.

3.2 START-UP

- A. Start fans to verify rotation and operation sequence prior to test and balance.

3.3 IDENTIFICATION

- A. Provide identification per Section 23 05 53.

END OF SECTION

SECTION 23 37 13

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 01 Specifications and Section 23 00 00, apply to this Section.

1.2 SECTION INCLUDES

- A. Grilles
- B. Diffusers
- C. Registers

1.3 RELATED SECTIONS

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 31 13 – Metal Ductwork
- C. Section 23 34 16 – HVAC Fans

1.4 REFERENCES

- A. ARI Standard 890-94 Rating of Air Diffusers and Air Assembles.

1.5 SUBMITTALS

- A. Provide submittal data on all items specified in this section in accordance with Specification Section 23 00 90, General Conditions, and Division 01.
- B. Product data for review prior to placement of purchase order:
 - 1. Outlets
 - 2. Grilles
 - 3. Registers
 - 4. Control devices
 - 5. Diffusers
 - 6. Similar equipment
- C. Product data shall be submitted for each device specified. Data shall be arranged to match grille schedule.
- D. If a manufacturer other than the one scheduled on the plan is used, the sizes shown on the plans shall be checked for performance, noise level, face velocity, throw, pressure drop, etc., before the submittal is made.
- E. Selections shall meet the manufacturer's own published data for the above performance criteria.

- F. If grilles other than those scheduled by name are furnished, manufacturer shall be prepared to demonstrate compliance with noise criteria at Engineer's request and to Engineer's satisfaction.

1.6 COORDINATION

- A. Coordinate this work with work under Division 26 to insure that intended functions of lighting and air systems are achieved.
- B. Locations of outlets on plans are approximate and shall be coordinated with other trades to make symmetrical patterns.
- C. Locations shall be governed by the established pattern of the lighting fixtures or architectural reflected ceiling plan.
- D. The Contractor shall move any grille, register, or outlet up to four feet in any direction as directed by the Engineer at no additional cost.

PART 2 PRODUCTS

2.1 GENERAL

- A. Provide grilles, registers and diffusers as shown or scheduled on the plans. Conform to ARI 890-94.
- B. All air distribution devices in kitchen and any wet areas such as locker rooms, showers and restrooms shall be 100% aluminum construction.
- C. All air distribution devices for 1-hour structures (walls or ceilings) shall be steel construction conforming to all codes and standards.

2.2 MANUFACTURERS

- A. Metalaire
- B. Krueger
- C. Titus
- D. Nailor
- E. Price

2.3 PERFORMANCE CRITERIA

- A. Throw: Velocity at the end of the throw, in the 5'-0" occupancy zone, will be between 25 to 50 FPM.
- B. Noise levels (NC Curve):
 - 1. Not to exceed those scheduled below.
 - a. Classrooms, Libraries, and Offices - 25 N.C.
 - b. Cafeterias - 30 N.C.
 - c. Gymnasiums - 40 N.C.

- C. All devices shall be tested per Air Diffusion Council and labeled as such.

2.4 FINISHES

- A. Paint exposed devices with factory standard prime coat or factory finish coat. Architect/Engineer to determine final color of grille.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Where called for on the schedules, the grilles, registers and ceiling outlets shall be provided with deflecting devices and manual dampers. These shall be the standard product of the manufacturer, subject to review by the Engineer.
- B. All ceiling devices shall be furnished to be compatible with the ceilings in which they are installed.

END OF SECTION

SECTION 23 43 23

BIPOLAR IONIZATION AIR PURIFICATION SYSTEM

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 01 Specifications and Section 23 00 00, apply to this Section.

1.2 DESCRIPTION OF WORK

- A. This section describes the design, performance and installation of a bipolar ionization air purification system intended for use on the project. Ionization units shall be supplied to provide between 500 and 1500 negative ions per cubic centimeter in the areas served.
- B. Where the air purification system is intended to reduce outside ventilation air in accordance with the International Mechanical Code and ASHRAE 62.1, the manufacturer shall provide calculations to justify such reduction.

1.3 RELATED SECTIONS

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 31 13 – Metal Ductwork
- C. Section 23 37 13 – Diffusers, Registers, and Grilles

1.4 SUBMITTALS

- A. Provide submittal data on all items specified in this section in accordance with Specification Section 23 00 90, General Conditions, and Division 01.
- B. Submit product data indicating typical catalog data, including arrangements, dimensions, general assembly, and materials used in fabrication.
- C. Provide in table form a schedule similar to drawings with data listing all units, information, accessories, etc.
- D. Indicate mechanical and electrical service locations and requirements.

1.5 QUALITY ASSURANCE

- A. The air purification system shall be a product of an established manufacturer with a minimum of 10 outside air reduction installations in successful operation in the USA. Technologies that do not operate through a gas disassociation process like UV lights, powered particulate filters, and/or polarized media filters, will not be considered.
- B. A qualified representative from the manufacturer shall be available to inspect the installation of the air purification system to ensure installation in accordance with manufacturer's recommendation.

- C. The air purification system products shall be tested and listed by UL and ETL according to UL Standard 867 – Electrostatic Air Cleaners. Air purification system products shall specifically be tested and passed UL 2043 to ensure plenum rating.
- D. The operation of bi-polar ionization units shall conform to UL 867 with respect to ozone generation.
- E. The manufacturer must submit Indoor Air Quality calculations to confirm acceptable indoor conditions at the scheduled air flows in accordance with ASHRAE Standard 62.1. The calculations shall be independently validated to verify accuracy of the IAQ calculations and conformance with Standard 62.1 by third party testing on a previous installation.

1.6 RELATED WORK PERTAINING TO OTHER SPECIFICATIONS

- A. Electrical wiring
- B. Ductwork

1.7 REFERENCE CODES AND STANDARDS

- A. UL Standard 867 and Standard 2043
- B. National Electric Code NFPA 70
- C. ASHRAE Standard 62.1

PART 2 PRODUCTS

2.1 APPROVED MANUFACTURERS

- A. Plasma Air International
- B. Global Plasma Solutions
- C. Bioclimatic

2.2 PERFORMANCE CRITERIA

- A. Each piece of air handling equipment, so designated on the plans, details, equipment schedules and/or specifications shall contain a plasma ion generator with bipolar ionization output as described here within.
- B. The Bi-polar Ionization system shall be capable of:
 - 1. Effectively killing microorganisms downstream of the bipolar ionization equipment (mold, bacteria, virus, etc.).
 - 2. Controlling gas phase contaminants generated from human occupants, building structure, furnishings and outside air contaminants.
 - 3. Reducing space static charges.
 - 4. Reducing space particle counts.
 - 5. When mounted to the air entering side of a cooling coil, keep the coil free from pathogen and mold growth.
 - 6. All manufacturers shall provide documentation by an independent accredited laboratory that proves the product has minimum kill rates for the following pathogens given the allotted time and in space conditions.

- a. MRSA - 99.75% in 30 minutes
 - b. Influenza Virus (H1N1) - 80.5% in 30 minutes, 86.6% in 60 minutes
 - c. E. Coli - 99.43 % in 120 minutes
 - d. Cladosporium Cladosporiodes - 97.7% in 120 minutes
 - e. Aspergillus Niger - 97.1% in 120 minutes
 - f. Staphylococcus Aureus - 81.7% in 120 minutes
7. Manufacturers not providing the equivalent space kill rates shall not be acceptable. All manufacturers requesting prior approval shall provide to the engineer independent test data from an accredited independent lab confirming the kill rates and time per the above.
- C. The bipolar ionization system shall operate in such a manner that equal amounts of positive and negative ions are produced. Single pole ion devices shall not be acceptable.
1. Airflow rates may vary through the full operating range of a VAV system. The quantity of air exchange shall not be increased due to requirements of the air purification system.
 2. Velocity Profile: The air purification device shall not have a maximum velocity profile.
- D. Humidity: Plasma Generators shall not require preheat protection when the relative humidity of the entering air exceeds 85%. Relative humidity from 0 - 100%, condensing, shall not cause damage, deterioration or dangerous conditions to the air purification system.

2.3 EQUIPMENT REQUIREMENTS

- A. Electrode Specifications (Bi-polar Ionization):
1. Each plasma generator with bipolar ionization output shall include the required number of electrodes and power generators sized to the air handling equipment capacity. Electrodes shall be energized when the main unit disconnect is turned on and the fan is operating.
 2. Ionization output from each electrode shall be a minimum of 5 million ions/cc when tested at 2" from the ion generator.
 3. Manufacturer shall demonstrate that no voltage potential exists due to exposed electrical components in the duct system or plenum.
- B. Duct mounted units
1. Where so indicated on the plans and/or schedules, plasma ion generators shall be supplied and installed by the mechanical contractor. The contractor shall follow all manufacturer IOM instructions during installation.
 2. Ion generators shall be furnished with a factory-equipped gasketed mounting flange to prevent air leakage. Gasketed flange shall be a minimum of 1 1/8" wide around the perimeter of the ionizer to insure no leakage occurs.
 3. Ion generators shall be field installed in a location that is convenient for visual inspection, removal, and servicing. They shall include an ion indicator light clearly visible from below the installed location.
 4. Ion generators shall be wired from the 24V AC fan and common terminal of the control power circuit. Ion generators shall be capable of directly accepting 24V AC power. The use of loose step down transformers or power converters shall not be acceptable.

2.4 ELECTRICAL AND CONTROL REQUIREMENTS

- A. Ion generators shall contain a built-in power supply and operate on 24V AC and shall connect to the fan and common terminals of the fan coil unit or air handling unit served. Ion generators requiring a loose 24V, 120V or 230V transformer or power supply will not be accepted.
- B. Wiring, conduit and junction boxes shall be furnished and installed by the electrical contractor within housing plenums and shall be UL and NEC NFPA 70 approved.

- C. All plasma ion generators shall include internal short circuit protection, overload protection, and automatic fault reset. Overload protection and associated automatic fault reset shall occur internally to the unit and be performed through circuitry on the unit's PCB. Manual fuse replacement and manual fault reset of each unit shall not be accepted.
- D. All plasma ion generators shall include an external BMS interface to indicate ion generator status and alarm. Light emitting diode shall be visible from the ground for each unit and shall be on any time power is on to the unit and ions are being generated. Light signaling unit power only shall not be acceptable.

PART 3 EXECUTION

3.1 INSTALLATION REQUIREMENTS

- A. Ionization units shall be installed per manufacturer's installation instructions and requirements.

3.2 ASSEMBLY AND INSTALLATION

- A. Assemble ionization units and install in supply ductwork downstream of all coils and upstream of the first supply tap. Ionization units are not to be installed in return air ductwork.
- B. Electrical contractor shall complete single point power connections.
- C. Protect equipment from water and damage before and after installation.

3.3 COMMISSIONING & TRAINING

- A. A manufacturer's authorized representative shall provide start-up supervision and training of owner's personnel in the proper operation and maintenance of all equipment.
- B. Provide 5 copies of Operating and Maintenance Manuals.
- C. OPTIONAL ADD FOR HANDHELD ION COUNTER: Provide to the owner a portable hand held ion counter with a calibrated range of 0 to 20,000 ions/cm³ and an accuracy of +/- 25% within the specified range. Ion counter shall have automatic zeroing capability on 10 minute intervals.

3.4 WARRANTY

- A. Equipment shall be warranted by the manufacturer against defects in material and workmanship for a period of twelve months after shipment or eighteen months from owner acceptance, whichever occurs first. Labor to replace equipment under warranty shall be provided by the installing contractor

END OF SECTION

SECTION 23 81 23

COMPUTER ROOM AIR CONDITIONING UNIT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 01 Specifications and Section 23 00 00, apply to this Section.
- B. These specifications describe requirements for a mission critical environmental control system. The system shall be designed to control temperature and humidity conditions in rooms containing electronic equipment, with good insulation and vapor barrier. The manufacturer shall design and furnish all equipment to be fully compatible with the heat dissipation requirements of the room.

1.2 RELATED WORK

- A. Section 22 13 18 - Condensate Piping
- B. Section 23 00 00 - Basic Mechanical Requirements
- C. Section 23 09 23 - Energy Management Control System
- D. Section 23 31 13 - Metal Ductwork

1.3 REFERENCES

- A. ARI 430 - Standard for Central Station Air Handling Units.
- B. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
- C. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- D. SMACNA - HVAC Duct Construction Standards.
- E. ARI 410 - Standard for Forced Circulation Air-Cooling and Air-Heating Coils.
- F. ANSI/UL 900 - Test Performance of Air Filter Units.
- G. AMCA 300 - Reverberant Method for Sound Testing of Fans.
- H. ARI 260P - Method for Rating Air Handling Units for Sound.
- I. AMCA 301 - Method for Publishing Sound Ratings for Air Moving Devices.
- J. ASHRAE 68 - Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans.
- K. NEC - National Electric Code
- L. ASHRAE 52 - HVAC Air Filtration

1.4 QUALITY ASSURANCE

- A. Computer Units: Certify air volume, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI 430. Certify units with fan motor operating at 60 Hz. If air handling units are not certified in accordance with ARI 430, contractor shall be responsible for expenses associated with testing of units after installation to verify performance of fans. Any costs incurred to adjust fans to meet scheduled capacities shall be the sole responsibility of the contractor. Fans shall not be selected near the fan surge line.
- B. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410.

1.5 SUBMITTALS

- A. Provide submittal data on all items specified in this section in accordance with Specification Section 23 00 00, General Conditions, and Division 1.
- B. Submit unit performance including: capacity, nominal and operating performance, fan curves with fan operating point clearly marked.
- C. Submit Mechanical Specifications for unit and accessories describing construction, components and options.
- D. Submit shop drawings indicating overall dimensions as well as installation, operation and service clearances. Indicate lift points and recommendations. Indicate unit shipping, installation and operating weights including dimensions.
- E. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.
- F. Submit sound power levels by octave band for air handling units at scheduled design conditions. Provide sound power levels for "discharge", "inlet plus cabinet" and "casing radiated" sound paths in accordance with AMCA 300 and AMCA 301. If unit sound power levels exceed values of the scheduled units on drawings, whether the sound power levels are scheduled or not, the contractor shall submit detailed plan outlining steps to meet design noise levels. Comply with ARI-260P and ASHRAE 68.
- G. The contractor shall provide a 1/4 scale drawing of the mechanical equipment rooms where all air handling units will be located. The drawing shall show all piping, equipment and recommended clearances for the equipment. This drawing shall be furnished prior to commencement of work.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of the contract documents. Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Each section shall have lifting lugs or shipping skid to allow for field rigging and final placement of section.
- B. Deliver units to site with fan motors, sheaves, and belts completely assembled and mounted in units. Mount motors as specified in these contract documents.
- C. Store and protect products under provisions of the contract documents.

- D. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish. The contractor shall be responsible for the repair of the units if any damage occurs due to improper storage and handling. The contractor shall protect the units with tarpaulins, not plastic covering.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until filters are in place, bearings lubricated, and fan has been test run under observation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Liebert
- B. Aaon
- C. Additional manufacturers to submit substitution request 10 days prior to bid.

2.2 COOLING SYSTEM

- A. Air-Cooled Refrigeration System
 - 1. Refrigeration System
 - a. Single refrigeration circuit shall include a liquid line filter drier, a refrigerant sight glass with moisture indicator, an adjustable externally equalized expansion valve, and a liquid line solenoid valve. The indoor evaporator refrigerant piping shall be spun shut with a nitrogen holding charge. Field relief of the Schrader valve shall indicate a leak-free system.
 - 2. Evaporator Coil
 - a. The evaporator coil shall be A-frame design with offset orientation. It shall be constructed of rifled copper tubes and aluminum fins. A stainless steel condensate drain pan shall be provided.
 - 3. Digital Scroll Compressor
 - a. The compressor shall be digital scroll-type with variable capacity operation from 20-100%. Compressor solenoid valve shall unload the compressor to provide variable capacity operation. The compressor shall have a suction gas cooled motor, vibration isolators, internal thermal overloads, manual reset high pressure switch, rotalock service valves, low pressure and high pressure transducer, crankcase heater, internal centrifugal oil pump, and an operating speed of 3500 RPM at 60Hz. Compressor shall be located outside the airstream and shall be removable and serviceable from the rear of the unit.
 - 4. R-407C Refrigerant
 - a. The system shall be designed for use with R-407C refrigerant, which meets the EPA clean air act for phase-out of HCFC refrigerants.

2.3 CABINET CONSTRUCTION AND ACCESSIBILITY

- A. Cabinet Construction
 - 1. The exterior panels shall be MIG welded, formed sheet metal, and powder coated with color paint to protect against corrosion. The panels shall be insulated with a minimum 1 in. of 1.5lb density fiber insulation. The main front panel

- B. Serviceability
 - 1. The cabinet shall be designed so all components are easily accessible for service and maintenance.
- C. Locking Disconnect Switch
 - 1. A manual disconnect switch shall be mounted in the electrical panel and be capable of disrupting the flow of power to the unit. The electric panel compartment can only be accessed with the switch in the “off” position.
- D. Filtration
 - 1. The filter chamber shall be an integral part of the system, located within the cabinet and removable from the top of the unit. The filters shall be 2" thick with an ASHRAE 52.2 MERV7 rating (40% ASHRAE 52.1). A filter clog alarm shall be included.
 - 2. Provide two (2) sets of unit filters. One set, minimum, shall be utilized during the construction phase of the project. During the construction phase of the project the contractor shall maintain clean filters in the unit. The construction filters shall be replaced at time of owner occupancy with clean unused filters.
- E. Electric Reheat
 - 1. The low-watt density, 304/304, stainless steel, finned-tubular electric reheat coils shall be capable of maintaining room dry bulb conditions when the system is calling for dehumidification. The reheat section shall include UL/CSA recognized safety switches to protect the system from overheating. The capacity of the reheat coils shall be controlled in one stage. The reheat elements shall be accessible from the front of the cabinet.
- F. Steam Generating Canister Humidifier
 - 1. A canister-type steam generating humidifier shall be factory-installed in the cooling unit and operated by the microprocessor control system. It is complete with disposable canister, all supply and drain valves, steam distributor and electronic controls. The need to change the canister is indicated on the microprocessor controller.
- G. Dual-Float Condensate Pump
 - 1. Condensate pump is complete with integral primary and secondary float switches, pump, motor assembly and reservoir. The secondary float shall send a signal to the local alarm and shut down the unit upon high water condition.
- H. Microprocessor Control With Display
 - 1. The computer room air conditioning unit(s) shall be controlled by the on board microprocessor controller. The standard user interface is the display panel which presents system information and allows all parameters to be viewed and adjusted. It features push-button navigation, operational status LEDs, and a password protection system. Unit-to-Unit communication with other computer room air conditioning units shall be included as standard.
 - 2. The microprocessor controller shall be compatible with all remote monitoring and control devices. Options are available for BMS interface via MODbus, Jbus, BACNet, Profibus and SNMP.
 - 3. The display and housing shall be viewable while the unit panels are open or closed. The controls shall be menu driven. The display shall be organized into three main sections: User Menu, Service Menu and Advanced Menu. The system shall display user menus for: active alarms, event log, graphic data, unit view/status overview (including the monitoring of room conditions, operational status in % of each function, date and time), total run hours, various sensors, display setup and service contacts. A password shall be required to make system changes within the service menus. Service menus shall include: setpoints, standby settings (lead/lag), timers/sleep mode, alarm setup, sensor calibration, maintenance/wellness settings, options setup, system/network setup, auxiliary boards

and diagnostics/service mode. A password shall be required to access the advanced menus, which include the factory settings and password menus.

4. All unit alarms shall be annunciated through both audio and visual cues, clearly displayed on the screen, automatically recorded in the event log and communicated to the customers Building Management System/Building Automation System. The microprocessor controller shall activate an audible and visual alarm in event of any of the following conditions:
 - a. High Temperature
 - b. Low Temperature
 - c. High Humidity
 - d. Low Humidity
 - e. Fan Fault
 - f. Change Filters
 - g. Loss of Air Flow
 - h. Loss of Power
 - i. Humidifier Problem
5. System Auto Restart – The auto restart feature shall automatically restart the system after a power failure. Time delay shall be programmable.

2.4 MULTI UNIT COORDINATION

- A. The microprocessor controller shall be capable of a “teamwork” mode which will prevent multiple units in an area from operating in opposing modes. Teamwork allows the control to optimize a group of connected cooling units equipped with a microprocessor controller using a network. Below are three possible modes of operation.
 1. **Teamwork Mode 1:** Is best in small rooms with balanced heat loads. The controlling temperature and humidity sensor readings of all units in operation (fan On) are collected to be used for an average or worst-case sensor reading (user-selectable). The master unit shall send the operating requirements to all operating units in the group. The control band (temperature, fan and humidity) is divided and shared among the units in the group.
 2. **Teamwork Mode 2:** The Liebert iCOM calculates the worse-case demand for heating, cooling humidification and dehumidification. Based on the greatest demand within the group, each unit operates independently, meaning that the unit may respond to the thermal load and humidity conditions based on the unit’s controlling sensors.
 3. **Teamwork Mode 3 - Optimized Aisle:** May be employed in large and small rooms with varying heat loads. Optimized Aisle is the most efficient teamwork mode that allows the unit to match cooling capacity with heat load. In the Optimized Aisle mode, the fans operate in parallel. Fans can be controlled exclusively by remote temperature or using static pressure with a secondary remote temperature sensor(s) as an override to ensure that the inlet rack temperature is being met. Cooling (Compressors or Economizer) is controlled through unit supply air conditions. Liebert iCOM calculates the average or worst-case sensor reading (user-selectable) for heating, cooling humidification and dehumidification. Based on the demand within the group, units will be allowed to operate within that mode until room conditions are satisfied.

2.5 COMMUNICATION INTERFACES

- A. Remote Shutdown Terminal
 1. The remote shutdown terminal shall provide the customer with a location to remotely shut down the unit.
- B. Common Alarm Contact
 1. The common alarm contact shall provide the customer with a set of normally open (n/o) contacts for remote indication of unit alarms.

C. Reheat / Humidifier Lockout

1. The reheat and humidifier lockout shall include the necessary relays to disable the reheat and humidifier from an external 24 volt signal.

2.6 HEAT REJECTION

A. Air-Cooled Condenser

1. The outdoor air-cooled condenser shall be the low profile, multiple direct drive, propeller fan type. The condenser shall balance the heat rejection of the compressor at 105°F ambient. The condenser shall be constructed of aluminum and contain a copper tube, aluminum fin coil arranged for vertical air discharge.

2.7 WARRANTY

1. One year Parts only warranty
2. 5 Year Compressor Only: Manufacturer 1st year standard parts only warranty + 2nd through 5th year compressor only extended warranty

PART 3 EXECUTION

3.1 GENERAL

- A. Install units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated and maintain manufacturer's recommended maintenance clearances.
- B. Install and connect electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's electrical connection diagram submittal to electrical contractor.
- C. Install and connect devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's piping connection diagram submittal to piping contractor.
- D. Startup units in accordance with manufacturer's startup instructions. Test controls and demonstrate compliance with requirements. These specifications shall describe requirements for a computer room environmental control system. The system shall be designed to maintain temperature and humidity conditions in the rooms containing electronic equipment.
- E. Equipment manufacturer to provide startup.
- F. The manufacturer shall design and furnish all equipment to be fully compatible with heat dissipation requirements.

END OF SECTION

SECTION 23 81 26

SPLIT SYSTEM HVAC UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 1 Specifications and Section 23 00 00, apply to this Section.

1.2 SECTION INCLUDES

- A. Split system HVAC units.

1.3 RELATED SECTIONS

- A. Section 22 13 18 – Condensate Piping
- B. Section 22 16 01 – Natural Gas Piping and Appurtenances
- C. Section 23 00 00 – Basic Mechanical Requirements
- D. Section 23 05 29 – Hangers and Supports for HVAC Piping and Equipment
- E. Section 23 05 93 – Testing, Adjusting and Balancing for HVAC
- F. Section 23 09 23 – Energy Management Control System
- G. Section 23 23 00 – Refrigerant Piping
- H. Section 23 31 13 – Metal Ductwork

1.4 REFERENCES

- A. Refer to Section 23 00 00 for complete names of references identified in this section.
 - AGA American Gas Association
 - AHRI 210/240 Unitary Air-Conditioning and Air Source Heat Pump Equipment
 - AHRI 270 Sound Rating of Outdoor Unitary Equipment
 - ANSI/ASHRAE 15 Safety Code of Mechanical Refrigeration
 - ASHRAE90.01-2001 Energy Standard for Buildings Except Low Rise Residential Buildings
 - ASHRAE 62-2001 Ventilation for Acceptable Indoor Air Quality
 - D.O.E. Department of Energy
 - IECC International Energy Conservation Code
 - NFPA 70 N.E.C. National Electrical Code
 - UL Underwriters Laboratory

1.5 SUBMITTALS

- A. Product Data:
 - 1. Provide submittal data on all equipment specified in this section in accordance with Section 23 00 90, General Conditions, and Division 1.

- B. Submittals shall include:
 - 1. Unit model number
 - 2. Refrigerant type
 - 3. Sound rating in accordance with AHRI 270
 - 4. Cooling efficiency in accordance with AHRI Standard 210
 - 5. All accessories
- C. Submit product data indicating typical catalog of information including arrangements.
- D. Submit product data sheets indicating dimensions, general assembly, and materials used in fabrication.
- E. Provide in table form a schedule similar to drawings with data listing all unit information, data, accessories, etc.
- F. Indicate mechanical and electrical service locations and requirements.
- G. Submit letter from air conditioning manufacturer stating refrigerant line design has been reviewed.
- H. Submit manufacturer's installation instructions.
- I. Shop Drawings: (adjust as required)
 - 1. Submit 1/4" per foot shop drawing(s) showing all piping, ductwork, and equipment shown by drawings and specifications. Submit drawings on all mechanical rooms. The drawings shall be coordinated with structural, and electrical, and fire sprinkler drawings.
- J. Equipment Start-up Report
 - 1. Submit an equipment start up report as provided by the equipment manufacturer. Start-up report shall include the following, but not limited to: verification of system air flow, proper operation of all motors and fans, proper tensioning of belts and pulleys, proper operation of on-board microprocessor control system, proper control of economizer damper, proper compressor operation, and proper operation of cooling, heating, and dehumidification modes.

1.6 QUALITY ASSURANCE

- A. UL listed and must display UL label on all units.
- B. All units must comply with ASHRAE Standard 90.1 and the applicable International Energy Conservation Code.
- C. Unit performance data must be rated in accordance with AHRI Standard 210/240 and must display the AHRI symbol on all standard units.
- D. Conform to applicable ANSI/NFPA 70 code for internal wiring of factory wired equipment.
- E. Air conditioning manufacturer to visit site and inspect installation of units and refrigerant lines, and provide letter stating installation conforms to installation instructions.
- F. Tested in accordance with the Department of Energy.
- G. The air conditioning equipment manufacturer shall be solely responsible for their equipment that does not comply with the performance of their published catalogues and specifications.

1.7 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data.
 - 1. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, including filter replacement and unit lubrication.
- B. Air conditioning manufacturer to visit site and inspect installation of units and refrigerant lines, and provide letter stating installation conforms to installation instructions.

1.8 WARRANTY

- A. Complete 1 year warranty on all equipment.
- B. Additional 4 year warranty provided for the compressors and heat exchangers.
- C. Additional 9-year warranty provided for galvanized heat exchangers.
- D. Additional 14-year warranty provided for stainless steel heat exchangers.
- E. The warranted compressor assembly consists of the starter, rotor, eccentric shaft, eccentric rods, pistons, wrist pins, suction valves, discharge valves, unloading mechanisms, oil pump, and the housing in which these parts are enclosed.
- F. The warranty shall indicate model, serial number of the unit and commencing date. The commencing date of the warranty shall be after the building has been accepted for occupancy.

PART 2 PRODUCTS

2.1 MANUFACTURERS: HEAT PUMP

- A. 3 to 5 tons – 17.0 SEER
 - 1. Lennox
 - 2. Trane
 - 3. Units to have two stage compressor and a minimum two speed fan.

2.2 MANUFACTURERS: ELECTRIC FURNACE

- A. 3 to 5 tons – 17.0 SEER
 - 1. Lennox
 - 2. Trane
 - 3. Units to have two stage compressor and a minimum two speed fan.

2.3 SPLIT SYSTEM HEATING/ COOLING UNITS

- A. Minimum Cooling Efficiencies:
 - 1. EER ratings by AHRI Standard 210/ 240 and AHRI Standard 340/360:
 - a. All units to comply with ASHRAE 90.1.
 - b. All units to comply with International Energy Conservation Code 2015.
- B. Natural Gas Furnaces:
 - 1. Heating capacities:
 - a. Equal to or greater than those scheduled on plans.

2. Ignition:
 - a. Equip with electronic pilot standard ignition
 - b. Standing pilot not allowed
 3. Efficiency:
 - a. Minimum 92% AFUE rating
 4. Heat exchanger material:
 - a. Aluminized steel
 - b. Bear AGA label.
- C. Electric Furnaces/Air Handlers:
1. Heating capacities:
 - a. As scheduled on plans at rated voltage.
 2. Three-phase electrical power:
 - a. Impose an equal electrical load on all phases of heater.
 - b. Electrical resistance elements which are not balanced over all three phases are not acceptable.
- D. Heat Pump Units
1. Features:
 - a. Crankcase heaters
 - b. Timed off control
 - c. Low Ambient cooling to 45°F
 - d. Hi/Low pressure switches
 - e. Over current protection
 - f. Filter Dryer
 - g. Provide hail guards on all condensing units.
 - h. Factory installed defrost control to operate on demand
 - i. Provide any reference specialties that manufacturer requires
 - j. Refrigerant R-410A
- E. Condensing Units:
1. Features:
 - a. Crankcase heaters
 - b. Timed off control
 - c. Low Ambient cooling to 45°F
 - d. Hi/Low pressure switches
 - e. Over current protection
 - f. Filter Dryer
 - g. Provide Hail Guards on all Condensing Units
 - h. Provide any reference specialties that manufacturer requires
 - i. Refrigerant 410-A
- F. All Air Handlers:
1. Features:
 - a. 2 inch filter racks to be provided at each air handler.
 - b. Easy access to filters
 - c. Provide extra set of filters, Farr 3030 pleated 2" thick. $MERV \geq 6.0$.
 - d. Low voltage terminal strip
 - e. All blowers shall deliver a minimum of 450 cfm/ton at .5" E.S.P.
 - f. Furnish and install auxiliary drain pans below each air handler. Provide float switches for all auxiliary drain pans.
 2. **Class I motorized outside air dampers. All outside air dampers to be low leak dampers. Dampers shall have an air leakage rate not greater than 4 CFM/ sqft. and shall be labeled by an approved agency when tested in accordance with AMCA 500D.**

- G. Accessories:
1. 2-Stage Compressor Unit:
 - a. All split system units with two stage compressors are to have a minimum of two fan speeds. In first stage cooling, the compressor is to be in first stage, and the fan is to be set to low speed. In second stage cooling, the compressor is to be in second stage, and the fan is to be set to high speed. Set differential temperature between first stage cooling and second stage cooling at 2°F (adj.).
 2. Unit without CO₂ Sensor:
 - a. RTU motorized outside dampers to open to maximum position when fan is ON, and spring return closed when fan is OFF. All outside air to be filtered.
 3. Unit with Economizer Mode and Fault Detection and Diagnostics.
 - a. All cooling only units are to be provided with a dry bulb economizer. When outdoor dry bulb conditions are met, and the space temperature sensor is calling for cooling, the economizer mode of the unit shall provide free cooling to the space.
 - b. All units 3 tons and above are to be provided with a dry bulb economizer. When outdoor dry bulb conditions are met, and the temperature sensor is calling for cooling, the economizer shall provide free cooling to the space. The dehumidification cycle and heating modes shall be disabled during economizer mode.
 - c. All units 10 tons and above are to be provided with a dry bulb economizer and a power exhaust fan. The powered exhaust fan shall only be enabled during economizer mode.
 - d. All economizers must be equipped with fault detection and diagnostics. The unit shall be capable of reporting faults to a fault management application system or displayed on the zones thermostat. The fault detection system shall be capable of detecting the following faults:
 - (1) Air temperature sensor failure.
 - (2) Not economizing when the unit should be economizing.
 - (3) Economizing when the unit should not be economizing.
 - (4) Dampers not modulating.
 - (5) Excess outdoor air.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with the plans, manufacturer's instructions and approved shop drawings.
- B. Contractor to provide and install thermostat wire from air handler to condensing units.
- C. Contractor to provide and install flexible watertight conduit for wiring.
- D. Coordinate with plumbing contractor on all condensate piping.
- E. Install roll type filter media over all return air openings during construction if unit is operated. Replace as required.
- F. Accessories:
 1. Unit Without CO₂ Sensor:
 - a. Furnish motorized outside air dampers to allow scheduled amount of outside air on all units. Dampers to open to maximum position when fan is on, spring close when fan is off. All outside air to be filtered.

3.2 IDENTIFICATION

- A. Provide identification per Section 23 05 53.

3.3 EQUIPMENT START UP

- A. Equipment manufacturer to provide start-up.
- B. Install and make hook-up to float switches.
- C. Measure:
 - 1. Outside air temperature, entering and leaving conditions of evaporators and condensers, compressor amps, indoor blower amps, gas pressure, pressure drop across evaporator coil.
 - 2. Operate all units in heating and cooling modes with outside air in operation.
 - 3. Provide report with final request for payment.
 - 4. Install new, clean filters prior to test and balance.
 - 5. Provide connection to refrigeration piping system and evaporators.

END OF SECTION