23 05 01 BASIC HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 Special Note

A. All provisions of the Bidding Requirements, General Conditions, and Supplementary Conditions, including Divisions 00 and 01, apply to work specified in this Division.

B. The scope of the Division 23 work includes furnishing, installing, testing and warranty of all work and complete HVAC systems as shown on the mechanical drawings, and as specified in Division 23 and elsewhere in the project documents.

C. Understanding that the contractors for various Divisions are sub-contractors to the Prime Contractor, assignments of work by division are not intended to restrict the Prime Contractor in assignment of work among the contractors to accommodate trade agreements and practices or the normal conduct of the construction work. If there is a conflict of assigned work between Divisions 02 thru 33 and Divisions 00 and 01, Divisions 00 and 01 shall take precedence.

1.2 Permits and Regulations

A. Include payment of all permit and inspection fees applicable to the Division 23 work. Furnish for the Owner certificates of approval from the governing inspection agencies, as a condition for final payment.

B. Work must conform to applicable local, state and federal laws, ordinances and regulations. Where drawings or specifications exceed code requirements, the drawings and specifications shall govern. Install no work contrary to minimum legal standards.

1.3 Inspection of Site

A. Inspect the project site and the premises of the existing building. Conditions shall be compared with information shown on the drawings. Report immediately to Nexus Engineering Group any significant discrepancies which may be discovered. After the contract is signed, no allowance will be made for failure to have made a thorough inspection.

1.4 Drawings and Specifications

A. The drawings indicate the general arrangement of the work and are to be followed insofar as possible. The word "provide", as used, shall mean "furnish and install". If significant deviations from the layout are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to Nexus Engineering Group for approval before proceeding with the work.

B. Make all necessary field measurements to ensure correct fitting. Coordinate work with all other trades in such a manner as to cause a minimum of conflict or delay.

C. The drawings and specifications shall be carefully studied during the course of bidding and construction. Any errors, omissions or discrepancies encountered shall be referred immediately to Nexus Engineering Group for interpretation or correction, so that misunderstandings at a later date may be avoided. The contract drawings are not intended to show every vertical or horizontal offset which may be necessary to complete the systems. Having ductwork, pipe and fittings fabricated and delivered in advance of making actual measurements shall not be sufficient cause to avoid making offsets and minor changes as may be necessary to install ductwork, piping and equipment.

D. Nexus Engineering Group shall reserve the right to make minor adjustment in locations of system runs and components where considered desirable in the interest of concealing work or presenting a better appearance where exposed. Any such changes shall be anticipated and requested sufficiently in advance as to not cause extra work, or unduly delay the work. Coordinate work in advance with all other trades and report immediately any difficulties which can be anticipated.

E. Equipment, ductwork or piping shall not be installed in the dedicated electrical space above or in the working space required around electrical switchgear, motor control centers or panelboards as identified by the National Electric Code (NEC).

F. Where any system runs and components are so placed as to cause or contribute to a conflict, it shall be readjusted at the expense of the contractor causing such conflict. Nexus Engineering Group's decision shall be final in regard to the arrangement of ductwork, piping, etc., where conflict arises.

G. Provide offsets in system runs, additional fittings, necessary drains and minor valves, traps, dampers and devices required to complete the installation, or for the proper operation of the system. Exercise due and particular caution to determine that all parts of the work are made quickly and easily accessible.

H. Should overlap of work among the trades become evident, this shall be called to the attention of Nexus Engineering Group. In such event, none of the trades or their suppliers shall assume that they are relieved of the work which is specified under their branch until instructions in writing are received from Nexus Engineering Group.

1.5 Asbestos Materials

A. If, in the performance of the work, materials are observed which are suspected to contain asbestos, the Contractor shall immediately inform the Nexus Engineering Group who in turn will notify the Owner. Work that would expose workers to the inhalation of asbestos particles shall be terminated. Work may be resumed only after a determination has been made and unsafe materials have been removed or encapsulated and the area declared safe.

B. Material provided for work performed under Division 23 shall not contain asbestos.

1.6 Coordination Drawings

A. The Division 23 Contractor shall prepare and be responsible for 0.25inch scale electronic coordination drawings. These drawings shall be produced using a computer aided drafting software of a mutually agreed upon format with the Division 21, 22, 23, 26, 27 and 28 Contractors. Each Contractor shall prepare their own electronic drawings, using common backgrounds obtained from Nexus Engineering Group and Structural Engineer. The Division 23 Contractor shall be responsible for consolidating (merging) the drawings into combined coordination drawings, and lead the conflict resolution process, with all contractors working together to obtain finished coordinated drawings. No work shall be installed until all contractors have approved and signed-off with their approval, and drawings have been submitted and reviewed by the Engineer.

B. Review by the Engineer is cursory. It is the Contractors responsibilities to ensure that all work is coordinated, including fit above ceilings, and that specified ceiling heights are maintained.

C. In addition, submit separate "Sheet Metal Only" drawings for review by the Engineer.

1.7 Inspection

A. All work shall be subject to inspection of Federal, State and local agencies as may be appropriate, and of the Architect and Engineer.

B. Obtain final inspection certificates and turn over to the Owner.

1.8 Record Drawings

A. Maintain a separate set of field prints of the contract documents and hand mark all changes or variations, in a manner to be clearly discernible, which are made during construction and the coordination process. Upon completion of the work, and within 90 days of system acceptance, these drawings shall be turned over to Nexus Engineering Group. This shall apply particularly to underground and concealed work, and to other systems where the installation varies to a degree which would justify recording the change.

1.9 Operating and Maintenance Manuals

A. Assemble digital copies of operating and maintenance manuals for the HVAC work.

B. All “approved” shop drawings and installation, maintenance and operating instruction pamphlets or brochures, wiring diagrams, parts list and other information, along with warranties, shall be obtained from each manufacturer of the principal items of equipment. In addition, prepare and include a chart listing all items of equipment which are furnished under this contract, indicating the nature of maintenance required, the recommended frequency of checking these points and the type of lubricating media or replacement material required. Name and address of a qualified service agency. A complete narrative of how each system is intended to operate.

C. Final air balance reports and as-built automatic temperature controls drawings and specifications shall also be included.

D. The manuals shall be submitted to the Engineer for review. Upon approval, manuals shall be turned over to the Owner.

1.10 Warranty

A. Warrant all workmanship, equipment and material entering into this contract for a period of one (1) year from date of final acceptance or date of beneficial use, as agreed to between Contractor and Nexus Engineering Group. Any materials or equipment proving to be defective during the warranty period shall be made good without expense to the Owner. Use of equipment for temporary heating or cooling is not the start of the warranty period.

1. Certain items of equipment are specified to have multi-year parts and labor warranties. Refer to individual equipment specifications.

B. This provision is intended specifically to cover deficiencies in contract completion or performance which are not immediately discovered after systems are placed in operation. Also included shall be supplementary assistance in balancing, adjusting or providing operating instructions as the need develops, and replacing overload heater elements in starters where necessary to keep systems in operation. Heater element sizes shall not exceed the motor manufacturer's recommendations.

C. This provision shall not be construed to include maintenance items such as replacing filters, re-tightening or repacking glands, greasing, oiling, belt tightening and cleaning strainers after these have been done for final close-out.

D. Provisions of this warranty shall be considered supplementary to warranty provisions under Division 01 General Conditions.

PART 2 - PRODUCTS

2.1 Materials and Equipment

A. Materials and equipment furnished shall be in strict accordance with the specifications and drawings and shall be new and of best grade and quality. When two or more articles of the same material or equipment are required, they shall be of the same manufacturer.

2.2 Listing and Labeling

A. All equipment and appliances shall be listed and labeled in accordance with the Mechanical Code. Testing shall be performed by an Approved Agency, with the seal or mark of the Agency affixed to each piece of equipment or appliance.

2.3 Reference Standards

A. Where standards (NFPA, NEC, ASTM, UL, etc.) are referenced in the specifications or on the drawings, the latest edition is to be used except, however, where the Authority Having Jurisdiction has not yet adopted the latest edition, the edition so recognized shall be used.

2.4 Equipment Selection

A. The selection of materials and equipment to be furnished shall be governed by the following:

1. Where trade names, brands, or manufacturers of equipment or materials are listed in the specification, the exact equipment listed shall be furnished. Where more than one name is used, the contractor shall have the option of selecting between any one of the several specified. All products shall be first quality line of manufacturers listed.
2. Where the words "or approved equal" appear after a manufacturer's name, specific approval must be obtained from the Engineer during the bidding period in sufficient time to be included in an addendum. The same shall apply for equipment and materials not named in the specifications, where approval is sought.
3. Where the words "equal to" appear, followed by a manufacturer's name and sometimes a model or series designation, such designation is intended to establish quality level and standard features. Equal equipment by other manufacturers will be acceptable, subject to the Engineer's approval.

B. Substitute equipment of equal quality and capacity will only be considered when the listing of such is included as a separate item of the bid. State the deduction or addition in cost to that of the specified product.

C. Before bidding equipment, and again in the preparation of shop drawings, verify that adequate space is available for entry and installation of the item of equipment, including associated piping and accessories. Also verify that adequate space is available for servicing of the equipment.

D. If extensive changes in pipe, duct or equipment layout, electrical or control wiring, or equipment are brought about by the use of equipment which is not compatible with the layout shown on the drawings, necessary changes shall be deemed to be included in this contract, including other effected trades.

2.5 Shop Drawings

A. Electronic copies of shop drawings and descriptive information of equipment and materials shall be furnished. Submit to Nexus Engineering Group and/or Engineer for review as stated in the General Conditions and Supplementary Conditions. These shall be submitted as soon as practicable and before equipment is installed and before special equipment is manufactured. Submittal information shall clearly identify the manufacturer, specific model number, approval labels, performance data, electrical characteristics, features, specified options and additional information sufficient to evidence compliance with the contract documents. Product catalogs, brochures, etc. submitted without project specific items marked as being submitted for review will be rejected and returned without review. Shop drawings for equipment, fixtures, devices and materials shall be labeled and identified same as on the Contract Documents. If compliance with the above criteria is not provided shop drawings will be subject to rejection and returned without review. Samples shall be submitted when requested or as specified here with-in.

B. The review of shop drawings by Nexus Engineering Group or the Engineer shall not relieve the Contractor from responsibility for errors in the shop drawings. Deviations from specifications and drawing requirements shall be called to the Engineer's attention in a separate clearly stated notification at the time of submittal for the Engineer's review.

C. Shop drawings of the following HVAC equipment and materials shall be submitted:

1. Vibration isolators.
2. Piping insulation.
3. Ductwork insulation.
4. Ductwork.
5. Condensing unit.
6. Ductwork hangers and supports.
7. Rooftop heating and cooling units.
8. Fans.
9. Motor operated dampers.
10. Air outlets and inlets.
11. Automatic temperature control system.
12. Wind analysis.
13. Firestopping.
14. HVAC equipment and ductwork labeling.

PART 3 - EXECUTION

3.1 Pipe Testing

A. All piping provided in this work shall be tested, including all condensate drainage piping.

B. Pipe testing for HVAC piping shall be:

1. Condensate drainage piping, same as for plumbing drainage piping.
2. Refrigerant piping - refer to appropriate Refrigeration Sections.
3. Other piping - refer to appropriate Sections.

C. Testing shall be performed prior to application of insulation. Ensure that air is vented from piping when piping is hydrostatically tested.

D. Leaks discovered during testing shall not be patched. Threaded connections shall be either tightened or replaced. Small leaks in welded pipe may be chipped and rewelded.

3.2 Operation and Adjustment of Equipment

A. As each piping system and air distribution system is put into operation, all items of equipment included therein shall be adjusted to proper working order. This shall include balancing air and water systems, adjusting fan speeds, belts, pulleys, tightening packing glands, and adjusting all operating equipment.

B. Caution: Verify that all bearings are lubricated, all motors are operating in the right direction, and correct drive settings and overload heater elements are provided on all motors. Do not depend wholly on the electrician's judgment in these matters. Follow specific instructions in regard to lubrication. Do not oil or grease presealed ball bearings unless upon manufacturer's specific instructions.

3.3 Operating Demonstration and Instructions

A. Set the various systems into operation and demonstrate to the Owner and Engineer that the systems function properly and that the requirements of the Contract are fulfilled.

B. Provide the Owner's representatives with detailed explanations of operation and maintenance of equipment and systems. A thorough review of the operating and maintenance manuals shall be included in these instructional meetings.

C. O&M manuals shall be submitted, reviewed and approved prior to scheduling of demonstrations.

3.4 Spare Filters

A. Furnish one complete initial set of filters and one complete set of spare filters for each filter bank in the project. This is in addition to filters used for temporary heating.

END OF SECTION

23 05 02 A
ELECTRONIC FILES HEAPY RELEASE FORM TO CONTRACTORS

Project: Montauk Turkey Pilot

Owner: Montauk

Heapy Engineering Project Number: 2023-07014

Heapy Engineering Project Manager: Tim Krzywicki

The Provider, named below, will furnish the Recipient, named below, certain documents prepared by the Provider or its sub consultants in an electronic format. These documents are hereinafter collectively referred to as "Electronic Files". The Electronic Files are instruments of the Provider services performed solely for the Owner's benefit and to be used solely for this Project. The Provider does not represent that the information contained in the Electronic Files are suitable for use on any other project or for any other purpose. If the Electronic Files are used for any other project or purpose without the Provider's specific written permission, the risk of such use shall be assumed solely by the Recipient or other user.

Prior to the use of the Electronic Files the Provider and the Recipient agree to the following terms and conditions:

1. The Provider and Recipient fully understand that the data contained in these electronic files are part of the Provider’s Instruments of Service. The Provider shall be deemed the author of the drawings and data, and shall retain all common law, statutory law and other rights, including copyrights.

2. The Recipient confirms their request to the Provider for Electronic Files for the Project listed above, which the Recipient understands are to be provided only in accordance with, and conditioned upon, the terms and conditions of the Agreement and Waiver for Use of Electronic Files).

3. The Provider agrees that the Recipient may use the Electronic Files for the sole purpose of preparing shop drawings and/or coordination drawings for the above Project only. Any Electronic Files provided are strictly for the use of the Recipient in regard to the Project named above, and shall not be utilized for any other purpose or provided by the Recipient to any entity other than its subcontractors for the Project named above.

4. The Recipient acknowledges that the furnishing of Electronic Files in no way relieves the Recipient from the responsibility of shop drawings or other schedules as set forth in the Contract between the Contractor and the Owner.

5. The Recipient acknowledges:

    a. That the Electronic Files do not contain all of the information of the Bid Documents or Contract Documents for the construction of the Project above.

    b. That information in the Bid Documents or Contract Documents may be revised or modified in the future.

c. The Provider does not have, and will not have, any duty or obligation to advise or give notice to the Recipient of any such revisions or modifications.

d. That the Recipient agrees that its use of the Electronic Files is at the Recipient's sole risk of liability, and that the Recipient shall make no claim or demand of any kind against the Provider arising out of Recipient's receipt or use of the Electronic Files.

6. The Provider makes no representation or warranty of any kind, express or implied, with respect to the Electronic Files and specifically makes no warranty that the Electronic Files shall be merchantable or fit for any particular purpose, or accurate or complete. Furthermore, any description of said Electronic Files shall not be deemed to create an implied or express warranty that such Electronic Files shall conform to said description.

7. Due to the unsecured nature of the Electronic Files and the inability of the Provider or the Recipient to establish controls over their use, the Provider assumes no responsibility for any consequences arising out of the use of the data. It is the sole responsibility of the Recipient to check the validity of all information contained within the Electronic Files. The Recipient shall at all times refer to the Construction Documents of the project during all phases of the project. The Recipient shall assume all risks and liabilities resulting from the use of this data, and the Recipient agree(s) to waive any and all claims and liability against the Provider and its sub consultants resulting in any way from the use of the Electronic Files.

8. Electronic Files are provided strictly as a courtesy by the Provider solely for the convenience of the Recipient, and are not part of the Bid Documents or Contract Documents for the Project. The Electronic Files do not replace or supplement the paper copies of any drawings, specifications, or other documents included in the Contract Documents for use on the project.

    a. The Recipient assumes full responsibility in the use of Electronic Files, including the responsibility to see that all manual modifications, addenda, bulletins, clarifications and Change Orders to the drawings executed as a part of the Contract Documents have been incorporated.

9. As stated herein, the possibility exists that the Electronic Files provided may differ from the Bid Documents or Contract Documents for construction of the Project. The Provider shall not be responsible, nor be held responsible, for differences between Electronic Files, the Bid Documents, and Contract Documents. The Bid Documents or Contract Documents for the Project may be modified by the Provider at any time, either before or after construction begins. The Provider has no responsibility, either before or after any such modification, to determine or to advise the Recipient whether any such modification causes Electronic Files provided to the Recipient to be out of date, inconsistent with the Bid Documents or Contract Documents, or otherwise unsuitable or unfit for use in any way.

10. The Recipient assumes all risk and liability for any losses, damages, claims, or expenses (including defense and attorney fees) resulting from its receipt, use, or possession of Electronic Files furnished by the Provider. The Provider makes no representation, warranty or guarantee that the Electronic Files:

    a. Are suitable for any other usage or purpose.

    b. Have any particular durability.

    c. Will not damage or impair the Recipient's computer or software.

    d. Contain no errors or mechanical flaws or other discrepancies that may render them unsuitable for the purpose intended by the Recipient.

11. Recipient agrees to indemnify, defend and hold harmless the Provider, agents, employees, and the Owner from, and against, any and all claims, suits, losses, damages or costs, of any kind or nature, including attorney's fees, arising from or by reason of the Recipient's use of Electronic Files provided by the Provider, and such defense and indemnification obligation duties shall survive any use under this Agreement and Waiver for Use of Electronic Files.

12. The Recipient agrees that the Provider shall have no responsibility whatsoever for problems of any nature arising from transmitting and storing electronic files at a Recipient requested FTP or project management site or the conversion of the Electronic Files by the Recipient or others for use in non-native applications. The Provider will not provide Electronic Files in compressed formats. Recipient agrees to accept the files in the format provided by the Provider, and that Recipient's conversion or electronic file storage at the Recipient's requested site, shall be at Recipient's sole risk.

13. Recipient acknowledges:

    a. That the Electronic Files provided by the Provider are a graphical representation of the building in order to generate two-dimensional industry standard drawings.

    b. That the data contained in the Electronic Files may not be 100% accurate and should not be used for dimensional control, building layout, shop drawings, or any other similar purpose

    c. That any schedule of materials produced directly from the Electronic Files has not been checked for accuracy.

    d. That the information in the Electronic Files should be used only for comparative purposes and shall not be relied upon for accurate quantity estimates or used in establishing pricing.

14. Electronic Files provided by the Provider will only contain elements and content that the Provider deems necessary and appropriate to share. No specific Level of Development (LOD) is implied or expected. The Recipient agrees that no proprietary content, MvParts or Revit Families or any other AutoCAD MEP or Revit MEP content shall be removed from the model and/or used for any other purpose but to support this specific project.

15. The Provider, at its sole discretion, may modify the Electronic files before they are provided to the Recipient. Such modifications may include, but are not necessarily limited to, removal of certain information. The Provider, at its sole discretion, may refuse to provide some or all Electronic Files requested by Recipient.

16. The availability of Electronic Files that were not prepared by the Provider is subject to the consent of the Owner or consultant that prepared those Electronic Files. The Provider will not negotiate with the Owner or consultant or repeatedly solicit the Owner or consultant to obtain such consent. Neither this Agreement and Waiver for Use of Electronic Files nor any such separate Consultant's consent may be assigned or transferred by Recipient to any other person or entity.

    Provider (Name of Company): _____

    Recipient (Name of Company): _____

    Name of authorized Recipient Representative: _____

    Title of authorized Recipient Representative: _____

    E-mail address of authorized Recipient Representative: _____

    Signature of authorized Recipient Representative: _____

    Date: _____

    NOTE: Select requested Electronic File Format, File Transfer Medium and complete applicable Cost Summary.

    A. Electronic File Format (select one):

    1. ☐ .DWG Format - List of Drawings Requested: _____
    _____

    2. ☐ Revit Project Model Requested (Model only, no Views included)

    B. File Transfer Medium (select one):

    ☐ Heapy FTP ☐ User's FTP site ☐ Project FTP site (when available)

    C. Delivery of Electronic Files Cost Summary:

Available Electronic .DWG file format:
☐ 2023 DWG

If a different file version is required than the indicated available version state the requested version:

_____ .DWG
Note that an additional charge per sheet will be incurred.

Cost of Preparation of Division 23 Electronic .DWG Files:

First Drawing: $50.00 $50.00

Additional Drawings $15.00 each _____ x $15.00 = $ _____

Conversion to .DWG version different from available .DWG:
$5.00 additional/sheet _____ x $ 5.00 = $ _____

Total Cost: (Please make check payable to Heapy Engineering and include a copy of this form.)$ _____

All files will be bound together.

Available electronic Revit file format:

☐ 2023.RVT

Cost of Preparation of Division 23 Electronic Revit Model Files:

Revit Project Model without Views	$500.00

Total Cost: (Please make check payable to Heapy Engineering and include a copy of this form.)$ _____

_____

23 05 02 AGREEMENT AND WAIVER FOR USE OF ELECTRONIC FILES

PART 1 - GENERAL

1.1 The Engineer, at their sole discretion and without obligation, makes graphic portions of the contract documents available for use by the contractor in electronic format. These electronic files are proprietary, and remain the Engineer's Instruments of Service and shall be for use solely with respect to this project, as provided in the Standard Form of Agreement between Owner/Architect and Engineer.

1.2 Electronic files shall be released only after bids have been received for the project and contracts have been signed with the contractors.

1.3 The contractor shall acknowledge receipt of electronic files in the requested format for this project. The electronic files are provided as a convenience to the User, for use in preparing shop drawings and/or coordination drawings related to the construction of only the project identified in the Agreement. The electronic files and the information contained within are the property of the Engineer and/or the Architect and/or the Owner, and may not be reproduced or used in any format except in conjunction with the project identified in the Agreement.

1.4 The User acknowledges that the information provided in the electronic files is not a substitution or replacement for the Contract Documents and does not become a Contract Document. The User acknowledges that neither the Engineer, the Architect, the Consultants, the Client or the Owner make any warrant or representation that the information contained in the electronic files reflect the Contract Documents in their entirety. The User assumes full responsibility in the use of the electronic files, including the responsibility to see that all manual modifications, addenda, bulletins, clarifications and Change Orders to the drawings executed as a part of the Contract Documents have been incorporated.

1.5 The User acknowledges that the receipt of electronic files in no way relieves the User from the responsibility for the preparation of shop drawings or other schedules as set forth in the Contract between the Contractor and the Owner.

1.6 Electronic files are available in a .DWG or .RVT format for a cost as indicated in the Agreement and Waiver Form. **Providing the documents in a .DWG version that differs from the product version that the .DWG files were initially created in will incur additional charges per sheet, as indicated in the Agreement and Waiver Form.** Charges are for the Engineer's time to prepare the documents in the format stated. They are available through the Engineer's office on a C.O.D. basis only. A sample of the format will be provided by the Engineer upon request by the contractor, for the purpose of testing the compatibility of the format to the contractor's systems.

1.7 All drawings will be in an AutoCAD file format, when requested to be .DWG format.

1.8 All project models will be furnished without views.

1.9 All electronic files shall be stripped of the Project's name and address, the Architect's and Engineer's and any consultant's name and address, and any professional licenses indicated on the contract documents, (and all dimensions, verbiage, and statistical information). Use of these electronic files is solely at the contractor's risk, and shall in no way alter the contractor's Contract for Construction.

1.10 The User agrees to indemnify, hold harmless and defend the Engineer, the Architect, the Consultants, the Owner, the Client and any of their agents from any litigation resulting from the use of (by any means of reproduction or electronic media) these files. The Engineer makes no representation regarding fitness for any particular purpose, or suitability for use with any software or hardware, and shall not be responsible or liable for errors, defects, inexactitudes, or anomalies in the

data, information, or documents (including drawings and specifications) caused by the Engineer's or its consultant's computer software or hardware defects or errors; the Engineer's or its consultant's electronic or disk transmittal of data, information or documents; or the Engineer's or its consultant's reformatting or automated conversion of data, information or documents electronically or disk transmitted from the Engineer's consultants to the Engineer.

1.11 The contractor waives all claims against the Engineer, its employees, officers and consultants for any and all damages, losses, or expenses the contractor incurs from such defects or errors in the electronic files. Furthermore, the contractor shall indemnify, defend, and hold harmless the Engineer, and its consultants together with their respective employees and officers, harmless from and against any claims, suits, demands, causes of action, losses, damages or expenses (including all attorney's fees and litigation expenses) attributed to errors or defects in data, information or documents, including drawings and specifications, resulting from the contractor's distribution of electronic files to other contractors, persons, or entities.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 Attached "Agreement" shall be submitted with accompanying payment to the Engineer prior to delivery of electronic files.

END OF SECTION

23 05 04 BASIC HVAC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 Temporary Heating and Cooling

A. The temporary heating and cooling for construction is provided by the Contractor. Refer to Division 01 - General Requirements.

B. Fuel and electric costs attendant to temporary heating and cooling are not included in Division 23.

C. The use of the permanent HVAC systems for temporary heating and cooling during the latter stages of construction shall be allowed. Expedite completion of system as practicable to this end. Maintain the system during this period. Provide and maintain temporary air filters (same as specified permanent filters) to protect coils and ducts. Replace temporary filters with the clean specified filters when the systems are turned over to the Owner. Air filters specified for the systems and units, including specified spare filters, are not to be used for temporary service.

D. Cover all return duct openings with temporary MERV 8 filter media. Stop fans during heavy dust generating operations. Before turning the system over to the Owner, clean duct interiors and interior surfaces and components of the air handling equipment.

E. Warranty periods on equipment, materials and system shall commence upon Owner acceptance of the building or systems. Temporary heating or cooling use shall not jeopardize or alter the warranty requirements.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 Workmanship

A. Materials and equipment shall be installed and supported in a first-class and workmanlike manner by mechanics skilled in their particular trades. Workmanship shall be first-class in all respects, and the Engineer shall have the right to stop the work if highest quality workmanship is not maintained.

3.2 Protection

A. Each Contractor shall be entirely responsible for all material and equipment furnished in connection with their work. Special care shall be taken to properly protect all parts thereof from theft, damage or deterioration during the entire construction period in such a manner as may be necessary, or as directed by Nexus Engineering Group.

B. The Owner's property and the property of other contractors shall be respected at all times. Provide drop cloths and visqueen or similar barriers where dust and debris is generated, to protect adjacent areas.

3.3 Cutting and Patching

A. Refer to Division 01 - General Requirements and Special Conditions for information regarding cutting and patching.

B. Plan the work well ahead of the general construction. Where pipes and ducts are to pass thru new walls, partitions, floors, roof or ceilings, place sleeves in these elements or arrange with the General Trades to provide openings where sleeves are not practical. Where sleeves or openings have not been installed, cut holes and patch as required for the installation of this work, or pay other trades for doing this work when so directed by Nexus Engineering Group. Any damage caused to the building shall be repaired or rectified.

C. Where pipes and ducts are to pass thru, above or behind existing walls, partitions, floors, roof or ceiling, cutting, patching and refinishing of same shall be included in this contract. Core drilling and saw cutting shall be utilized where practical. Contractor to examine where floors and walls, etc. are to be cut for presence of existing utilities.

C. When cutting or core-drilling floor verify location of existing electrical, plumbing or steel reinforcement. Use X-ray method to verify existence of obstructions. Either re-route existing system brace floor or alter location of new work to maintain existing system.

D. All sleeves and openings not used or partially used shall be closed to prevent passage of smoke and fire.

E. All materials, methods and procedures used in patching and refinishing shall be in accordance with applicable provisions of specifications governing the various trades, and shall be completed by skilled workmen normally engaged in these trades. The final appearance and integrity of the patched and refinished areas must meet the approval of the Architect. Wall, floor and ceiling refinishing must extend to logical termination lines (entire ceiling of the room repainted, for instance), if an acceptable appearance cannot be attained by finishing a partial area.

F. Provide steel angle or channel lintels to span openings which are cut in existing jointed masonry walls where the opening span exceeds 16 inches. Provide framing around roof openings for required support of the roof deck.

G. Engage a Roofing Contractor on a subcontract basis for roofing and roof insulation work necessitated by the HVAC work. The Roofing Sub-Contractor shall be certified for installation and repair of the roofing system so as to maintain the existing roofing warranty.

3.4 Removals, Alterations and Reuse

A. Refer to the drawings for the scope of remodeling in the existing building.

B. Cooperate with all trades regarding all removal and remodeling work.

C. Materials and equipment which are removed shall not be reused within the scope of this project unless specifically noted to be relocated or reused. Turn over to the Owner and place where directed on the premises all removed material and equipment so designated by the Owner. All material and equipment not claimed by the Owner shall become the property of the Contractor responsible for removal and shall be removed from the premises.

D. Refinish any surface disturbed under this work to match existing, except where refinishing of that surface is included under the General Contract.

3.5 Painting

A. In addition to any painting specified for various individual items of equipment, the following painting shall be included:

1. Ferrous metal installed outside the building which is not factory or shop painted or galvanized shall be given a prime coat of paint and two finish coats of ultraviolet resistant paint.
2. Equipment and materials which have been factory or shop coated (prime or finished painted or galvanized), on which the finish has been damaged or has deteriorated, shall be cleaned and refinished equal to its original condition. The entire surface shall be repainted if a uniform appearance cannot be accomplished by touch up.
3. Apply Z.R.C. Galvilite cold galvanizing compound or approved equal, for touch-up of previously galvanized surfaces.

B. Paint, surface preparation and application shall conform to industry standards. All rust must be removed before application of paint.

C. Finish painting is included in the General Contract. Refer to the Cutting and Patching paragraph in this Section for finishing requirements.

3.6 Miscellaneous Equipment Connections

A. Certain categories of equipment require duct connections as shown on the drawings.

B. Make all final connections to these equipment, as indicated and in accordance with the manufacturer's recommendations.

3.7 Miscellaneous Component Installations

A. Certain miscellaneous items and components are furnished loose and require installation into the duct systems, piping systems, and other HVAC systems. These items shall be installed per the suppliers and manufacturers instructions.

B. This shall include, but by no means be limited to, items such as balancing dampers, backdraft dampers, motorized dampers, gravity dampers, fire and/or smoke dampers, sound attenuation products, control valves and components and other similar items.

C. Provide compatible connection means for all items being installed.

D. Provide bulb wells for temperature control equipment, and coordinate accordingly. Other types of control devices (dp switches, flow switches, flow meters, etc.) shall also be installed, with devices, needed fittings (tees, weldolets, threadolets, etc.), locations and installation details closely coordinated.

E. Provide all required access means (access doors, etc.) required for installation, service and inspection.

END OF SECTION

23 05 05 FIRESTOPPING

PART 1 - GENERAL

1.1 Firestopping assemblies shall be provided at penetrations of piping and non-fire dampered ducts thru fire rated floors, fire rated floor-ceiling and roof ceiling assemblies, fire rated walls and partitions and fire rated shaft walls and partitions. In addition, firestopping assemblies shall be provided at penetrations thru 0-hour rated floors. Refer to the drawings for fire rated building elements and HVAC drawings for pipe and duct layouts.

1.2 New piping and ductwork penetrating existing building elements shall be firestopped.

1.3 Firestopping assemblies shall be tested and rated in accordance with ASTM E814, E119 and listed in accordance with UL 1479, as published in the UL Fire Resistance Directory. Firestopping shall provide a fire rating equal to that of the construction being penetrated.

1.4 Firestopping materials, assemblies and installation shall conform to requirements of the code and the Authority Having Jurisdiction.

1.5 For those firestopping applications that exist for which no UL tested system is available through any manufacturer, a manufacturer's engineering judgment derived from similar UL system designs or other tests will be submitted to local authorities having jurisdiction for their review and approval prior to installation. Engineer judgment drawings must follow requirements set forth by the International Firestop Council.

1.6 Shop drawings shall be prepared and submitted for review and approval. Submittals shall include manufacturer's specifications and technical data of each material, documentation of U.L. firestopping assemblies and installation instructions. Submittals shall include all information required by the Building Code.

PART 2 - PRODUCTS

2.1 Firestopping materials shall be manufactured and/or supplied by Hilti, 3M, Tremco, or Specified Technologies Inc (STI).

2.2 Materials shall be in the form of caulk, putty, sealant, intumescent material, wrap strip, fire blocking, ceramic wool and other materials required for the UL listed assemblies. These shall be installed in conjunction with sleeves and materials for fill and damming.

2.3 Combination pre-set floor sleeve and firestopping assemblies shall be equal to Hilti CP 680.

PART 3 - EXECUTION

3.1 Installation of all materials and assemblies shall be in accordance with UL assembly drawings and the manufacturer's instructions.

3.2 Installation shall be done by an experienced installer who is certified, licensed or otherwise qualified by the firestopping manufacturer as having the necessary training and experience.

3.3 Firestopping shall not be installed at fire dampers that would impair the needed free expansion of damper, sleeve and retaining angles in a fire condition. Refer to the installation instructions of the fire damper manufacturer.

3.4 Refer to 23 31 13 HVAC Ductwork for duct sleeve requirements where firestopping is required.

END OF SECTION

23 05 07 PIPING MATERIALS AND METHODS

PART 1 - GENERAL

1.1 Piping materials and methods shall be as specified herein and as shown on the drawings.

1.2 Included in this section are:

A. Pipe, fittings and joining methods.

B. Unions and flanges.

C. Dielectric connectors.

D. Pipe sleeves, openings, curbing and escutcheons.

E. Installation methods of piping.

1.3 Refer to other Sections in Division 23 for selection of piping materials for the various services. Piping materials and installation methods peculiar to certain individual systems are specified in Sections related to those systems.

1.4 Refer to Section 23 05 05 Firestopping for firestopping requirements.

1.5 Welders shall be qualified and fully certified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications. Submit welder certifications for record.

1.6 Welding procedures and testing shall comply with ANSI Standard B31.1.0 - Standard Code for Pressure Piping, Power Piping and The American Welding Society Welding Handbook.

1.7 Where pipes penetrate walls and floors other than those required to be fire rated, the annular space between the sleeve, core drilling or opening and the pipe or pipe insulation shall be closed to retard the passage of smoke.

PART 2 - PRODUCTS

2.1 Copper tubing, conforming to ASTM B88, Standard Specification for Seamless Copper Water Tube and Fittings and Joints, shall be:

A. Type C4
Pipe - Type "L" seamless hard drawn copper tubing.
Fittings - wrought or cast DWV, solder ends, ASTM B16.
Joints - soldered with lead-free tin alloy, 95-5 tin-antimony or silver-bearing tin equal to Harris "Stay-Brite", "Stay-Brite 8" or "Bridgit".

2.2 Unions and flanges shall be:

A. Unions on copper tubing, all bronze construction 150 lb., solder ends.

2.3 Piping and conduits extending thru the roof may be fitted with a manufactured pipe curb weatherproofing assembly, with required curb cap and all associated boot accessories/clamps to form weathertight curb cap seal, constructed of heavy gauge galvanized steel with minimum 1.5” thick curb insulation and wood nailer, equal to Pate cpba. Provide curbs with cants where required by roofing contractor.

2.4 Pipe sleeves shall be:

A. Schedule 40 black steel pipe or 18 gauge galvanized steel in poured concrete floors, walls and roof decks.

B. 26 gauge galvanized sheet steel or Schedule 40 black steel pipe in other than poured concrete.

2.5 Escutcheon plates shall be split-ring chromium plated pressed steel. Plates shall be sized to cover the surface penetration and sleeve. Plates shall be installed on exposed piping in finished rooms and areas where pipes penetrate walls, floors, ceilings or overhead structure.

PART 3 - EXECUTION

3.1 Pipe and tubing shall be cut and fabricated to field measurements and run parallel to normal building lines. Pipe ends shall be cut square and ends reamed to remove burrs. The pipe interior shall be cleaned of foreign matter before erection of the pipe.

3.2 Piping shall be pitched for drainage. The low points shall be fitted with a 0.75 inches drain valve (with hose thread adapter if not piped to a floor drain) except that on piping 1.25 inches and smaller where a drain valve is not shown, a drain plug is acceptable. Hose thread adapters on drain valves of potable water piping shall be fitted with a non-removable vacuum breaker.

3.3 Piping shall be installed consistent with good piping practice and run concealed wherever possible. Coordinate with other trades to attain a workmanlike installation.

3.4 Piping shall be supported as specified in Section 23 05 29 Hangers and Supports for HVAC Piping. Pipe alignment in both the horizontal and vertical must be tightly maintained. Misalignment must be corrected to the satisfaction of the Engineer before insulation is applied and the system accepted.

3.5 Internals of sweat end valves shall be removed when damage or warping could occur due to applied heat of soldering. Where silver brazing is specified, solder connection of valves shall be used to reduce the danger of damage.

3.6 Close open ends of piping during installation to keep interior of the pipe clean.

3.7 Piping shall not be run above electrical switchgear or panelboards, nor above the access space in the immediate vicinity of the equipment, in accordance with the National Electric Code (NEC).

3.8 Unions and flanges shall be installed at pipe connections to fixtures and equipment and as required for erection purposes.

3.9 Pipe sleeves shall be placed, and structural footing relieving arch requirements shall be coordinated, in the initial stages of construction before concrete, masonry and other general construction activity. Means shall be taken to ensure that the sleeve will not move during or after construction. Beams, columns and other structural members shall not be sleeved except upon approval of the project Structural Engineer.

3.10 Length of wall sleeves shall be such that the sleeve ends are substantially flush with both sides of the wall or partition. Floor sleeves shall be flush with the bottom and top of the floor slab except, in mechanical rooms and other areas which might have water on the floor, sleeves shall project a minimum of 1 inch above finished floor. Pipe sleeves shall be sized to allow insulation to pass thru the sleeve, for insulation requiring continuous vapor barrier (domestic cold water, chilled water, refrigerant, etc.). Where vapor barrier continuity is not needed, the sleeve may be sized to pass

the pipe only or the insulation as well. Refer to the following paragraph for qualifications and exceptions relating to firestopping.Where firestopping is not required, the annular space between the sleeve, core drilling or opening and the pipe or pipe insulation shall be closed with caulking to retard the passage of smoke.

3.11 Refer to 23 05 05 Firestopping. Pipe sleeves which are a part of firestopping assemblies shall conform to the requirements of the assembly with particular emphasis regarding size, annular space, length, passage or non-passage of insulation and the installation of the sleeves.

3.12 Where firestopping is not required, the annular space between the sleeve, core drilling or opening and the pipe or pipe insulation shall be closed with caulking to retard the passage of smoke.

3.13 Cooling condensate drain piping shall be installed per details and equipment manufacturer's instructions. Horizontal runs shall be pitched to drain, constructed with DWV fittings, and provided with a clean-out every 50 LF of piping unless shown more frequently on the plans.

END OF SECTION

23 05 13 ELECTRICAL REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 Motors, starters, disconnects, devices, fuses, wiring and other electrical work included in Division 23 shall be factory installed or furnished and field installed as specified in the various specification sections and as shown on the drawings. Refer to the project documents for requirements related to each trade. Coordinate all aspects of electrical components and wiring to complete the systems.

1.2 Equipment control panels containing power control components shall be marked with the minimum SCCR rating. The rating shall not be less than the available fault current. Refer to the electrical drawings for the calculated available fault at the distribution panel, MCC or panelboard serving the equipment. Include confirmation of being protected from the fault current in the equipment shop drawing submittal.

1.3 Note: Equipment with Electronically Commutated Motors (ECM's) are sometimes factory programmed to limit current draw to the motor, to limit the available brake horsepower to better match specified performance and reduce required power circuiting. This reduced brake horsepower is likely below the motor's nameplate rating. The electrical design documents may be sized based on the ECM's nameplate motor horsepower. The equipment supplier shall notify the Division 23 and 26 contractors and the Engineer if the maximum overcurrent protection on the design documents differs from their selected equipment's nameplate data. Any required revisions to the electrical circuiting, including maximum over-current protection devices, shall be documented on the shop drawing submittal. The required revisions must be forwarded to the Division 26 contractor with enough time to adjust the over-current protection and the electric circuit installation. However, any additional cost associated with increased electrical feeder/breaker sizes or lack of coordination listed above shall be the Division 23 contractor's responsibility.

1.4 Refer to the Electrical drawings and verify adequacy of feeder size, sets of conductors and size, disconnecting means and other electrical requirements. Compare these to the requirements of the equipment to be furnished and report deficiencies and / or discrepancies to the Engineer in the bid period for resolution by addendum. Bear all costs for electrical changes where such issues are not properly resolved.

1.5 Equipment and devices shall comply with applicable standards of NEMA and shall be UL listed. All work shall comply with the National Electrical Code.

1.6 Electrical equipment, devices, fuses, wire, conduit and methods shall comply with applicable provisions of Division 26 - Electrical.

PART 2 - PRODUCTS

2.1 Motors

A. General purpose motors shall be induction type 1750 rpm NEMA Design "B" with copper windings, Class B or F insulation, and motor enclosure to suit the application. Service factor shall be 1.15 minimum.

B. Two-speed motors shall be two-winding type with six leads unless otherwise specified.

C. Motors for other than general duty application shall be furnished to suit the application and operating environment.

D. Premium efficiency motors shall be equal to Century "E + 3", General Electric "Energy Saver Premium Efficiency", Baldor "Super E Premium Efficient" or Reliance "Premium Energy

Efficient" series. Motor efficiencies shall be tested and conform to NEMA Standard Publication MG-1 and IEEE 112 Test Method B.

E. Motors used with Adjustable Frequency Motor Controllers (Variable Frequency Drives) shall be rated for inverter service in accordance with NEMA Standard Publication MG-1, Part 31 and designed with Class F or H insulation, but with a Class B temperature rise. Motors connected to VFD's shall be furnished with AEGIS SGR shaft grounding ring kit, installed by the equipment manufacturer.

F. Motor sizes shown on the drawings are to be considered minimum. Motors furnished shall be sized so as to not operate in the service factor range. Motors for direct driven pumps and fans shall be selected so as to not operate in the service factor range at any point on the curve.

G. Compare the electrical power requirements of the intended equipment with power feeders to the equipment shown on the Electrical drawings. Verify adequacy and compatibility of voltage, phase, wiring capacity, number and size of conductors (versus equipment connection points), maximum over-current protection, fusing and other information to that required for the equipment. If the selected equipment requires revision of the electrical, include any added cost to do so.

2.2 Magnetic starters shall comply with provisions of Division 26 - Electrical specifications and shall be NEMA construction (IEC rated not acceptable) with thermal overload element on each phase, 115 volt control voltage and hand-off-automatic switch, where appropriate. An integral control transformer shall be incorporated in the starter for each motor of 200 volt and greater. A single control transformer is acceptable for multiple motor packaged equipment, however, when such is the manufacturer's standard. Duplex type units (pumps, compressors, etc.) are not included in this exception. A control transformer shall be provided in each starter to ensure standby operating capability.

2.3 Wire and conduit shall comply with applicable provisions of Division 26 - Electrical specifications. Control wiring lighter than No. 12 AWG is acceptable where lesser ampacity will permit. All power and control wiring shall be overcurrent protected per the National Electric Code.

PART 3 - EXECUTION

3.1 Motor connections of factory assembled equipment shall be made with flexible conduit except for plug-in electric cord connections.

3.2 All power wiring shall be run in conduit. Control wiring shall be run in conduit except where open wiring is specified in the various sections.

3.3 Fuses shall be furnished and installed in fuse clips of equipment and switches.

END OF SECTION

23 05 14 ADJUSTABLE FREQUENCY MOTOR CONTROLLER

PART 1 - GENERAL

1.1 Provide a single enclosure adjustable frequency speed control package for induction motors where shown on the drawings and included in the Specifications with input power at the voltage and phase as scheduled on the drawings. The output power rating of the controller shall not be less than the full load rating of the motor, plus 5 percent. Controller shall be the latest design solid-state device, listed by UL, CSA or etc.

1.2 The adjustable frequency controller is to be PWM (pulse-width-modulated) design for motor voltage, current and frequency control. Impact three-phase AC line voltage is rectified to DC voltage for full conversion to near sensor output.

1.3 The supplier of the drives shall have factory trained service personnel on staff and shall submit documentation showing so with the shop drawings. Lack of documentation will result in unapproved shop drawings. The supplier shall also provide a 5-year parts and labor warranty, and a 5-year service contract for the supplied drives.

1.4 The drive shall have the same control logic board for all horsepower ratings. The 32-bit microprocessor will deliver the computing power necessary for complete three phase motor control.

1.5 The drive MTBF (Mean Time Between Failures) shall not be less than 20 years.

1.6 The term “Variable Frequency Drive”, “VFD”, “Variable Speed Drive” and other similar terms as used in Division 23 and on the drawings shall refer to Adjustable Frequency Motor Controller.

1.7 Motors connected to VFD’s shall comply with 23 05 13 Electrical Requirements for HVAC Equipment and shall be furnished with AEGIS SGR shaft grounding ring kit, installed by the equipment manufacturer.

1.8 Mechanical equipment, appliances and supports that are exposed to wind shall be designed and installed to resist the wind pressure determined in accordance with the building and mechanical code. Refer to specification 23 05 30 Bases and Supports for HVAC Equipment for additional requirements.

PART 2 - PRODUCTS

2.1 Manufacturers and Suppliers

A. Adjustable frequency motor controllers shall be manufactured by Yaskawa by Stoermer Anderson, ABB, Franklin Control Systems, Allen Bradley (1336 plus II), Mitsubishi, or Eaton.

B. Suppliers of adjustable frequency motor controllers must be an authorized service agent of the controller. Proof of this shall be provided with shop drawing submittals.

C. When adjustable frequency motor controllers are specified to be included in a factory-installed packaged system specified elsewhere in these specifications, the manufacturer of the controller is not limited to the acceptable manufacturers listed above. However, the supplier of the packaged system shall be an authorized service agent for the adjustable frequency motor controller being provided.

2.2 The controller shall be capable of varying its output in response to a remote 0 10 VDC or 4 20 mA signal, proportional to drive monitor functions. Provide controls mounted in face of the enclosure for the following functions:

A. Digital operator keypad and display, with copy function, provides local control and readout capability: Hand/Off/Auto, Speed Reference, and Reset commands.

B. Power On, Run on Drive, Run on Bypass (when bypass is specified), and Fault LED Pilot Lights.

C. Door mounted (face of cover) diagnostic indicator with touchpad interface shall incorporate:

1. Controller Run
2. Voltage to Motor
3. Current to Motor
4. Speed Indication in Hertz, Percent, RPM
5. KW
6. Elapsed Time Meter
7. Overtemperature
8. Overcurrent
9. Overfrequency
10. Overvoltage
11. Undervoltage
12. Motor Overload
13. Ground Fault
14. Short Circuit
15. Phase Loss
16. Control Circuit Fault

D. "Manual/Auto" speed control selector switch and manual speed adjustment with switches and indication on face of cover. Switch shall select control of motor speed from either the ATC system or the manual speed adjustment.

2.3 The controller shall include the following inputs and output functions at a labeled terminal strip. All inputs and outputs must be completely isolated from the analog reference signal:

Inputs

1. Remote/Local operation selection
2. Detection of external overheat condition
3. Preset speed selection
4. Serial communication selection
5. PI control disable
6. Run/Stop control
7. Fault reset
8. Manual/Remote speed reference
9. Speed Control Signal
10. External Trip Contact NO/NC
11. Freezestat Trip
12. Smoke Detector Trip

Outputs

1. Two (2) programmable multiple function output relays providing any two (2) of the following: zero speed detection, low and high frequency detection, missing frequency reference, overtorque/undertorque detection, serial communication status, or no load detection (broken belt alert).
2. Trip “Fault” (Form C Contact)
3. Output Frequency (0-10VDC)
4. Choice of Output Current, Voltage and Frequency

2.4 Speed control shall be linear from 10 to 100 percent of full speed. Both the minimum and maximum speed limits shall be adjustable. The controller output frequency shall not change as a result of up to a 10 percent input voltage fluctuation. The acceleration and deceleration rates shall be fully adjustable. Provide current limit function to avoid excessive automatic acceleration and deceleration when an overcurrent condition exists. The volts to hertz ratio shall be adjustable. Critical frequency rejection points shall be provided and shall be programmable, minimum of 3; deadband available.

2.5 The speed control output transistors are to be Insulated Gate Bipolar Transistor (IGBT) type for PWM design to facilitate a switching frequency of up to 12 kHz to eliminate the audible noise associated with PWM designs. The audible noise emitted from the motor must be within 5 db of the noise during across-the-line operations at all frequencies within the human audible spectrum (up to 12 kHz operating frequency). The drive must be selected for operation at or above 5 kHz without derating to satisfy the conditions for current, voltage or horsepower as shown on the drawings.

2.6 The controller shall permit disconnection of power from the input or output line voltage with the controller running under load without damage to the controller components. The controller shall be able to withstand an output line short (phase to phase or phase to ground) without damage to the controller components. Controller shall shut down on short circuit and detection of any of the following conditions: current 110 percent above rated current for 60 seconds; phase loss; input overvoltage and undervoltage; high internal temperature; ground fault and under frequency. Short circuit current rating (SCCR) shall not be less than 65,000 amps RMS, 100,000 amps RMS with link choke.

2.7 The controller shall have an automatic restart function to attempt restart after the unit trips off when power is lost to the unit. A time delay shall be provided between restarts. The unit shall not attempt to restart more than five times in the automatic mode. In addition, the controller shall have a power loss ride thru feature of at least 2 seconds (120 cycles) to prevent unnecessary trip out due to momentary input power interruptions.

2.8 The drive system (motor and controller) shall provide a minimum power factor of .95 at power input throughout the speed range, and a minimum efficiency (output to input line) of .82 at 100 percent speed and .70 at 50 percent speed.

2.9 The controller and any associated hardware shall be load tested at the controller manufacturer's plant prior to shipment.

2.10 The controller shall not create any feedback noise on the input line that will adversely affect electronic or microprocessor based equipment (such as computers or electron microscopes), and the controller shall not impress voltage or current spikes on the system. The minimum requirements shall conform to IEEE Standard 519, Special Applications for Line Notching and Distortion maximum 5 percent THVD at the point of connection to other building loads. The manufacturer shall provide at no additional cost any equipment to meet this requirement; i.e., A.C. line filters of the RLC type and/or isolation transformer, or both as required to meet full compliance with IEEE 519, if controller does not meet all standards.

2.11 Provide a 3 percent or 5 percent AC line reactor on all equipment that does not comply with the THVD requirements stated above.

2.12 Provide 5 percent output reactor and dv/dt filter where motor lead length is greater than 50 feet. Also provide terminations suitable for shielded output power cables.

2.13 The controller shall meet the requirements for Radio Frequency Interference (RFI) above 7 MHz per FCC regulations, Part 15, Subpart J for Class A devices.

2.14 The following additional functional features shall be provided for the controller:

A. Each controller shall be provided with a door interlocked disconnect means and semi-conductor rated fuses.

B. Input line circuit breaker – a main power circuit breaker shall be provided for input power. Door shall be interlocked and through-the-door breaker operating mechanism included. The breaker shall be able to be padlocked with the door open or closed. Breaker to be rated for short circuit current available.

C. Output Overload Relay - Provide an overload relay for motor protection with manual reset pushbutton, all inside the enclosure. Provide the proper size overload elements to match motor nameplate ratings before allowing the motors to be put into service. Provide overload for each motor where multiple motors are served by one controller.

D. NEMA 3R Enclosure – Controllers located outdoors or exposed to an unconditioned environment shall be provided in a ventilated and heated enclosure intended for outdoor use that will allow for operation down to -15 degF.

PART 3 - EXECUTION

3.1 Provide complete wiring diagrams for use in interfacing the BAS equipment. Also submit these diagrams with the shop drawings.

3.2 Wiring shall be in strict accordance with the manufacturer's recommendations. Provide the controller, all control and interlock wiring, and all set-up and commissioning. Coordinate power wiring requirements.

3.3 Each controller shall be mounted to a Unistrut frame where indicated on drawings. Provide 8 inches square by 0.375 inch painted steel base plate at floor below each vertical Unistrut channel to distribute weight on floor. Floor set controller shall be set on 4 inches high concrete base. Small units may be direct mounted to the air-handling unit casing when the AHU manufacturer approves such installation.

3.4 Controller shall be mounted on unistrut framing system.

3.5 Shielded VFD cable (see Specification section 26 05 19 Low-Voltage Electrical Power Conductors) shall be provided between drive and motor for entire length of motor lead.

3.6 Refer to "Identification" Paragraph for nameplate requirements.

3.7 Check full load ampere and service factor rating for each motor after installed and furnish the proper size overload heater elements to protect the motor.

3.8 Each controller shall be started up under the supervision of the manufacturer's representative. Start-up services shall consist of an initial start-up programming and check out of the drive for proper operation. After initial startup the representative shall meet with and work with the Contractor as part of commissioning the Automatic Temperature Control system, providing additional programming and control interface as directed. In addition to start up services, the manufacturer's representative shall provide a minimum of one (1), four hour training classes at the job site for Owner operation, maintenance and servicing.

END OF SECTION

23 05 29 HANGERS AND SUPPORTS FOR HVAC PIPING

PART 1 - GENERAL

1.1 All piping shall be supported from the building structure.

1.2 All products and assemblies installed with-in the building shall not exceed a maximum flame spread of 25 and a smoke development of 50 as established by UL 723 or ASTM E84 test methods. However, “discrete” combustible components as defined by the mechanical code may be UL 2043 listed in lieu of UL 723 or ASTM E84.

PART 2 - PRODUCTS

2.1 Manufacturers listed below are basis of design. Other applicable manufacturers are B-line, Erico, Fee, Mason and PHD.

2.2 Hangers for horizontal piping shall be equal to:

A. General service
   1. Clevis type. Anvil Fig. 260.
      a. Clevis type hangers with rollers, Anvil Fig. 181, for insulated piping systems where the length of the hanger rod between the top of the hanger and the attachment device is 3 inches or less, and where required elsewhere herein or on the drawings, to allow for expansion travel.

B. Uninsulated copper tubing
   1. Copper plated clevis type - Anvil Fig. CT-65 (or plastic-coated clevis).

2.3 Hanger Supports

A. Hanger Rods
   1. Hanger rods shall be solid steel, threaded end or all thread rod, of diameter listed below. A hanger attachment device (beam clamps, concrete inserts, etc.) and locking nuts at the hanger attachment shall be provided on each hanger. Locking nuts shall be provided at each clevis, trapeze and swivel ring type hanger.

Pipe Sizes	Min. Rod Dia.
2” and smaller	0.375"

2.4 Refer to Part 3 for Hanger rod and cabling attachment devices for attachment to the structure.

2.5 Pipe riser supports shall be as follows:

A. Riser clamps (for downward loads) on cold service piping (cold water, chilled water, refrigerant suction, etc.) - insulated pipe riser clamp assembly, Pipe Shields, Inc. E1000, with polyisocyanurate insulation, galvanized steel jacket, steel top thrust plates and steel riser clamps.

B. Riser clamps (for downward loads) on piping other than cold service - Anvil Fig. 261 except, on copper tubing, CT-121 (copper plated) or CT-121C (plastic coated).

2.6 Trapeze Hangers

A. General Service 3” pipe size and smaller.
   1. Trapeze Hangers with Piping Below may be used for one or more piping systems running in parallel except for steam and steam condensate piping systems.

a. Horizontal support members shall be Unistrut or Anvil galvanized steel type U-section(s) secured directly to the underside of structure or suspended from structure with two or more threaded hanger rods, all sized for minimum 3:1 safety factor of loads imposed, but no smaller than the specified rod size for the single largest pipe on the rack. Maximum spacing of trapeze hangers shall be based on the smallest pipe size on the rack. For piping suspended (not attached directly to the horizontal support members) hangers, rods, and cabling shall be in compliance with paragraphs 2.2 Hangers and 2.3 Hanger Supports above.
b. For piping clamped directly to the horizontal support members Anvil Strut Clamps may be used or equal by Unistrut.

2. Hangers and clamps for insulated piping systems shall be over-sized to surround the pipe insulation and include non-compressible insulation inserts and saddles as specified in 23 07 19 HVAC PIPE INSULATION or equals by Anvil. Trapeze hangers with Piping Above may be used for one or more piping systems running in parallel except for steam and steam condensate piping systems.
   a. Horizontal support members shall be Unistrut or Anvil galvanized steel type U-section(s) suspended from structure with threaded hanger rods, all sized for minimum 3:1 safety factor of loads imposed, but no smaller than the specified rod size for the single largest pipe on the rack. Maximum spacing of trapeze hangers shall be based on the smallest pipe size on the rack.
   b. For piping clamped directly to the horizontal support members, Anvil Strut Clamps may be used, or equal by Unistrut.
   c. Clamps for insulated piping systems shall be over-sized to surround the pipe insulation and include non-compressible insulation inserts and saddles as specified in "Insulation Inserts and Saddles" paragraph below.

2.7 Insulation Inserts and Saddles

A. Hangers on insulated horizontal piping shall be oversized to surround the pipe insulation. To protect the insulation from damage or inordinate compression due to concentrated weight, provide insulation inserts and shields as specified in 23 07 19 HVAC Pipe Insulation or equals by Anvil.

B. Insulation saddles (shields) shall be compatible with pipe insulation materials and thicknesses. Vapor barrier shall be continuous.

PART 3 - EXECUTION

3.1 Spacing of hangers and supports shall be as follows, unless otherwise shown on drawings:

1. Copper tubing (vertical) - at the base, at each floor level, and 10 ft. maximum spacing.

2. Copper tubing (horizontal) - 6 ft. spacing for tubing 1.25 inches size and smaller, 8 ft. spacing for 1.50 inches thru 2.5 inches sizes, 10 ft. spacing for tubing 3 inches size and larger.

3.2 Attachment of pipe hanger rods and cabling to the structure shall be with:

A. Beam clamps in steel construction equal to Anvil Figures 92, 93, 94 or 14. Provide anchoring where clamps are attached to sloping surfaces of beam flanges and where otherwise required to ensure permanent attachment.

B. Unistrut type channel support system may be utilized where a number of pipes are run parallel. Channel shall be pre-set or attached to the structure with inserts or clamps.

C. Attachment to steel deck is prohibited. Span from steel structural members with supplementary steel shapes where direct attachment to structural members is not practical. This does not apply to steel deck with concrete slab poured on the deck. Refer to A. and B. above.

D. Attachment to manufactured trusses, joists, purlins, and other engineered structural members and supports shall be done in strict accordance with the structural engineer's or manufacturer's recommendations. Refer to the architectural and structural drawings for type of engineered structural systems being used. Connections to these structural members shall be made with connection devices and methods approved by the structural engineer or manufacturer. Provide additional supports with supplemental steel shapes when spacing between structural members exceeds specified distances. In the case of existing trusses, the structural engineer must review and approve pipe hanger attachment methods.

3.3 Pipe hangers shall be adjusted to proper elevation, hanger rods set in a vertical position and locking nuts secured before pipe insulation is installed.

3.4 Extended legs of pipe riser clamps shall be shortened as needed to maintain concealment of the clamp within the pipe chase. Ensure that adequate support is still maintained.

3.5 Hanger and support assemblies which are not factory plated (galvanized or copper) and will remain exposed on completion of the project shall be painted before installation.

3.6 Do not bend hanger rod to set in vertical position. Use manufactured hanger rod attachments that swivel to allow the hanger rods to hang vertically, or provide supplemental steel attached to the building structure and standard hanger rod attachments to allow the hanger rods to hang vertically. Refer to Manufacturers Standardization Society (MSS) Standard MSS SP-58 on Materials, Design and Manufacturer for best practices on pipe hangers and supports.

END OF SECTION

23 05 30 BASES AND SUPPORTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 Equipment shall be supported on concrete bases, roof curbs and structural steel supports as shown on drawings or as specified. All bases, curbs and supports shall be included except as otherwise noted.

1.2 Wind Load Analysis

A. HVAC equipment, ductwork, piping, conduits, etc. exposed to wind shall have positive attachment to the building structure or ground to comply with wind load requirements of the building and mechanical codes.

B. Wind speed design shall be 120 MPH. Refer to structural drawings for additional design requirements.

C. The contractor shall retain a specialty consultant to perform wind load calculations in accordance with the code and additional requirements specified in this Section. A professional engineer experienced in wind load attachment design and installation and licensed in the state where the project is located shall be responsible for calculations, attachment selections and installation details.

D. The Wind Load Analysis consisting of attachment design, calculations, attachment selection, installation details including anchoring methods, fastener specifications, embedment and/or welded length, etc..shall be submitted for review and record. This submittal shall be signed and sealed by a professional engineer, as stated above. This submittal will become part of the project design calculations, included in the project records, and when required, will be submitted to the authority having jurisdiction.

E. The wind load attachment design shall clearly indicate the attachment points to the building structure and design forces in all horizontal and vertical axes at the attachment points. The wind load attachment engineer shall coordinate all attachments with the projects structural engineer of record, who shall verify the attachment methods and the ability of the building structure to accept the loads imposed.

F. The wind load attachment design shall be based on actual equipment data (dimensions, weight, center of gravity, etc.) obtained from submittals or the manufacturers. The equipment manufacturer shall verify that the attachment points on the equipment can accept the combination of wind load, weight, and other loads imposed.

G. At the project Engineer of Record's discretion, equipment submittals may not be approved until the Wind Load Analysis has been submitted. It is the contractor's responsibility to schedule and coordinate the process in a timely fashion, including follow-up Wind Analysis submittals for equipment approved pending a Wind Analysis submittal.

PART 2 - PRODUCTS

2.1 Support for equipment shall be by one or more of the following methods:

A. Concrete bases and pads with anchor bolts cast in place. Provide a 6" thick concrete pad that is minimum 4" wider than the equipment in each direction, formed on all sides and hand troweled to a smooth, dense finish with neatly chamfered corners. Large concrete pads on grade shall be constructed with reinforcing steel or reinforcing roadway mesh, and perimeter footers to below frost depth. Set anchor bolts as required for the equipment.

B. Structural steel angles, beams or channels, unistrut type channels or pipe. Supports shall be fabricated into a rigid framework with welded or bolted connections and cross bracing or sway bracing. Supports shall be set on slab with base plates, or attached to the building structure as required. Brackets for relatively lightweight equipment may be attached to the wall. Equipment shall be set on and attached to the framework.

C. Solid steel hanger rods supported from the structure above similar to pipe hangers. Provide sway bracing for equipment supported in this manner.

2.2 Provide exact dimensions, locations and other detail for the specific equipment provided that requires bases or supports. Set anchor bolts as required for the equipment.

2.3 Equipment roof supports shall be heavy gauge galvanized steel support curbs with base plate, continuous welded corner seams, integral raised cant to match roof insulation, internal insulation, wood nailer and counterflashing. Unless otherwise noted, top of curbs shall extend 12" above the finished roof surface, 18" above for intake applications. For sloped roofs, the curb shall have a built-in slope to match roof slope so that top of curb is level.

2.4 Refer to 23 34 00 HVAC Fans and 23 34 23 HVAC Gravity Roof Ventilators for requirements associated with that equipment.

PART 3 - EXECUTION

3.1 Roof support curbs shall be installed and leveled and secured to the roof deck/structure. Roof insulation and roofing shall be removed and repaired to maintain the integrity of the roofing system. Provide wood cant strips around the curb only if recommended for the roofing system.

3.2 Bracing and Attachment

A. All equipment and curbs exposed to wind shall be installed and attached to structure in strict accordance with the wind load attachment design provided by the engineer to conform with requirements of the Code and referenced standards and in strict accordance with the manufacturers written instructions.

B. No rigid connections between equipment and the building structure shall be made that would degrade noise and vibration control.

C. Coordinate work with other trades. When conflicts develop in installation, they shall be brought to the attention of all involved parties and a suitable solution must be determined.

D. Each manufacturer of equipment shall furnish a statement stamped by a professional engineer indicating that the equipment is designed and constructed to withstand wind loads required by the code. Statement shall be based on analysis, testing or experience data, and supporting documentation shall be available upon request.

3.3 Attachment to manufactured trusses, joists, purlins, and other engineered structural members and supports shall be done in strict accordance with the structural engineer's or manufacturer's recommendations. Refer to the architectural and structural drawings for type of engineered structural systems being used. Connections to these structural members shall be made with connection devices and methods approved by the structural engineer or manufacturer. Provide additional supports with supplemental steel shapes when spacing between structural members exceeds specified distances. In the case of existing trusses, the structural engineer must review and approve hanger attachment methods.

END OF SECTION

23 05 49 VIBRATION CONTROL FOR HVAC

PART 1 - GENERAL

1.1 Vibration isolators shall be provided at equipment as shown on the drawings and as herein specified.

1.2 The supplier of isolation equipment shall study the application, the equipment to be isolated and the structure. The supplier shall assume responsibility to determine required minimum deflections and optimum deflection characteristics accounting for dynamic and static forces.

PART 2 - PRODUCTS

2.1 Following is a description of the various types of isolators, bases and rails required. Catalog designations are those of Mason Industries.

Type A1
Ribbed or waffled neoprene pad. Series W.

Type B1
Neoprene-in-shear mount, double deflection. Series ND.

Type E1
Steel rails for equipment mounting with spring mounts. Series RSL.

Type J1
Hanger rod vibration isolator with combination steel spring and neoprene-in-shear isolators. Series 30N.

2.2 Springs shall have a minimum additional travel to solid equal to 30 percent of the rated deflection.

2.3 Vibration isolators under equipment outside subject to wind loading shall be furnished with integral vertical limit stops.

2.4 Vibration isolators installed outside shall be furnished weather-protected with springs PVC coated and other ferrous parts hot dip galvanized or cadmium plated.

2.5 Isolators shall be as manufactured by Mason Industries, Kinetics, Vibro-Acoustics, Amber Booth, or Vibration Eliminator. All isolators shall be of one manufacturer.

PART 3 - EXECUTION

3.1 Manufacturer's instructions shall be followed carefully in setting and adjusting vibration isolators. Ensure that no direct hard surface to surface contact exists. Fasten to the building structure as recommended by the isolation supplier.

3.2 Where electrical connections are made to equipment mounted on isolators, caution the Electrical Contractor to connect thru flexible conduits.

3.3 Refer to Section 23 05 29 Hangers and Supports for HVAC Piping for spring isolator sections in pipe hanger rods.

END OF SECTION

23 05 53 IDENTIFICATION OF HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 Identification of Division 23 equipment shall consist of equipment labeling and duct marking as specified hereinafter.

1.2 Each item of major equipment shall be labeled. This shall include air handling units, fans, condensers, and other similar equipment.

1.3 Pipe markings shall be applied to all piping.

1.4 Duct markings shall be applied to all ductwork.

1.5 Labels, tags and markers shall comply with ANSI A13.1 for lettering size, colors and length of color field.

1.6 Equipment and device identification specified in other sections shall be provided as a part of those requirements.

1.7 Submit product data noting materials, sizes and dimensions for identification systems.

PART 2 - PRODUCTS

2.1 Equipment labeling shall be either, or a mix, of the following:

A. Permanently attached engraved brass or plastic laminated signs with 2 inch high lettering. Signs on exterior equipment shall be brass.

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

2.2 Pipe markings shall be:

A. Plastic semi-rigid snap-on type, manufacturer's standard pre-printed color-coded pipe markers extending fully around the pipe and insulation.

B. Non-metallic piping that is insulated for plenum rating purposes shall be labeled with White letters on Brown background. Labeling shall state “INSULATION REQUIRED FOR PLENUM RATING – DO NOT REMOVE”.

C. On piping and insulation 6 inches and greater diameter, full band as specified above or strip-type markers fastened to the pipe or insulation with laminated or bonded application or by color-coded plastic tape not less than 1.50 inches wide, full circle at both ends of the marker.

D. Arrows for direction of flow provided integral with the pipe marker or separate at each marker.

2.3 Duct markings shall be laminated plastic color-coded pressure sensitive vinyl tape, 2.50 inches width, 3 mils minimum thickness. Identification shall include service (supply, return, exhaust, outside air) and direction of flow.

2.4 Duct access door and panel markings shall be similar to duct markings to identify the device (FIRE DAMPER, SMOKE DAMPER, FIRE/SMOKE DAMPER, CONTROL DAMPER, SMOKE DETECTOR, etc.).

2.5 Labels, markings and tags shall be manufactured by W.H. Brady, Seton, Allen, Kolbi, MSI or Industrial Safety Supply.

PART 3 - EXECUTION

3.1 Identification labeling, marking and tagging shall be applied after insulation and painting has been completed.

3.2 Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified or scheduled on drawings.

3.3 The Contractors shall coordinate labeling, marking and tagging to attain coordinated and consistent systems of identification.

3.4 Equipment labeling shall consist of unit designation as shown on the drawings.

3.5 Duct markers shall be placed:

A. At each piece of equipment.

B. At 25 ft. centers in mechanical rooms and concealed spaces, but at least once per room.

C. At 50 ft. centers in exposed finished areas, but at least once per room.

D. On mains at each branch take-off.

E. On duct access panels.

END OF SECTION

23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 Provide air balancing of the new systems. Balancing work shall be performed by qualified personnel of a member firm of the Associated Air Balance Council (AABC) or a member firm of the National Environmental Balancing Bureau (NEBB), who has no affiliation with the Contractor or any of its Sub-Contractors. Include a certification sheet signed and sealed by the certified testing and balancing authority. Include a list of instruments to be used for procedures, along with proof of calibration.

1.2 Methods, procedures, equipment, certifications, report forms and reporting information shall be in accordance with the standards of AABC or NEBB and latest edition of the SMACNA TAB Procedural Guide and industry practice.

1.3 During the bid period, call to attention any requirements for additional balancing dampers, test ports, gage cocks, thermometer wells, flow control devices, valves, balancing valves and fittings and manual volume dampers which are deemed necessary in addition to those shown on the drawings, and provide such so that proper balancing can be performed. Prior to installation of the systems, verify that the proper number and location of balancing devices are adequate for completion of the balancing work.

1.4 Prepare a balancing plan that includes strategies and step-by-step procedures. This plan should include a list of items that must be completed before balancing can proceed. Prepare a schedule to ensure adequate time for the balancing process and submit this schedule to the Nexus Engineering Group for review.

1.5 Refer to other Sections of Division 23 for requirements related to the balancing work.

1.6 Verify that all equipment start-up services have been completed before the beginning of any balancing work. After initial start-up has been completed, inform the balancer that the systems are operating properly, that all safety interlocks and protective devices are functioning, and the systems are ready to be balanced.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 Air Balance

A. Obtain job specific fan curves for each fan being balanced, new and existing, and include in report.

B. Record nameplate data from fan, motor, and air handling cabinet.

C. Record and measure fan and motor sheaves indicating number and size of belts along with center-to-center distances.

D. Test and record actual operating fan rpm.

E. Measure and record actual running amperage.

F. Each air supply, return, and exhaust system, when installation is completed, including the installation of clean filters, shall be set in operation for balancing. Determine the best location in main and branch ducts for accurate duct airflow measurements. Each air outlet and inlet device, item of equipment (fan coils, air control units, etc.), shall be balanced to the quantities listed on

the drawings within plus or minus 10 percent, except when more stringent requirements are required as defined below. Central fan systems (AHU's, exhaust fan systems, etc.) shall be balanced to within plus or minus 5%. Intended pressure relationships in areas required by recognized standards and practice shall be attained.

G. Adjust drive pulleys to attain fan speed required for the installed condition. Pulleys and belts of fixed drives and of adjustable drives not having sufficient adjustment range shall be changed out, at the direction of the balancer or Engineer, to obtain fan speed required for the installed condition. Labor /or materials required to make the recommended changes shall be included in Division 23.

H. Measure velocity reading across coils, filters, and dampers on the intake side of the fan. Include data in the report.

I. Coordinate with the Temperature Controls Installer in setting supply and return fan inlet vanes, variable frequency drives and outside air, return air and vent air dampers. Supply air systems shall have ampere reading measured in the full heating, full cooling and economizer modes to determine the maximum brake horsepower.

J. Witness all duct pressure and leakage tests. Refer to 23 31 13 and coordinate accordingly.

K. Total air quantities of the supply fan and the exhaust fan shall be determined by pitot tube traverse. Where impossible to take good pitot tube traverses of duct system, use total sum of terminal device air volume readings. Final settings of fan speeds shall be determined with variable speed drives at full speed.

L. Check airflow patterns from the outside-air louvers and dampers and the return and exhaust-air dampers, through the supply-fan discharge and mixing damper. Report any issues with stratification, poor mixing or short circuiting from one air stream to the other.

M. Check for airflow blockages.

N. Check for proper sealing of air-handling unit components. Report all issues in balancing report.

O. Check for proper sealing of air duct systems. Minor issues shall be reported in the balancing report. If a major issue is found, stop balancing work and report issue to the Engineer.

P. Balancing of air devices shall be done to provide adequate but not excessive pressure in the branch ducts to air devices. Dampers incorporated in air devices shall be used only as secondary balancing means when other branch dampers are provided.

Q. The report shall include, but not be limited to, fan curves, both actual and design fan cfm, rpm, brake HP, entering and leaving static pressures, motor data, voltage and amperage and drive information. System air flows by device, terminal, branch and system shall be reported.

In addition, a sketch shall be provided for each air system balanced or surveyed, depicting exact location that fan static pressure and fan CFM readings were taken, relative to fan inlet and discharge, and what duct accessories were in place near the reading location and between the reading location and the fan. The sketch shall also depict elbows and other duct transitions in place near the reading location and between the reading location and the fan. Air handling unit sketches shall depict all air path components with-in the unit, and static pressure readings across each item. Balance reports will be rejected without this information.

R. Mark equipment and balancing device setting with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-controls levers, and similar controls and devices, to show final setting.

3.2 An electronic copy of the final report shall be submitted to the Engineer for review and approval. An approved copy of the report shall be included in each set of operating and maintenance manuals.

3.3 Final Report contents: In addition to certified field report data, include the following:

A. Table of Contents with total number of pages defined for each section of the report.

B. Summary of Contents - include the following:

1. Indicated versus final performance.

2. Notable characteristics of systems.

3. Description of system operation sequence if it varies from the contract documents.

C. Nomenclature sheets for each item of equipment.

D. Notes to explain why certain final data in the body of reports varies from indicated values.

E. Fan Curves.

F. Manufacturers' test data.

END OF SECTION

23 07 13 DUCT INSULATION

PART 1 - GENERAL

1.1 All interior and exterior supply air, mixed air, and intake outside air ductwork and plenums shall be insulated unless specifically noted as “uninsulated” in the Duct Construction Schedule on the drawings, including ductwork in crawl spaces, attics, and buried under slab.

1.2 All interior and exterior return air ductwork and plenums shall be insulated unless specifically noted as “uninsulated” in the Duct Construction Schedule on the drawings, including ductwork in crawl spaces, and attics (when duct is above the roof insulation).

1.3 Unless noted otherwise below, exhaust and relief air ductwork shall be insulated from 24” upstream of the auto/backdraft damper to the point of exterior wall/roof penetration, or as noted on the Duct Construction Schedule on the drawings. Exterior exhaust air ductwork shall be insulated when noted on the Duct Construction Schedule.

1.4 Equipment and devices, accessories and stiffeners in insulated ductwork shall also be insulated. This includes but is not limited to external duct bracing and stiffeners, fire dampers, smoke dampers. The backside of supply air diffusers shall also be insulated to prevent condensation.

1.5 Required internal lining is indicated on the Duct Construction Schedule on the drawings. Refer to Section 23 31 13 - HVAC Ductwork and coordinate with the various trades.

1.6 Jacketing shall be provided on insulation located outside for weather protection.

1.7 Composite insulation assemblies shall meet UL 723 or ASTM E84 requirements and not exceed maximum flame spread of 25 and smoke development of 50, except as specifically allowed below, and “discrete” combustible components as defined by the mechanical code may be UL 2043 listed in lieu of UL 723 or ASTM E84. Identification of manufacturer, thermal resistance (R-value), flame spread and smoke-development shall be clearly marked on the exterior of the insulation at intervals as required by code.

1.8 Submittals

A. Submit product description, thermal characteristics and list of materials and thickness for each service and location.

B. Submit manufacturers published literature indicating proper installation procedures.

1.9 Delivery, Storage and Handling

A. Materials on site shall be stored in original factory packaging, labeled with manufacturer’s identification, including product density and thickness.

B. Protect insulation from weather and construction traffic, dirt, water, chemical and damage, in addition to storing in original wrapping.

PART 2 - PRODUCTS

2.1 Insulation shall be manufactured by Johns Manville, Owens Corning, Certainteed, Knauf, or Manson. Insulation for duct systems required to be insulated shall have a minimum installed R-value of 4.2 (at a 75 degrees F mean rating temperature) except as noted below:

Duct System	Minimum Installed R-Value

Supply air and return air located outdoors	R-6.0 (1)

Notes:
(1) Listed R-value may be a total R-value for internal insulation plus external insulation. Refer to Duct Construction Schedule on the drawings.

"Installed" R-value for blanket insulation is the calculated R-value with 25 percent compression. "Installed" R-value for board insulation is the published nominal R-value.

2.2 Insulation on concealed ductwork shall be fiberglass blanket insulation with factory applied reinforced foil and kraft paper vapor barrier jacket, minimum 1.50 inches thickness and 0.75 inch p.c.f. density, formaldehyde-free or GreenGuard Certified for low formaldehyde and VOC emissions.

2.3 Insulation on exposed ductwork shall be fiberglass board insulation with factory applied "all service" jacket with vapor barrier, minimum 2 inches thickness and 3 p.c.f. density, formaldehyde-free or GreenGuard Certified for low formaldehyde and VOC emissions.

2.4 Protective jacketing of outdoor ductwork systems and/or insulation systems shall be VentureClad 1577 CW series self-adhesive laminate, or equal by Foster Products. Finish and Color shall be Embossed Natural Aluminum (14.0 mils).

PART 3 - EXECUTION

3.1 Site Inspection

A. Before starting work, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of insulation materials and accessories can begin.

B. Verify that all insulation materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.

C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all insulation materials and accessories to be installed on the project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.2 Preparation

A. Ensure that all surfaces over which insulation is to be installed are clean and dry.

B. Ensure that insulation is clean, dry and in good mechanical condition with all factory-applied vapor or weather barriers intact and undamaged. Wet, dirty or damaged insulation shall not be acceptable for installation.

C. Ensure that pressure testing of ductwork and fittings has been completed prior to installing insulation.

3.3 Installation

A. Installation shall be done by tradesmen specializing in this work in strict accordance with manufacturer's recommendations.

B. Install all insulation materials and accessories in accordance with manufacturer's published instructions and recognized industry practices. External duct stiffeners and bracing shall be insulated same as for duct.

C. Board insulation with factory applied jacket shall be secured to the duct with weld pins and fasteners, 12 inches on center maximum. Vapor barrier jacket shall be lapped, stapled and sealed with adhesive and 3 inches wide ASJ pressure sensitive tape.

D. Maintain the integrity of factory-applied vapor barrier jacketing on all insulation, protecting it against puncture, tears or other damage. All staples used on cold insulation shall be coated with suitable sealant to maintain vapor barrier integrity.

E. External insulation on supply, exhaust, and return ductwork located outdoors shall be weatherprotected with field applied metal jacket. Tops of ducts shall be pitched to drain, and the jacket shall be firmly attached and secured, and over-lapping joints and seams shall be silicon caulked watertight. Longitudinal seams shall be located on the bottom.

F. Externally insulate the backsides of supply air devices that are mounted in ceilings and not internally insulated.

G. Self-adhesive laminate jacketing shall be installed in strict accordance with manufacturers instructions.

3.4 Protection

A. Advise as to requirements for protection of the insulation work during the remainder of the construction period, to avoid damage and deterioration of the finished insulation work.

B. Replace damaged insulation, which cannot be satisfactorily repaired, including insulation with vapor barrier damage and moisture-saturated insulation.

3.5 Safety Precautions

A. Employees shall be properly protected during installation of all insulation. Protection shall include proper attire when handling and applying insulation materials, and shall include (but not be limited to) disposable dust respirators, gloves, hard hats, and eye protection.

B. Conduct all job site operations in compliance with applicable provisions of the Occupational Safety and Health Act, as well as with all state and/or local safety and health codes and regulations that may apply to the work.

END OF SECTION

23 07 19 HVAC PIPE INSULATION

PART 1 - GENERAL

1.1 Piping systems shall be insulated as described below in their entirety, including pipe, fittings, unions, flanges, mechanical joint couplings, pump casings, air and/or dirt separators, valves, devices, specialties and all related items and equipment unless otherwise noted. Maintain access to covered P/T test ports, strainer caps, air vents, and similar accessories thru the use of removable and reusable caps, plugs and fittings.

1.2 Composite insulation assemblies shall not exceed maximum flame spread of 25 and smoke development of 50, except as specifically allowed below, as established by UL 723 or ASTM E84 test methods. However, "discrete" combustible components as defined by the mechanical code may be UL 2043 listed in lieu of UL 723 or ASTM E84.

1.3 The following HVAC piping shall be covered with insulation of thickness listed, to meet or exceed ASHRAE 90.1, latest publication:

Pipe System	.75" and smaller	1.0" to 1.25"	1.50" to 3"	4" to 6"	8" and larger
Cooling condensate drainage (1)	0.50"	0.50"	0.50"	0.50"	0.50"
Refrigerant suction	1"	1.50"	1.50"	1.50"	1.50"
Refrigerant liquid (2)	1"	1"	1"	1"	1"

Notes:
(1) Cooling condensate drainage – from cooling coil drain pans, associated floor drain sumps, traps and horizontal above ground piping to vertical stack (coordinate with plumbing).
(2) Insulate refrigerant liquid line when recommended or required by equipment manufacturer (such as for variable refrigerant volume / flow systems).

1.4 Submittals

A. Submit product description, thermal characteristics and list of materials and thickness for each service and location.

B. Submit manufacturers published literature indicating proper installation procedures.

1.5 Delivery, Storage and Handling

A. Materials on site shall be stored in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

B. Protect insulation from weather and construction traffic, dirt, water, chemical and damage in addition to storing in original wrapping.

PART 2 - PRODUCTS

2.1 Refrigerant piping and cooling condensate systems shall be insulated with closed cell elastomeric. Fiberglass is not permitted. Outdoor piping shall be jacketed as described below.

2.2 Closed cell elastomeric insulation for above grade use on systems operating at 200 degrees F and below and 6 inches or smaller pipe sizes shall be tubular closed cell pipe insulation, pre-slit longitudinally. Polyolefin insulation is not acceptable. Insulation shall be manufactured without the use of CFC's, HCFC's or HFC's. It shall meet ASTM C534 and also be formaldehyde free, low VOC, dust free, resistant to mold and mildew, and shall be 25/50 rated per ASTM E84. Thermal conductivity (k) shall be maximum 0.27 at 75 degrees mean rating temperature.

Closed cell elastomeric insulation shall be Armacell AP/Armaflex SS, K-Flex USA "Insul-Tube" or Aero Flex USA "Aerocel-SSPT". For systems operating at 180 degrees F or less, insulation shall utilize a self-sealing pressure sensitive closure system. Butt joints shall be sealed with Armaflex 520 BLV low VOC adhesive or equal. For systems operating between 180 degrees F and 200 degrees F, all joints and seams shall be sealed with Armaflex 520 BLV low VOC adhesive or equal.

For indoor systems, use shall be restricted to those systems requiring 2 inch thickness or less (due to 25/50 ASTM E-84 requirements).

Unless jacketed, for insulation located outside field paint with minimum 2 coats of an appropriate paint as recommended by the insulation manufacturer to prevent solar ultra-violet deterioration.

2.3 Fittings, valves, flanges and other devices, both exposed and concealed, requiring insulation shall be covered same thickness as pipe insulation with any of the following (except when removable insulation covers are specified):

A. For closed cell elastomeric insulation systems:

1. Miter cutting of tubular insulation using special tools and mitering devices; or
2. Oversized pipe insulation overlapped and shaped to conform to fitting, valve or device.

2.4 Hangers on insulated horizontal piping are to be oversized to surround the pipe insulation. To protect the insulation from damage or inordinate compression due to concentrated weight, the following shall be provided at each hanger:

A. Pipe 2 inches and smaller Equal to Anvil Fig. 168, 18 ga. sheet metal rib-lock shield with belled ends, 12 inches long.

B. Insulation saddles (shields) shall be compatible with pipe insulation materials and thicknesses. Vapor barrier shall be continuous.

2.5 For systems specified to have protective jacketing, jacketing shall be 0.016 inch aluminum with special Z-joint closure and factory supplied snap-straps. Joints and seams shall be sealed watertight.

PART 3 - EXECUTION

3.1 Site Inspection

A. Before starting work, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of insulation materials and accessories can begin.

B. Verify that all insulation materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.

C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all insulation materials and accessories to be installed on the

project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.2 Preparation

A. Ensure that all surfaces over which insulation is to be installed are clean and dry.

B. Ensure that insulation is clean, dry and in good mechanical condition with all factory-applied vapor or weather barriers intact and undamaged. Wet, dirty or damaged insulation shall not be acceptable for installation.

1. Due to condensation issues, fiberglass insulation shall not be installed until building is covered and conditioned.

C. Ensure that pressure testing of piping and fittings has been completed prior to installation.

3.3 Installation

A. Installation shall be done by tradesman specializing in insulation work in strict accordance with manufacturers' recommendations. Installers shall be factory trained and certified for the insulation systems being installed. Submit credentials upon request.

B. Install all insulation materials and accessories in accordance with manufacturer’s published instructions and recognized industry practices.

C. Install insulation on piping subsequent to installation of heat tracing and acceptance tests.

D. Overlap and seal all longitudinal joints. Staples and adhesive may be used as stated above. Tape and seal cross joints. Vapor barrier shall be continuous on insulation of all cold services. Vapor barrier type mastic shall be used where needed to maintain a vapor seal, including over staples.

E. Where insulation is terminated, insulation shall be beveled at 45 degrees and the beveled surface sealed with vapor barrier mastic. Except in ceiling spaces, PVC caps over straight cut ends which have been vapor sealed may be used in lieu of beveling.

F. Insulation on cold service piping shall be run thru floor and wall sleeves to maintain vapor barrier continuity. Insulation on other services may likewise be run continuous when sleeve size permits. Refer to the 23 05 07 Piping Materials and Methods for special considerations which must be given at fire rated wall and floor penetrations. Refer to Section 23 05 29 Hangers and Supports for HVAC Piping for non-compressible insulation or blocking material and sheet metal saddles required at pipe hangers. Refer to Section 23 05 23 General Duty Valves for HVAC Piping for valves requiring extended shaft necks. Provide insulation and vapor barrier on and around supports for pipe risers of services which require vapor seal so as to prevent sweating.

G. Provide removable insulation sections to cover parts of equipment which must be opened periodically or maintenance, and for cooling condensate piping clean-outs.

H. Items such as ASME stamp and manufacturers’ nameplates, may be left uninsulated unless omitting insulation would cause a condensation problem. When such is the case, appropriate tagging shall be provided to identify the presence of those items. Provide neatly beveled edges at interruptions of insulation.

3.4 Protection

A. Advise as to requirements for protection of the insulation work during the remainder of the construction period, to avoid damage and deterioration of the finished insulation work.

B. Replace damaged insulation, which cannot be satisfactorily repaired, including insulation with vapor barrier damage and moisture-saturated insulation.

3.5 Safety Precautions

A. Employees shall be properly protected during installation of all insulation. Protection shall include proper attire when handling and applying insulation materials and shall include (but not be limited to) disposable dust respirators, gloves, hard hats and eye protection.

B. Conduct all job site operations in compliance with applicable provisions of the Occupational Safety and Health Act, as well as with all state and/or local safety and health codes and regulations that may apply to the work.

3.6 Reinsulate piping where existing insulation has been damaged or removed in the performance of work in this project.

END OF SECTION

23 09 25 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 - GENERAL

1.1 This section describes all sensors, controllers, instruments, valves, actuators, devices, for use with the control system specified in Section 23 09 23 Building Automation System (BAS) for HVAC. All control devices (valves, dampers, actuators, etc.) shall be included.

1.2 Refer to the HVAC Drawings for sensor and device requirements.

1.3 All products used in the installation shall be new, currently under manufacture, and shall be applied in standard off the shelf products. This installation shall not be used as a test site for any new products unless explicitly approved by the Engineer in writing. Spare parts shall be available for at least 10 years after completion of this contract.

1.4 System shall conform to the following minimum standards over network connections:

A. Reporting Accuracy. System shall report values with the minimum end-to-end accuracy listed in Table 1.

B. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

TABLE 1: Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5ºC [±1ºF]
Ducted Air	±0.5ºC [±1ºF]
Outside Air	±1.0ºC [±2ºF]
Delta-T	±0.15ºC [±0.25ºF]
Relative Humidity	±5% RH (0 – 90% scale)
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized space)	±3% of full scale
Air Pressure (ducts)	±25 Pa [±0.1" w.g.]
Air Pressure (space)	±3 Pa [±0.01" w.g.]
Electrical (A, V, W, Power factor)	±1% of reading
(see Note 3)	

Notes:
(1) Accuracy applies to 10 percent - 100 percent of scale.
(2) For both absolute and differential pressure.
(3) Not including utility supplied meters.

TABLE 2: Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa [±0.2" w.g.]	0-1.5 kPa [0-6" w.g.]
	±3 Pa [±0.01" w.g.]	-25 to 25 Pa [-0.1 to 0.1" w.g.]
Airflow	±10% of full scale	
Space Temperature	±1.0ºC [±2.0ºF]	
Duct Temperature	±1.5ºC [±3.0ºF]	
Humidity	±5% RH	
Differential Enthalpy	±5 kJ/kg [±3 Btu/lb]	35 – 63 kJ/kg [20-36 Btu/lb]

PART 2 - PRODUCTS

2.1 Actuators And Operators

A. Electronic Actuators

1. Actuators shall include electronics to receive the digital controllers analog position signal and maintain the position through the use of positive position feedback. Torque of the actuator shall be the working pressures of the system for valves, the total static differential of an air system, plus 30 percent safety factors. Actuator shall be UL or other approved testing agency listed. Actuators shall be manufactured by Belimo Air Controls or approved equal.
2. Electronic actuators shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
3. Unless noted otherwise as “floating point control”, mechanical fail safe shall incorporate a spring-return mechanism to return to the device to its “normal” position on loss of power. Electronic fail safe shall incorporate an active balancing circuit to maintain equal charging rates among the Super Capacitors with a visual indication of the fail safe status on the actuator face with the power fail position field adjustable between 0 to 100 percent in 10 degree increments, an adjustable 0 – 10 second operational delay, and capable of changing the fail-safe position through an integrated switch without removing the mounted actuator.
4. All rotary spring-return actuators shall be capable of both clockwise and counter-clockwise spring-return operation. Linear actuators shall spring-return to the retracted position.
5. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range.
6. All 24 VAC/VDC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 8 W for DC applications. Actuators operating on 120 VAC or 230 VAC shall not require more than 11 VA.
7. All actuators shall have an external manual gear release to allow manual positioning of the device when the actuator is not powered. Spring-return actuators with more than 7 N•m [60 in-lb] torque capacity shall have a manual crank for this purpose.
8. Actuators shall be provided with a raceway fitting and a minimum 1m electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
9. Actuators shall be designed for a minimum of 60,000 full-stroke cycles at the actuator's rated torque.

2.2 Sensors And Transmitters

A. Any temperature or humidity sensing device mounted on an exterior wall shall be fitted with an insulated sub-base.

B. Binary Temperature Devices

1. Low-voltage space thermostats shall be 24 V, bimetal-operated type, concealed setpoint adjustment, 55 degrees F to 85 degrees F setpoint range, 2 degrees F maximum differential, and vented ABS plastic cover. Provide subbase with manual or automatic switching as required to perform the specified functions. Thermostats shall be single or multi-stage or modulating output as required to perform the functions specified.
2. Line-voltage space thermostats shall be bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type, or equivalent solid-state type, UL listed for electrical rating, concealed setpoint adjustment, 55 degrees F to 85 degrees F setpoint range, 2 degrees F maximum differential, and vented ABS plastic cover. Provide subbase with manual or automatic switching as required to perform the specified functions. Thermostats shall be single or multi-stage or modulating output as required to perform the functions specified.
3. Low-limit thermostats (freezestats). Low-limit airstream thermostats shall be UL listed, vapor pressure type or electronic type, with an element 20 ft. minimum length. Element shall cover the face of the coil at 1 ft. centers in a horizontal serpentine fashion and shall respond to the lowest temperature sensed by any 1 ft. section. When one freezestat cannot meet this requirement provide multiple freezestats. Unless noted otherwise, low-limit thermostats shall be manual reset type. Freezestats shall be supplied as DPST with one (1) set of normally closed contacts wired directly to fan circuit and one (1) set of normally open contacts to provide an alarm to the BAS.

C. Temperature Sensors

1. Temperature sensors shall be thermistors and be suitable for the application. Where feasible, provide the same sensor type throughout the project. Avoid using transmitters unless absolutely necessary. Sensor accuracy over the application range shall be 0.36 degree F or less between 32 to 150 degrees F. Stability error of the thermistor over five years shall not exceed 0.25 degree F cumulative. A/D conversion resolution error shall be kept to 0.1 degree F. Total error for a thermistor circuit shall not exceed 0.5 degree F.
2. Duct sensors shall be single point or averaging as shown or specified. Averaging sensors shall be a minimum of 5 feet in length per 10 sq. ft. of duct cross section. Mixed air and discharge air sensors shall be averaging type.
3. Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. The well must withstand the flow velocities in the pipe.
4. Space sensors shall be equipped with setpoint adjustment, occupancy mode override switch, display, and communication port. Thermostat cover shall be rectangular high impact ABS plastic (or equal) in a neutral cover.
5. Provide matched temperature sensors for differential temperature measurement.
6. Outdoor temperature sensors shall be platinum type and have a minimum accuracy of ± 0.5 degrees F from -40 degrees F to 140 degrees F and a measuring range from -20 degrees F to 120 degrees F. Outdoor temperature sensors shall be mounted on the north side of the building within a ventilated enclosure that protects the sensor from thermal building mass biasing, solar radiation and precipitation without affecting performance.

D. Humidity Sensors

1. Duct and room sensors shall have a sensing range of 20 percent to 80 percent. Accuracy shall be ± 5 percent of range. Accuracy shall be as stated in paragraph 1.4.
2. Duct sensors shall be provided with a sampling chamber.

3. Outdoor air humidity sensors shall have a sensing range of 0 percent to 100 percent RH. Accuracy shall be ± 5 percent of range. Accuracy shall be as stated in paragraph 1.4. They shall be suitable for ambient conditions of -40 degrees F to 140 degrees F. Outdoor humidity sensor shall be within a ventilated enclosure that protects the sensor from thermal building mass biasing, solar radiation and precipitation without affecting performance.
4. Humidity sensor's drift shall not exceed 1 percent of full scale per year.

E. Relays

1. Control relays shall be UL Listed plug-in type with dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
2. Time delay relays shall be UL Listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable ±200 percent (minimum) from setpoint shown on plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA enclosure suitable for location when not installed in local control panel.

F. Override Timers

1. Override timers shall be electronic UL Listed, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated type with LCD display unless otherwise specified.

G. Current Transformers

1. AC current transformers shall be UL/CSA recognized and completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for ±1 percent accuracy at 5 A full scale output.
3. Transformers shall be split-core type for installation on new or existing wiring.

H. Voltage Transmitters

1. AC voltage transmitters shall be self-powered single loop (two-wire) type, 4 to 20 mA output with zero and span adjustment.
2. Ranges shall include 100 to 130 VAC, 200 to 250 VAC, 250 to 330 VAC, and 400 to 600 VAC full-scale, adjustable, with ±1 percent full-scale accuracy with 500 ohm maximum burden.
3. Transmitters shall be UL/CSA recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1 requirements.

I. Control Transformers

1. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish overcurrent protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

J. DC Power Supply

1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in overvoltage and overcurrent protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.
a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC

Class B and VDE 0871 for Class B and MIL-STD 810C for shock and vibration. Line voltage AC input Class 1 (120 VAC or greater) units shall have UL recognition and/or CSA listing.

K. Surge and Transient Protection

1. Provide each digital controller with surge and transient power protection. Surge and transient protection shall consist of the following devices, installed externally to the controllers.
2. Power Line Surge Protection
   a. Provide surge suppressors on the incoming power at each controller or grouped terminal controllers. Surge suppressors shall be rated in accordance with UL 1449, have a fault indicating light, and conform to the following:
      1) The device shall be a transient voltage surge suppressor, hard-wire type individual equipment protector for 120 VAC/1 phase/2 wire plus ground.
      2) The device shall react within 5 nanoseconds and automatically reset.
      3) The voltage protection threshold, line to neutral, shall be no more than 211 volts.
      4) The device shall have an independent secondary stage equal to or greater than the primary stage joule rating.
      5) The primary suppression system components shall be pure silicon avalanche diodes.
      6) The secondary suppression system components shall be silicon avalanche diodes or metal oxide varistors.
      7) The device shall have an indication light to indicate the protection components are functioning.
      8) All system functions of the transient suppression system shall be individually fused and not short circuit the AC power line at any time.
      9) The device shall have an EMI/RFI noise filter with a minimum attenuation of 13 dB at 10 kHz to 300 MHz.
      10) The device shall comply with IEEE C62.41, Class "B" requirements and be tested according to IEEE C62.45.
      11) The device shall be capable of operating between -20 degrees F and +122 degrees F.
3. Telephone and Communication Line Surge Protection
   a. Provide surge and transient protection for DDC controllers and BAS network related devices connected to phone and network communication lines, in accordance with the following:
      1) The device shall provide continuous, non-interrupting protection, and shall automatically reset after safely eliminating transient surges.
      2) The protection shall react within 5 nanoseconds using only solid-state silicon avalanche technology.
      3) The device shall be installed at the distance recommended by its manufacturer.
4. Controller Input/Output Protection
   a. Provide controller inputs and outputs with surge protection via optical isolation, metal oxide varistors (MOV), or silicon avalanche devices. Fuses are not permitted for surge protection.

L. Current-Operated Switches and Relays

1. Current-operated switches and relays shall be self-powered, solid-state with adjustable trip current. The switches and relays shall be selected to match the current of the motor application and output requirements of the BAS.
2. Current switches and relays for fan or pump proof shall be fully adjustable and shall have L.E.D. indicators. Form "A" (normally open) relays shall not be polarity sensitive.

   a. For motors controlled by VFD's, the current switches and relays shall accommodate variable frequency drive (VFD) outputs down to 6 HZ without contact chatter, with an

adjustability range compatible with the motor application and operation. VFD motor loads of less than 1.5 amps may be multi-wound around current relay to increase "sensed" amperage to minimum setpoint for activation.

b. For EC Motors, the current switches and relays shall be specifically manufactured for EC Motors, and adjustable to accommodate the motor's "keep alive current". Coordinate switch and relay selection with the equipment and motor vendors.

M. Pressure transducers

1. Transducer shall have linear output signal. Zero and span shall be field adjustable.
2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50 percent greater than calibrated span without damage.
3. Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 1 - 5vdc or 4 to 20 mA output, required mounting brackets, and block and bleed valves.
4. Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 1 – 5vdc or 4 to 20 mA output, required mounting brackets, and five-valve manifold.
5. Air velocity pressure sensors shall use differential pressure to determine airflow rate and have repeatability within 1 percent of reading and an accuracy of ± 5 percent of range. The velocity range shall be from 0 to 3250 FPM.

N. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application, or as shown.

O. Local control panels

1. All indoor control cabinets shall be fully enclosed NEMA construction, suitable to the installed location, with [hinged door], key-lock latch, removable sub-panels. A single key shall be common to all field panels and sub-panels. Panels shall be unitized design for transducers, relays, gauges, etc.
2. Interconnections between internal and face-mounted devices pre-wired with color coded stranded conductors neatly installed in plastic troughs and/or tie wrapped. Terminals for field connections shall be UL Listed for 600 volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
3. Provide ON/OFF power switch with overcurrent protection for control power source to each local panel.
4. Provide 120V receptacle at each local panel location.

2.3 Control Dampers

A. Control dampers shall be parallel or opposed blade type as specified below or as scheduled or detailed on drawings.

1. Unless otherwise shown on drawings as opposed blade, outdoor / return air mixing dampers shall be parallel blade, arranged to direct air-streams toward each other.
2. Relief air and other modulating dampers shall be opposed blade type where modulating operation is required of the dampers.
3. Two-position shutoff dampers may be parallel or opposed blade type with blade and side seals.
4. Dampers shall be made to required / specified size without blanking off free area.
5. Outside air dampers and relief air dampers shall be spring return normally closed. Return air dampers shall be spring return normally open.

B. Frames shall be 4 inches x 1 inch x .080 inch (minimum) 6063T5 extruded aluminum hat channel with mounting flanges on both sides of the frame. Each corner shall be reinforced for maximum rigidity.

C. Blades shall be airfoil type 6063T5 extruded aluminum (maximum 6 inches depth) with integral structural reinforcing tube running full length of each blade.

D. Bearings shall be maintenance free and made of a resin-polycarbonate combination.

E. Seals shall be silicone type on all dampers exposed to outdoor air condition (outside air, relief air and dampers directly behind louvers). Seals on all other dampers shall be TPE/EPDM. Adhesive or clip-on type blade seals are not acceptable. Blade seals shall be field replaceable.

F. Individual damper sections shall not be larger than 48 inches x 60 inches. Provide a minimum of one damper actuator per section.

G. Linkage hardware shall be installed in the frame side and constructed of aluminum and corrosion-resistant, zinc-plated steel, complete with cup-point trunnion screws. Linkage attached to blade faces are not acceptable.

H. Axles shall be hexagonal (round not acceptable) to provide positive locking connection to blades and linkage.

I. Submittal shall include leakage, maximum airflow and maximum pressure ratings based on AMCA Publication 500. Dampers shall be tested and certified in accordance with AMCA 511 for Air Performance and Air Leakage. Parallel blade dampers shall be selected with a damper characteristic ratio of 2.5. Opposed blade dampers shall be selected with a damper characteristic ratio of 10. Include approach velocity, correction factor, pressure drop at 1500 fpm, and free area ratio on damper submittal.

J. Provide a damper operator for each panel. No jack shafting is permitted. Damper provided for direct coupled actuators shall have extended shafts.

K. Outside air and relief air dampers shall be insulated and thermally broken with an air leakage rating not to exceed 8 cfm/sq. ft. at 4 inches differential static pressure. Damper shall be a Tamco Series 9000 SC, Ruskin TED50 Series, Greenheck ICD or approved equal.

L. Return air and other control dampers shall be aluminum air foil and frame construction. Leakage rate shall not exceed 8 cfm/sq. ft. at 4 inches differential static pressure. Dampers shall be a Tamco Series 1000, Ruskin CD-50, Greenheck VCD or approved equal.

PART 3 - EXECUTION

3.1 Examination

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the Engineer for resolution before rough-in work is started.

B. Inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the Engineer for resolution before rough-in work is started.

C. Examine the project drawings and specifications. If head room or space conditions appear inadequate, or if any discrepancies occur between the plans and the temperature controls work and the plans and the work of others, then report these discrepancies to the Engineer and obtain

written instructions for any changes necessary to accommodate the temperature controls work with the work of others. Any changes in the work made necessary by the failure or neglect to report such discrepancies shall be made by and costs borne by this Contractor.

3.2 Installation Of Sensors

A. Install all sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

E. Mixed air temperature sensors shall be located a minimum of 12 inches in front of 1st downstream coil (to prevent false reading of M.A.T.).

F. Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across face area. Each bend shall be supported with a capillary clip.

G. Low limit thermostats (freezestats) shall be installed in a serpentine manner horizontally across the coil face at 1 ft. centers. Each bend shall be supported with a capillary clip. Provide minimum 1 ft. of sensing element for each 1 ft. of coil area. Freezestat controller shall be located outside of airstream and installed in strict accordance with manufacturer's instructions. For freezestats with auto-reset (refer to para 2.2-B.3 or control sequences), provide indoor NEMA 1 panel to house latching control relay, with reset button and light on face of panel. The latching relay shall have separate contacts for latching circuit (N.O.), AHU / fan safety circuits (N.C.) and DDC alarm input (N.O.). The circuit shall be arranged to automatically reset after power failure. For outdoor units, mount panel in mechanical room. For indoor units, mount panel on or near associated AHU.

H. Install outdoor air temperature sensors on north wall complete with sun shield at designated location.

I. Differential Air Static Pressure

1. Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable), or to the location of the duct high-pressure tap and leave open to the plenum.
2. Return Duct Static Pressure: Pipe the low-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor.
3. Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover at the specified location. Outdoor air pressure sensing points shall be located on each side of the building and piped together in a common manifold.
4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.

5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.

3.3 Actuators

A. Mount and link control damper actuators per manufacturer's instructions.

1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5 degrees open position, manually close the damper, and then tighten the linkage.
2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
3. Provide all mounting hardware and linkages for actuator installation.
4. Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5 degrees available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.
5. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.4 Local Control Panels

A. Local control panels shall be provided for the equipment being controlled. Panel shall be mounted in mechanical, electrical rooms or electrical closets. Mount panels on wall, columns or independent supports near each respective unit. Do not mount on the unit proper unless the unit has internal jam isolation and the control panel and unit have been designed for direct mounting.

3.5 Identification of Hardware and Wiring

A. All wiring and cabling, including that within factory fabricated panels, shall be labeled at each end within 2 inches of termination with the DDC address or termination number.

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

C. Identify control panels with minimum 0.50 inch letters on laminated plastic nameplates.

D. Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.

E. Identify room sensors relating to terminal box or valves with nameplates.

F. Manufacturers' nameplates.

G. Identifiers shall match record documents.

H. Upon completion of the project, furnish a complete set of these drawings and diagrams, framed under clear plastic, and hang on the wall of the Mechanical Equipment Room where directed.

END OF SECTION

23 09 47 CONTROL POWER AND WIRING FOR HVAC

PART 1 - GENERAL

1.1 Provide all electrical wiring, both line voltage and low voltage, which is required to perform the automatic control functions.

1.2 Where power sources are required beyond sources explicitly shown on the Division 26 drawings, these shall be provided under the Division 23 Contract. Where auxiliary contacts are required on starters to perform the required functions these, too, shall be provided under the Division 23 Contract. Where not provided under Division 26, auxiliary external relays may be provided in lieu of auxiliary contacts.

1.3 Wiring, both line and low voltage, shall comply with The National Electric Code (NEC) and shall be subject to approval of the local code enforcing authorities.

1.4 Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

1.5 Install all equipment in readily accessible locations as defined by the National Electrical Code (NEC).

1.6 Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

1.7 All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

1.8 Provide tagging or labeling of conduit so that it is always readily observable which conduit was installed or used in implementation of this Work.

1.9 All wiring and cabling, including that within factory fabricated panels, shall be labeled at each end within 5 cm [2 inches] of termination with the DDC address or termination number.

1.10 Communication conduits shall not be installed closer than six feet from high power transformers or run parallel within six feet of electrical high power cables. Care shall be taken to route the cable as far from interference generating devices as possible. Where communication wire must cross high power wire (deemed as 110VAC or greater) it must do so at right angles.

1.11 All shields shall be grounded (earth ground) at one point only to eliminate ground loops. All shield grounding shall be done at the controller location with the shield at the sensor/device end of the applicable wire being left long and “safed” off in an appropriate manner.

1.12 There shall be no power wiring, in excess of 30 VAC rms, run in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, all communication wiring and signal wiring shall be run using separate twisted pairs (24awg) in accordance with the manufacturer’s wiring practices.

PART 2 - PRODUCTS

2.1 Wire, conduit and installation methods shall conform to applicable provisions of Division 26 - Electrical except that wiring smaller than No. 12 and conduit smaller than 0.75 inch are permitted as appropriate for the application.

2.2 Communication wire shall meet the following requirements as a minimum. Control system manufacturers recommendations which exceed these requirements shall govern.

A. Category 6 plenum rated, 4 twisted pair, non-shielded (UTP) station cable (capable of transmission speeds up to 100 Mb/s) shall be used for control system networking. Cable shall be insulated with FEP material and sequentially marked at 2 foot intervals. Color as selected by Owner.

Gauge	24 AWG
Nominal O.D.	.17 in.
Min. Bend Radius	.5 in.
Standards/Certification	UL 444, UL 13 EIA/TIA 568, Cat. 5 PN-2841
DC Resistance	9.38 ohm/100 m
Maximum mutual capacitance of a pair @ 1 Khz	5.6 nF/100 m
Unbalanced Capacitance per pair to ground @ 1 Khz	330 pF/100 m
Impedance	100 ohm ± 15%
Structured Return Loss 10/100 Mhz	23/16 dB/100 m
Attenuation (max at 100 m)	4.1 dB @ 4 Mhz 8.2 dB @ 16 Mhz 22.0 dB @ 100 Mhz
NEXT (min. at 100 m)	53.0 dB @ 4 Mhz 44.0 dB @ 16 Mhz 32.0 dB @ 100 Mhz
Propagation Delay (min. @ 10 Mhz)	5.7 ns/m

2.3 Wiring and raceways

A. General: Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 26.

B. All insulated wire to be copper conductors, UL labeled for 90 degrees C minimum service.

C. Conduit for Control Wiring, Control Cable and Transmission Cable: Electrical metallic tubing (EMT) with compression fittings, cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections.

D. Outlet Boxes (Dry Location): Sheradized or galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.

E. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.

F. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type shall be suited to location.

G. Sensor and/or signal cabling for controller I/O shall be multi-conductor type, stranded copper conductors, shielded, with plenum rated outer jacket. Conductor size shall be as recommended by the manufacturer for cable length and device power consumption.

PART 3 - EXECUTION

3.1 All line voltage wiring and low voltage wiring in the following locations and applications shall be run in conduit regardless of local building code allowances:

A. Mechanical Rooms, Electrical Rooms and other similar equipment rooms.

B. Vertical risers (except if contained within a 2-hr or greater rated shaft).

C. Open Areas where wiring will be exposed to view or tampering.

D. Outdoors.

Other than the specific locations and applications above, low voltage wiring concealed above accessible ceilings may be run without conduit. Open wiring dropping into walls shall be run in conduit. Thermostats shall be installed on a single gang box and conduit shall be installed to extend into the plenum. Open wiring shall be bundled and supported at 3 ft. maximum intervals with a system of J-hooks. Open wiring in air plenums shall be rated for such use and so labeled.

3.2 Thermostats and other wall mounted sensors shall be installed on a single gang box. EMT conduit shall be installed from the wall box to the plenum; cabling within the wall shall be in conduit.

3.3 Provide electrical circuits from the nearest appropriate electrical panel to serve control panels, transformers, and other control equipment and devices. Circuits serving control panels and transformers for low voltage service shall be independent and used for no other purpose. Provide circuit wiring from the electrical panel. These circuits shall be clearly identified at the panels. Coordinate with Division 26.

END OF SECTION

23 21 13 HYDRONIC PIPING

PART 1 - GENERAL

1.1 Hydronic piping systems (condensate drainage, etc.) shall be as shown on the drawings and as specified herein. Systems shall include piping, valves, system specialties and accessories.

1.2 Piping systems shall conform to ANSI and State rules for pressure piping where applicable. Welders and fitters shall be fully certified for work performed.

1.3 Safety valves and all pressure vessels shall bear the appropriate ASME label.

1.4 Refer to Section 23 05 07 Piping Materials and Methods, Section 23 05 29 Hangers and Supports for HVAC Piping and other related sections for required provisions.

PART 2 - PRODUCTS

2.1 Pipe, fittings and joints for the hydronic systems shall be as listed below and as described in Section 23 05 07 Piping Materials and Methods.

2.2 Piping for the various service shall be:

A. Cooling Condensate drainage.

1. Copper – Type C4.

PART 3 - EXECUTION

3.1 Drawings (plans, schematics and diagrams) indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, pipe expansion, pump sizing and other design considerations; therefore, it is imperative that piping be installed as indicated. However, deviations shall be anticipated & expected to accommodate field conditions and as such deviations shall be submitted in writing/diagram form for review by the Engineer prior to installation.

3.2 Refer to Section 23 05 01 Basic HVAC Requirements and other equipment sections for system cleaning and flushing requirements.

3.3 Refer to Section 23 05 07 Piping Materials and Methods for installation of piping and accessory devices and equipment.

END OF SECTION

23 23 00 REFRIGERANT PIPING

PART 1 - GENERAL

1.1 Refrigerant piping and related devices shall be provided extending between split systems condensing unit indoor unit.

1.2 Refrigerant piping shall conform to ANSI B31.5 and ASTM B280. Refrigerant piping systems and components shall be engineered, installed, tested and placed in operation in accordance with ASME B31.5, latest edition.

1.3 Pipe arrangement, devices and sizing information shown on the drawings is limited due to variations in equipment manufacturers' requirements. The equipment supplier shall prepare project-specific drawings of each piping system showing numbers and sizes of piping, devices and accessories, coil circuitry, traps, double suction risers and other such detail required for the application shown on the drawings and as specified herein. Drawings shall be submitted to the Engineer for review with the equipment shop drawings.

1.4 The equipment supplier shall provide piping installation instructions to the Installing Contractor and supervision as needed to ensure that the piping system is installed in accordance with the equipment manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 Refrigerant tubing shall be Type "ACR" hard seamless copper thoroughly cleaned and dehydrated for use with the refrigerant used. Tubing which has not been so prepared and sealed or which has been open to the atmosphere for any length of time shall not be used. All changes in direction of piping shall be made with wrought copper fittings.

2.2 Refrigerant piping may be soft copper pre-charged refrigerant tubing with compatible end connections as may appropriate for project conditions.

2.3 Refrigerant devices and specialties shall be specifically designed for refrigerant applications and of construction pressure class consistent with the duty imposed.

A. A filter-drier shall be provided in the liquid line near the condensing unit or evaporator coil.

B. A thermal expansion valve shall be provided in the liquid line at each evaporator coil if an expansion valve or device is not integral with the unit. The expansion valve shall be diaphragm type with external equalizer and external superheat adjustment.

C. A liquid line electric solenoid valve or a "hard shutoff" thermal expansion valve shall be provided where the liquid line exceeds 50 ft. in length.

D. All refrigerant access ports shall be fitted with locking-type tamper-resistant caps.

PART 3 - EXECUTION

3.1 Pipe arrangement, devices and sizing information shown on the drawings is schematic in nature, limited due to variations in equipment manufacturers' requirements. The equipment supplier shall prepare project-specific drawings of each piping system showing numbers and sizes of piping, devices and accessories, coil circuitry, traps, double suction risers and other such detail required for the application shown on the drawings and as specified herein. Exact routing, and pipe quantities and sizing shall be per manufacturer’s requirements. Refrigerant piping shall conform to ANSI B31.5 and ASTM B280. Refrigerant piping systems and components shall be engineered, installed, tested

and placed in operation in accordance with ASME B31.5, latest edition. Drawings shall be submitted to the Engineer for review with the equipment shop drawings. Exact routing, and pipe quantities and sizing shall be per manufacturer's requirements.

3.2 All joints shall be brazed using silver brazing alloy while flowing an inert gas such as dry nitrogen through the piping.

3.3 Piping shall be hung from the building structure with clevis hangers and rods as described in 23 05 29 Hangers and Supports for HVAC Piping. Hangers for insulated pipe shall be oversized and a sheet metal saddle with belled ends incorporated to protect the insulation.

3.4 Each refrigerant piping system shall be 24-hour positive-pressure leak tested with dry nitrogen at 600 psi, and then 24-hour negative-pressure tested to between 200 and 500 microns, or per equipment manufacturer's requirements, whichever is more stringent. The test pressures shall be demonstrated to be maintained for at least 24 hours for each pressure test, with starting and ending pressures recorded and documented. A system shall be considered "proven-tight" when there is no more than a 40 psig loss during the positive-pressure test, and no more than a 50 micron rise for the negative-pressure test. If a test fails, triple nitrogen purge and repeat the test after the leak has been repaired. Once a system has been "proven-tight", the system shall then be purged and charged with the required amount of refrigerant per the equipment manufacturer's instructions.

END OF SECTION

23 31 13 HVAC DUCTWORK

PART 1 - GENERAL

1.1 Ducts, sheet metal plenums and associated devices, accessories and work items shall be provided as shown on the drawings and as specified hereinafter.

1.2 Ductwork, materials, construction, reinforcing and installation shall conform to SMACNA HVAC Duct Construction Standards, latest edition, and other applicable SMACNA standards. In addition, duct systems, components and accessories shall comply with applicable provisions of NFPA 90A, 90B, 96 and 255, and UL 181, 181A, and 181B, including smoke and flame ratings.

1.3 Variation of duct configuration or sizes other than those of equivalent or lower loss coefficient is not permitted except by written permission. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

1.4 Refer to the Duct Construction and Sealing Schedule on the drawings for information pertinent to the various duct systems, such as duct materials, SMACNA pressure class, seal and leakage class, external insulation, duct liner, etc.

1.5 Refer to the drawings for ductwork that is to be internally lined. Ductwork shall only be internally lined where scheduled or noted on the drawings.

1.6 Refer to 23 05 05 Firestopping for requirements related to non-fire dampered ductwork penetrating fire rated walls and partitions.

1.7 Mechanical equipment, appliances and supports that are exposed to wind shall be designed and installed to resist the wind pressure determined in accordance with the building and mechanical code. Refer to specification 23 05 30 Bases and Supports for HVAC Equipment for additional requirements.

PART 2 - PRODUCTS

2.1 Sheet metal shall be lock forming quality galvanized steel, ASTM A924/A924M and A653/A653M, G90 coating designation, 24 gauge minimum, except as otherwise noted or specified. Other materials and construction for special applications required are as shown on the drawings and specified below. ASTM A653 G90 coating shall be used for ductwork located outdoors as noted in the duct construction schedule on the drawings.

2.2 Ductwork, as noted on the drawings, that will remain exposed in finished areas which will be painted shall be fabricated of sheet metal with galvannealed or bonderized (phosphated) coating.

2.3 Flexible duct shall be installed as detailed on the drawings and shall not pass through any wall, floor, or ceiling. Flexible ducts and air connectors shall not pass through any fire-resistance-rated assembly.

A. Flexible air (duct) connectors for galvanized steel ductwork shall be:

Constructed of galvanized steel spiral wire mechanically locked to an airtight laminated aluminum foil, fiberglass and aluminized polyester duct fabric. Duct shall be rated at a minimum of 10 inches w.c. positive pressure and 4 inches w.c. negative pressure. Unless otherwise detailed on the drawings, length shall be limited to 4 feet for Air Terminal Units and 5 feet for Air Devices .

Insulated flexible duct shall have 1 inch thick R-4.2 fibrous glass insulation and .10 perm polyethylene vapor barrier outer jacket, equal to Flexmaster Type 5B or .05 perm reinforced

metalized vapor barrier outer jacket, equal to Flexmaster 5M. Insulated duct assembly shall conform to be UL 181 and listed as Class I Flexible Air Connector.

Non-insulated flexible duct shall be equal to Flexmaster NI-55, shall conform to UL181 and be listed as Class I Flexible Air Connector.

2.4 Interior duct liner for acoustical and thermal insulating purposes shall conform to ASTM C1071 and shall be GreenGuard Certified for low formaldehyde and low VOC emissions. Liner shall be 1.5 inches thick R-6.0 flexible fiberglass bonded with thermosetting resin. The interior (airside) surface shall be covered with a durable mat facing, which shall encapsulate the liner materials, provide a smooth face to the airstream and protect the liner from cuts and abrasions. The facing shall be treated with an EPA registered anti-microbial agent to reduce the potential for microbial growth. Edges of the liner shall be covered with an encapsulating coating to seal transverse liner edges and prevent surface flaring due to airstream. Noise Reduction Coefficient (NRC) for the liner shall be 0.70 or better. Liner shall not exceed 25/50 for flame spread/smoke developed per ASTM E84. Liner shall be rated for air velocities up to 5000 feet per minute and operating temperatures up to 250 degrees F. Note that duct sizes indicated on the drawings are inside clear dimensions, and that sheet metal dimensions are 3 inches greater in each dimension for rectangular ductwork, and 3 inches greater diameter for round ductwork. Liner shall be CertainTeed “Toughgard R”, or equal by Owens Corning, Johns Manville or Knauf.

2.5 Rectangular Ductwork

A. Elbows shall have an inside radius equal to the duct width. Where 90 degrees elbows are shown to be square on the drawings, they shall be square (mitered) with turning vanes, single vane type in lengths 32 inches and less, double wall in longer vanes, installed and supported per SMACNA. Elbows less than 90 degrees shall be radiused. Non-radiused elbows less than 90 degrees, with or without turning vanes, are not permitted.

B. Square Tee fittings shall include turning vanes. The widths of the two branch ducts shall add up to the width of the main duct, and the duct depths shall remain constant. Turning vanes shall be single vane type in lengths 32 inches and less, double wall in longer vanes, installed and supported per SMACNA.

C. Offsets and transitions shall conform to SMACNA. Unless shown otherwise on plans, transition angles shall be limited to 60 degrees on converging transitions as measured on the interior, and 30 degrees on diverging transitions as measured on the interior.

D. Branch take-offs, where not detailed otherwise, shall be with a static boot (45 degrees clinch collar) per SMACNA. Straight tap take-offs are not permitted.

E. Divided flow branches shall conform to SMACNA. Bull head tees without vanes are not permitted.

F. Manufactured duct connectors similar to Ductmate Industries “25”, “35” and “45” may be used on rectangular ductwork except where welding or brazing is specifically required. Adhere strictly to manufacturer’s instructions. SMACNA duct gauge thickness and reinforcing shall be maintained when using this joining method, or the manufacturer’s requirements, <u>whichever is more stringent</u>. Connector components shall be constructed from same material as the duct section being connected.

2.6 Fan Transitions

A. Fan inlet – Maximum 15 degrees diverging as measured on the interior, and 30 degrees converging as measured on the interior, and first duct elbow shall be minimum 2.5 fan inlet diameters away unless shown otherwise on plans.

B. Fan Discharge -- Maximum 15 degrees diverging as measured on the interior, and 30 degrees converging as measured on the interior, and first duct elbow shall be minimum 2.5 fan inlet diameters away unless shown otherwise on plans

2.7 Round and Flat Oval Ductwork:

A. Round and flat oval duct shall be factory or shop formed spiral lock seam, United McGill Air Products "Uni Seal" or "Uni Rib" or equal by Langdon, Semco, Tangent Air, Precision Duct or approved equal.

B. Acoustically lined round and flat oval duct shall be double wall spiral lock seam duct equal to United McGill Air Products "Acousti k27" with solid liner and 1 inch thick R – 3.7 fiberglass insulation, or equal by Langdon, Semco, Tangent Air, Precision Duct or approved equal. Fittings shall be double wall insulated with solid liner, of construction similar to single wall fittings. Duct sizes list on the drawings are inside clear dimensions.

C. In lieu of the above, round duct, fittings and connectors may be Linx Industries' Lindab "Safe" (single wall) or "ISOL" (double wall) duct systems with fitting ends factory equipped with double lipped "U" profile EPDM gasket. Spiral ducts shall conform to Lindab standards and shall be calibrated to published dimensional tolerances of Lindab. Insulation R-valves and liner types shall be as specified above.

D. Elbows and fittings for spiral lock seam round and flat oval ductwork shall be factory solid welded, equal to United McGill Air Products "Uni Seal" and "Acousti-k27" with beaded sleeve transverse joint connectors, or equal by Langdon, Semco, Tangent Air, Precision Duct or approved equal. For duct systems classified at less than 3" w.c., elbows and fittings may be roll pressed type. Elbows shall be long radius type and, where shown, square type ells shall be mitered with turning vanes. Branch take offs shall utilize a 45 degree entry low loss tap or a conical lateral tap to minimize pressure loss, except that streamlined conical taps may be used where space constraints dictate. Tee fittings shall include elongated proportional turning vanes to equalize airflow around the ells. Wye branches shall be used at end of runs unless shown otherwise. Offsets and transitions shall conform to SMACNA. Transition angles shall be limited to 60 degrees on converging transitions as measured on the interior, and 30 degrees on diverging transitions as measured on the interior. Divided flow branches shall conform to SMACNA. Bull head tees without vanes are not permitted.

E. Construction, reinforcing, supports, etc. shall either conform to SMACNA or to the duct manufacturer's standards, <u>whichever is more stringent</u>.

2.8 Air device duct connections for round duct branch connections to rectangular sheet metal ducts shall be 24 gauge sheet metal, equal to Flexmaster Series FL, straight side, minimum 24 gauge with and without manual damper, as described on the drawings. When manual damper is provided it shall be minimum 22 gauge with stamped re-enforcements and include .375" square shaft and locking quadrant equal to Ventlok 639 or Rossi "Everlock", with 2" standoff and nylon bushings. Air terminal unit duct connections for round duct branch connections to rectangular sheet metal ducts shall be 24 gauge sheet metal conical type equal to Flexmaster Series CB. Connectors installed on interior lined rectangular duct shall have an integral insulation guard sleeve. Rectangular tap-to-round branch connection with static boot configuration shall be equal to Flexmaster Type STO. Buckley "Air Tite" fittings or similar by "Snap Rite", equal to the specified Flexmaster fittings, with neoprene gasket and adhesive facing, additionally secured with minimum four sheetmetal screws, may be used for air device duct taps to rectangular sheet metal duct which is not internally lined.

2.9 Duct sealants containing asbestos are prohibited. All duct sealants, tapes and connectors shall be listed and labeled in accordance with UL 181A, 181B or 181C as applicable to the application. Duct sealant materials shall be one or more of the following (compatible with the application):

A. LEED Compliant solvent based sealers and mastics equal to Design Polymerics, with a maximum VOC content of 50 grams/liter.

B. Water base duct sealers and mastics equal to United McGill or Foster Products when the installation environment is above 40 degrees F.

C. Acetone based duct sealers and mastics, equal to Precision Adhesives, when the installation environment is between 0 degrees F and 40 degrees F, zero reportable V.O.C.'s.

D. Mineral impregnated fiber tape with liquid sealant duct joint sealer equal to that manufactured by Hardcast, Inc., Two Part II Sealing System, maximum V.O.C. of 135 g/l.

2.10 Duct Access Doors (Non-Grease Ducts)

A. Access doors shall be factory fabricated constructed of the same material as the ductwork (except galvanized sheet metal for fiberglass duct), complete with hinged door, cam lock latches, frame and neoprene gasket between door and frame. Doors in insulated ductwork (internal and external) shall have double wall insulated doors. Access doors shall be 16 inches x 16 inches minimum except smaller where duct size will not permit such size.

B. Access doors and panels shall be designed to provide tight seal commensurate with the duct pressure. Apply duct sealer or rubber gasket between frame and duct. On ducts of 3 inches S.P. and higher construction class, mechanical fastening of the frame and rubber gasket shall be provided.

C. Where sufficient clearance is not available to allow the door to swing open 90 degrees, an access panel with neoprene gasket, frame, chain connected to both the panel and ductwork, and cam lock latches on all four sides shall be provided in lieu of the hinged door.

2.11 Plenum access doors shall be factory fabricated and as described for duct access doors except that doors shall be 18 inches x 48 inches (unless otherwise noted) with overlapping frame, continuous piano hinge and heavy duty latches (with lever on both outside and inside) equal to Ventfabrics "Ventlok No. 202. Two latches shall be provided except on doors 50 inches and higher three shall be provided. Frame shall be mechanically fastened to the plenum wall.

2.12 Ductwork that crosses building seismic joints or expansion joints shall be fitted with flexible connectors that will accommodate the building movement in all directions. Connectors shall be manufactured by Mercer Rubber or approved equal, multiple plies and arches of elastomer-impregnated fabric or cord, EPDM construction with mounting flanges, all rated for 250 degrees F service at pressure rating consistent with the associated duct system. Refer to duct construction schedule. Grease ductwork shall not be fitted with flexible connectors.

PART 3 - EXECUTION

3.1 Duct thickness, construction, reinforcing, support and installation, shall conform to SMACNA HVAC Duct Construction Standards, latest edition and other applicable SMACNA standards. Cable support systems are not allowed. Duct reinforcing shall be external to the duct except that rectangular ducts of 3 inches s.p. class or greater with a dimension exceeding 48 inches may utilize internal tie-rod supports in accordance with SMACNA. Only round tubing, rods or conduit is permitted as tie-rods, utilizing the minimum diameters required by SMACNA.

3.2 Transverse joints and longitudinal seams shall be assembled with sealant to conform to SMACNA sealing requirements as indicated in the Duct Construction Schedule on the drawings. Selection of sealant materials shall be compatible with the application. Sealants shall be applied in accordance with manufacturer's recommendations, including application temperature ranges.

3.3 Attachment of hangers and straps to the structure shall be with:

A. Pre-set concrete inserts in concrete construction of 4 inches minimum depth.

B. After-set concrete inserts, in 4 inches minimum depth concrete, set in drilled holes. Powder actuated driven fasteners are not permitted.

C. Beam clamps in steel construction. Provide anchoring where clamps are attached to sloping surfaces of beam flanges and where otherwise required to ensure permanent attachment.

D. Unistrut type channel support system may be utilized. Channel shall be pre-set or attached to the structure with inserts or clamps.

E. Attachment to steel deck is prohibited. Span from steel structural members with supplementary steel shapes where direct attachment to structural members is not practical. This does not apply to steel deck with concrete slab poured on the deck. Refer to A. and B. above.

F. Attachment to manufactured trusses, joists, purlins, and other engineered structural members and supports shall be done in strict accordance with the structural engineer's or manufacturer's recommendations. Refer to the architectural and structural drawings for type of engineered structural systems being used. Connections to these structural members shall be made with connection devices and methods approved by the structural engineer or manufacturer. Provide additional supports with supplemental steel shapes when spacing between structural members exceeds specified distances. In the case of existing trusses, the structural engineer must review and approve hanger attachment methods.

3.4 Ductwork outside shall be sealed with mineral impregnated fiber tape. Ductwork shall be supported per SMACNA and as noted or detailed on the drawings. Ductwork, whether externally insulated or not, shall be jacketed as specified in 23 07 13 Duct Insulation.

3.5 Ductwork with galvannealed or bonderized coating shall be wiped clean to remove dirt, dust, oil and other contaminates in the shop before delivery to the jobsite. Care shall be taken in storage and installation to maintain cleanliness of the surfaces. Prior to painting, again wipe the surfaces clean.

3.6 Flexible air (duct) connectors shall be attached to metal duct with Panduit nylon banding straps or stainless steel clamps. Nylon banding straps shall be tightened utilizing a cable tie gun. Outer jacket of insulated flexible duct shall be closed at the ends with sealant and nylon banding straps or U.L. listed aluminum foil duct tape equal to Nashua No. 617022 with UL 181 listing printed on the face. Maximum length shall be 7 ft. with support at 4 ft. maximum spacing. Duct shall be free of sags and sharp bends. Utilize flexible duct elbow supports at all elbows. Flexible supports shall be UL listed for ceiling return air plenum use per UL 2043, UL 723 or ASTM E84, as manufactured by Titus (Flexright) or Thermaflex (Flex Flow) or approved equal. Independently supported radius'd sheet metal elbows may be used in lieu of flexible duct elbow supports when installed directly on air devices.

3.7 Flexible air (duct) connectors shall not be installed:

A. Where ductwork is exposed.

B. Thru any wall, ceiling, floor or fire rated or smoke rated assembly.

C. In the immediate vicinity of, and connecting to, air devices in fire rated ceilings where the assembly details require steel ductwork.

3.8 Interior duct liner shall be installed at time of ductwork fabrication. Liner shall be installed in strict accordance with the manufacturer's instructions and SMACNA standards. Liner shall provide full

coverage of the ductwork, with all edges neatly butted together without gaps or interruptions. Adhesive shall cover at least 90 percent of the sheet metal surface. In addition, mechanical fasteners shall be utilized where required by SMACNA standards, NAIMA standards, or the liner manufacturer. Fasteners shall not compress the liner more than 10 percent of the liner thickness. Raw exposed liner edges resulting from shop cutting of the liner shall be treated with a sealant to protect the fibrous liner material from moisture or erosion due to air movement. Provide metal nosing at the leading edge of transverse joints at fan discharge and any joint preceded by an unlined section of ductwork. In addition, metal nosing is required at every transverse joint when the air velocity exceeds 3000 feet per minute. Repair any damage to liner coating with repair sealant/coating approved by the liner manufacturer. Protect liner and lined ductwork from dirt and moisture during fabrication, transport and storage, as well as during and following installation of the ductwork.

3.9 Duct and plenum connections to air supply, return or exhaust units and fans (other than power roof ventilators or any Type I grease duct fan) shall be made with a 4 inches wide intervening section of flexible incombustible fabric equal to Ventfabrics "Ventglas", to prevent the transmission of fan noise and vibration to the ductwork. Fastening shall consist of angle clamps and bolts made up to be air tight similar to Ventfabrics "Metaledge".

3.10 Duct access doors shall be provided for access to equipment, damper operators, devices and instruments inside the duct, at each fire damper, smoke damper and duct smoke detector (refer to Electrical drawings) and where otherwise shown. A wall or ceiling access panel shall be provided where duct access is required thru a wall or inaccessible ceiling. Refer to 23 05 04 Basic HVAC Materials and Methods for such access panels.

3.11 Access door and fire damper shall be so arranged and located such that the spring catch and fusible link are accessible when the damper is closed. The door shall be sized to permit entry of arms or body in resetting of the damper. Special consideration must be given for larger dampers and spring loaded horizontal dampers.

3.12 Coordinate openings required for the passage of ductwork thru walls, partitions, floors and roofs with the General Contractor. Sleeves are not required except as stated below.

3.13 Floor sleeves for ductwork shall project 4 inches above the finished floor in equipment rooms and areas of similar usage, and shall form a waterproof seal. Exceptions shall be at locations where the opening is protected from drainage falling thru by means of concrete curbs or shaft walls. Provide 4 inch high x 4 inch wide concrete curbs with beveled edges to protect floor openings related to work in equipment rooms or an equally effective waterproofing metal curb.

3.14 Sheet metal sleeves in conjunction with fire dampers shall be placed in walls and floors to pass ductwork.

3.15 Where a fire damper is not required in a duct penetrating a fire rated wall or partition, the opening shall be fitted with a sleeve conforming to the requirements of the firestopping assembly.

3.16 Annular spaces around ducts or duct insulation passing thru non-fired rated walls and partitions shall be closed with caulking or other compatible material to retard the passage of smoke. Annular spaces around ducts not fitted with fire dampers that pass thru non-fire rated floors shall be similarly closed.

3.17 Stored ductwork shall be blocked up off the ground and completely covered with visqueen. Open ends of both stored and erected duct shall be capped or covered with visqueen secured with duct tape before the end of each day's work to preclude contamination or entry of foreign materials. Factory made covers with elastic banding as manufactured by Duct Cap are also an acceptable means for temporary duct closure.

3.18 Ductwork and piping shall not be run above electrical switchgear or panelboards, nor above the access space in the immediate vicinity of the equipment in accordance with The National Electric Code.

3.19 Coordinate duct layout carefully with other trades to avoid conflict with structural elements, lighting and plumbing heating piping. Flattening of ductwork and offsets to fit ductwork in available space is generally shown. In the absence of such, arrange the ductwork to maintain concealment and allow ceilings and lights to be installed as intended. Do not hang ductwork until possible interference with electrical and mechanical trades have been resolved. Having ductwork fabricated and delivered in advance shall not be justification for interference with other trades.

3.20 Provide a complete set of ¼ inch = 1 foot 0 inch sheetmetal fabrication drawings. The drawings shall be used for overall coordination with the other trades. Meet with the other trades prior to developing and finalizing these drawings. The ¼ inch sheet metal drawings shall be true fabrication drawings started "from scratch" in that direct duplication of the contract drawings will not be accepted. In addition to plan layouts, fabrication drawings submitted for review shall include the following:

A. Fabrication, assembly, and installation details, including plans, elevations, sections, details of components, and attachments to other work.

B. Duct layout, indicating pressure classifications and sizes in plan view.

C. Fittings.

D. Reinforcing details and spacing.

E. Seam and joint construction details.

F. Penetrations through fire rated and other walls.

G. Terminal unit, coil, humidifier, and other air-side equipment installations.

H. Hangers and supports, including methods for building attachment, vibration isolation and duct attachment.

3.21 Provide a leak test on all ductwork located in chases and shafts, on all outdoor ductwork, and on 25 percent of ductwork classified 3 inches of static pressure and higher based on the Duct Construction and Sealing Schedule shown on the drawings.

A. Leakage test procedures shall follow the outlines and classifications in the SMACNA HVAC Duct Leakage Test Manual. Where classifications specified exceed SMACNA standards the specified classification shall be considered the minimum standard. Negative pressure ductwork may be tested with equivalent positive pressure.

B. The leakage amount shall not exceed the allotted amount for the pressure class or the allotted amount for that portion of the system, whichever is applicable.

C. Leak test shall be conducted before any ceilings or shafts are enclosed.

D. A leakage test report shall be submitted certifying that the duct has been tested per SMACNA requirements and providing detailed test data and results.

E. If tested section fails to meet allotted leakage level, make modifications to bring section into compliance, and retest until acceptable leakage levels are obtained.

F. The leakage test shall be witnessed by the Air Balancer (who shall sign-off on the test results).

END OF SECTION

23 33 00 AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 Ductwork accessories specified herein shall include manual balancing dampers, backdraft dampers, and fire dampers. Refer to the drawings for scope and application.

1.2 Balancing dampers are also specified to be furnished with "spin-in" duct taps specified in Section 23 31 13 HVAC Ductwork and in Section 23 37 00 Air Outlets and Inlets. Automatically controlled dampers are specified in the temperature controls sections and also specified as integral components of air handling equipment, fans, VAV control units and other such equipment.

1.3 Manual balancing dampers, in addition to those shown, which will be required to effect a positive balancing of air in the system shall be provided in the ductwork. The company or agent who is to balance the air systems shall call the HVAC Contractor's attention to requirements for additional balancing dampers which are deemed necessary.

1.4 Fire dampers shall be provided where shown on the drawings and where otherwise required to conform to the NFPA 90A and Building Code requirements.

PART 2 - PRODUCTS

2.1 Dampers and accessory items shall be constructed of galvanized steel, except those in ducts of stainless steel, aluminum, PVC coated or other such materials shall be stainless steel to maintain the intended corrosion resistance of the system.

2.2 Balancing dampers shall be single cross-blade up to 12 inches blade width and in larger sizes, multiple blade type 6 inches maximum width with opposed blade arrangement. Dampers shall have a full length continuous drive shaft and be controlled by a locking quadrant positioner with handle and minimum .375” square shaft, equal to Rossi “Everlock” or Ventlok #641 and for externally insulated ducts Rossi “Everlock” with 2” stand-off or Ventlok #644. For ductwork classified as 2” and greater, provide HiVel Ventlok Acorn Nut, End Bearing and gasket hardware.

2.3 Backdraft dampers shall be adjustable counter-balanced type with extruded aluminum frame and blades and extruded vinyl edge seals, equal to Ruskin CBD6. Backdraft dampers in stainless steel, aluminum, PVC or “wet” ductwork shall be stainless steel counter-balanced equal to Carnes FANA/FAPA.

2.4 Fire dampers shall be as follows:

A. Dampers shall be constructed and tested to conform with UL 555, shall be UL labeled and shall be rated for use in static or dynamic systems, as indicated on the drawings, or as required by the Mechanical Code All fire dampers installed in corridor walls shall be dynamic rated, even when indicated as static on drawings, and shall demonstrate acceptable closure performance when subjected to minimum 150 feet per minute velocity across the face of the damper in conformance with the UL 555 fire exposure test.

B. Review the architectural drawings to determine wall ratings and select dampers accordingly.

C. Dampers shall be as manufactured by Ruskin, Greenheck, Nailor or Carnes, equipped with a 165 degree (unless otherwise noted) fusible link. Pressure level construction shall conform to that of the duct as indicated in the Duct Construction Schedule on the drawings.

D. The following is a description of fire damper types:

1. TYPE "A"
   Low velocity (below 2000 fpm) with folded blade curtains stored in the air stream.

2. TYPE "B"
   Low velocity (below 2000 fpm) with folded blade curtains stored out of air stream.

PART 3 - EXECUTION

3.1 Fire dampers shall be installed in conformance with manufacturer's instructions and SMACNA recommendations. Dampers shall be installed in sheet metal wall or floor sleeves along with retaining angles and duct access doors or panels. Sleeve and duct connections shall be breakaway type or rigid type with corresponding gauge requirements in accordance with the manufacturer's instructions and SMACNA recommendations. Provide a duct access door for each damper, minimum 12"x12" or removable duct section (bolted and gasketed double wall duct section) per NFPA 80 and labeled "FIRE DAMPER", "SMOKE DAMPER", or "FIRE–SMOKE DAMPER" as appropriate.

Ceiling radiation dampers shall be installed in accordance with the details listed in the fire-resistance-rated assembly and the manufacturer's installation instructions and listing.

3.2 Fire dampers and associated access doors shall be so arranged and located such that the spring catch and fusible link are accessible when the damper is closed.

3.3 Accessibility of each fire damper shall be demonstrated to the Owner by disconnecting the link, closing the damper, reopening and re-attachment of the fusible link.

END OF SECTION

23 34 00 HVAC FANS

PART 1 - GENERAL

1.1 Fans shall be provided as specified below and shown on the drawings, complete with motors, drives and associated devices.

1.2 Fans shall be constructed, rated and labeled in accordance with AMCA Standard 210 67 and AMCA 300. Fans shall be statically and dynamically balanced throughout the operating range. The class of the fan provided shall be adequate for the duty specified plus a 10 percent increase in static pressure. Shop drawing submittals shall state maximum fan RPM for fan class provided. No infringement will be allowed on this requirement. Submittals shall include fan curves showing operating point(s), system curves, and surge lines.

1.3 Classification for Spark Resistant Construction shall conform with AMCA 99.

1.4 Refer to Section 23 05 13 Electrical Requirements for HVAC Equipment for required provisions.

1.5 Refer to Section 23 05 49 Vibration Control for HVAC for vibration isolator types.

1.6 Provide dimensional drawings and product data on each exhaust fan assembly. Provide fan curves for each fan at the specified operation point with the flow, static pressure, and horsepower clearly plotted. For multiple fan assemblies, fan curves shall be adjusted to show assembly operation.

1.7 Dampers shall be tested and licensed for air performance and leakage in accordance with ANSI/AMCA standard 500-D and AMCA publication 511.

1.8 Equipment shall carry an all-inclusive manufacturer's parts and labor warranty for a period of one (1) year(s) from date of final acceptance or date of beneficial use, as agreed to between Contractor and Nexus Engineering Group. The all-inclusive parts and labor warranty for ECM's and associated controllers shall be for a period of 5 years. Any materials, equipment, or controls found to be defective during this warranty period shall be made good without expense to the Owner, including any required replacement of fluids, glycol, or refrigerant. The warranty shall include a delayed start-up provision such that the warranty does not begin at time of delivery. The labor for the warranty shall be performed by the manufacturer's authorized service agent.

1.9 Mechanical equipment, appliances and supports that are exposed to wind shall be designed and installed to resist the wind pressure determined in accordance with the building and mechanical code. Refer to specification 23 05 30 Bases and Supports for HVAC Equipment for additional requirements.

PART 2 - PRODUCTS

2.1 Induction motors 1 HP and larger shall be "premium efficiency" series motors. Motors shall be 1750 rpm unless specifically noted otherwise. Drives and couplings shall be protected with guards conforming with OSHA standards. Motors connected to VFD's shall comply with 23 05 13 Electrical Requirements for HVAC Equipment and shall be furnished with AEGIS SGR shaft grounding ring kit, installed by the equipment manufacturer. Refer to Section 23 05 13 Electrical Requirements for HVAC Equipment.

2.2 The following lists types of fans, related construction features and manufacturers. All fans of any one listed type shall be of the same manufacturer.

A. Type B1 - Centrifugal Exhaust with Integral Stack

Centrifugal utility blower shall be single inlet with flat blade backwardly inclined centrifugal wheel, motor, direct drive, weather protective cover to enclose motor and drive, with integral stack. Housing shall be galvanized or primed and finished with enamel paint. Stack material to be a minimum of 18 gauge. Stack to match outlet dimensions of the fan and shall not add additional static pressure drop to the exhaust fan. No discharge rain caps or flapper caps are permitted as to interfere with exhaust airflow.

Access panel(s) with gaskets and latches shall be provided on the fan scroll for cleaning of the fan wheel and scroll.

Threaded drain connection with plug shall be located at lowest part of scroll housing to prevent moisture build-up in the interior of fan

Vibration isolators shall be type as indicated on the drawings. Isolators shall be mounted to isolation rails structural base. Vibration isolators for exterior mounted equipment shall be weather protected.

Fans shall be manufactured by Greenheck FJI, or Cook.

2.3 Motor HP shall be sufficient to handle the full load of the fan, including drive losses, at the selected condition without exceeding the motor rating. In no case shall the motor size be less than shown without prior approval from the Engineer. All motors greater than .083 HP but less than 1 HP shall be ECM motors or shall have a minimum motor efficiency of 70%. EC motors shall be provided with motor mounted speed pot control, 0-10 volt DC external speed control, and with a 24V transformer for external speed control and damper control with input voltage compatible with the fan motor voltage. Controllers shall be by the fan manufacturer. All motors 1 HP and larger shall be "premium efficiency" series. Motors connect to VFD's shall comply with 23 05 13 Electrical Requirements for HVAC Equipment and shall be furnished with AEGIS SGR shaft grounding ring kit, installed by the equipment manufacturer. Refer to Section 23 05 13 Electrical Requirements for HVAC Equipment.

2.4 Motorized backdraft dampers, where specified, shall be furnished with an electronic damper actuator with voltage compatible with the fan motor voltage and electric service to the fan. If not compatible, a transformer shall be provided with the fan and damper actuator to afford the appropriate voltage. Where the fan motor is fed from a Variable Frequency Drive controller (VFD) provide a control contactor or relay and extend the control from the VFD damper control output relay to open/close the damper when associated fan motor is started/stopped.

2.5 Motorized backdraft dampers shall be insulated damper with extruded aluminum thermally broken airfoil blades with an AMCA air leakage class rating of class 1A at 1 in. wg and class 1 at 4 in. wg. Damper shall be parallel blade configuration with the motor actuator mounted outside of the airstream. Dampers shall be Greenheck ICD-44, Ruskin TED50, Tamco 9000 SC, or approved equal.

PART 3 - EXECUTION

3.1 Install fans and roof curbs level and plumb, in accordance with manufacturer's written instructions. Support units as described below using the vibration control devices specified in Section 23 05 49 Vibration Control for HVAC.

A. Base mounted unit: Set unit on equipment base using vibration isolators as specified. Secure unit to equipment base.

3.2 Arrange installation of fans to provide access space around fans for service and maintenance.

3.3 Adjust damper linkages for proper damper operation. Motorized backdraft dampers are to be wired to open when the fan operates. Coordinate with Division 26.

3.4 Fans with E.C. Motors shall be commissioned and set-up by a factory authorized technician to meet project requirements, and interface coordinated with the B.A.S.

3.5 Factory furnished devices which are not installed and wired in the factory shall be field installed and wired by Division 23, complete and ready for operation.

3.6 Perform the following operations and checks before start-up.

A. Remove shipping blocking and bracing.

B. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork and electrical are complete. Verify proper thermal overload protection is installed in motor starters and disconnects.

C. Verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation. Align belts and reinstall belt guards.

D. Lubricate bearings, pulleys, belts and other moving parts with factory-recommended lubricants.

E. Verify manual and automatic volume control, and fire and smoke dampers in connected ductwork systems are in the full-open position.

END OF SECTION

23 34 23 HVAC GRAVITY ROOF VENTILATORS

PART 1 - GENERAL

1.1 Roof ventilators shall be provided as specified and shown on the drawings, complete with all associated devices.

1.2 Equipment shall carry an all-inclusive manufacturer's parts and labor warranty for a period of one (1) year(s) from date of final acceptance or date of beneficial use, as agreed to between Contractor and Nexus Engineering Group. Any materials, equipment, or controls found to be defective during this warranty period shall be made good without expense to the Owner, including any required replacement of fluids, glycol, or refrigerant. The warranty shall include a delayed start-up provision such that the warranty does not begin at time of delivery. The labor for the warranty shall be performed by the manufacturer's authorized service agent.

1.3 Mechanical equipment, appliances and supports that are exposed to wind shall be designed and installed to resist the wind pressure determined in accordance with the building and mechanical code. Refer to specification 23 05 30 Bases and Supports for HVAC Equipment for additional requirements.

PART 2 - PRODUCTS

2.1 Roof ventilators shall be all aluminum with reinforced rectangular formed weatherhead, counterflashing base for curb mounting and bird screen. Relief and exhaust air units, where so noted, shall have the underside of the hood insulated to prevent condensation of the discharge air on the underside of the hood.

2.2 Exterior of the ventilator head shall be mill finish aluminum.

2.3 A metal roof curb with straight sides and wood nailer on top shall be provided with each fan. Provide wood cant strips around the curb only if recommended for the roofing system. Curb shall be insulated type. Curb height shall be such that top of curb extends 18" above the finished roof surface. For sloped roofs, the curb shall have a built-in slope to match roof slope so that top of curb is level.

2.4 Backdraft dampers, set within the roof curb, shall be motor operated, insulated and thermally broken. Motor shall be 120V.

2.5 Roof ventilators shall be manufactured by Acme, Greenheck, PennBarry, Cook, Carnes, Ilg or Cesco.

PART 3 - EXECUTION

3.1 Each roof curb shall be installed and the ventilator mounted on and secured to the curb. Shim the curb so that the top is level. Ventilators shall be level and plumb in accordance with manufacturer's instructions. Roof support curbs shall be installed and leveled and secured to the roof deck/structure. Roof insulation and roofing shall be removed and repaired to maintain the integrity of the roofing system. Provide wood cant strips around the curb only if recommended for the roofing system.

END OF SECTION

23 35 00 SPECIAL EXHAUST SYSTEMS

PART 1 - GENERAL

1.1 Fans for special exhaust systems shall be provided as specified below and shown on the drawings, complete with motors, drives and associated devices.

1.2 Fans shall be constructed, rated and labeled in accordance with AMCA Standard 210 67 and AMCA 300. Fans shall be statically and dynamically balanced throughout the operating range. The class of the fan provided shall be adequate for the duty specified plus a 10 percent increase in static pressure. Shop drawing submittals shall state maximum fan RPM for fan class provided. No infringement will be allowed on this requirement. Submittals shall include fan curves showing operating point(s), system curves, and surge lines.

1.3 Classification for Spark Resistant Construction shall conform to AMCA 99.

1.4 Refer to Section 23 05 13 Electrical Requirements for HVAC Equipment for required provisions.

1.5 Refer to Section 23 05 49 Vibration Control for HVAC for vibration isolator types.

1.6 Provide dimensional drawings and product data on each exhaust fan assembly. Provide fan curves for each fan at the specified operation point with the flow, static pressure and horsepower clearly plotted. For multiple fan assemblies, fan curves shall be adjusted to show assembly operation. Type L1, L2, and L3 exhaust fans shall include nozzle velocity of exhaust fan, total exhaust flow, and discharge plume rise at specified wind velocity and calculated as indicated below.

1.7 Dampers shall be tested and licensed for air performance and leakage in accordance with ANSI/AMCA standard 500-D and AMCA publication 511.

1.8 Equipment shall carry an all-inclusive manufacturer's parts and labor warranty for a period of one (1) year(s) from date of final acceptance or date of beneficial use, as agreed to between Contractor and Nexus Engineering Group. Any materials, equipment, or controls found to be defective during this warranty period shall be made good without expense to the Owner, including any required replacement of fluids, glycol, or refrigerant. The warranty shall include a delayed start-up provision such that the warranty does not begin at time of delivery. The labor for the warranty shall be performed by the manufacturer's authorized service agent.

1.9 Mechanical equipment, appliances and supports that are exposed to wind shall be designed and installed to resist the wind pressure determined in accordance with the building and mechanical code. Refer to specification 23 05 30 Bases and Supports for HVAC Equipment for additional requirements.

PART 2 - PRODUCTS

2.1 Induction motors 1 HP and larger shall be "premium efficiency" series motors. Motors shall be 1750 rpm unless specifically noted otherwise. Drives and couplings shall be protected with guards conforming with OSHA standards. Motors connected to VFD's shall comply with 23 05 13 Electrical Requirements for HVAC Equipment and shall be furnished with AEGIS SGR shaft grounding ring kit, installed by the equipment manufacturer. Refer to Section 23 05 13 Electrical Requirements for HVAC Equipment.

2.2 The following lists types of fans, related construction features and manufacturers. All fans of any one listed type shall be of the same manufacturer.

A. Type L2 – High Plume Dilution Exhaust Fan

1. Provide nozzle velocity of exhaust fan, total exhaust flow, and discharge plume rise at wind velocity of 10 mph. Discharge plume rise shall be calculated in accordance with chapter 9 of the ASHRAE Laboratory Design Guide, 2nd Edition, including stack downwash, and shall meet or exceed the scheduled value. Unless noted otherwise on the drawings discharge velocity from the nozzle shall be minimum 3000 fpm. Base fan performance at standard conditions (density 0.075 Lb. /ft^3). Each fan shall be direct driven with motor, bearings, sheaves and belts visible and serviceable without contact with the exhaust airstream. Each fan system shall be equipped with 316 stainless steel lifting lugs for corrosion resistance. Fasteners exposed to corrosive exhaust shall be stainless steel. Curb cap shall be hot rolled steel coated with corrosion resistant coating. Fan assemblies that use flexible connectors that can fail and cause loss of laboratory containment shall not be acceptable. Fan assembly shall be designed for a minimum of 125 mph wind loading, without the use of guy wires.

2. Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence. Fan housing shall be manufactured of welded steel with corrosion resistant coating. No uncoated metal fan parts will be acceptable. Fan housings that are fabricated of polypropylene that have lower mechanical properties than steel, have rough interior surfaces in which corrosive, hazardous compounds can collect, or structurally degrade due to the UV component of the sunlight shall not be acceptable. A multi-stage air induction discharge nozzle shall be supplied by the fan manufacturer designed to efficiently handle an outlet velocity of up to 7000 FPM. High plume dilution fans shall be constructed, rated, and labeled in accordance with AMCA Standard 260. The nozzle shall include corrosion resistant coating and the material shall be welded steel or aluminum. The multi-stage nozzle shall induce ambient air at a minimum of 160% of fan CFM capacity. An integral fan housing drain shall be provided to drain rainwater from the fan and stack. A bolted & gasketed access door shall be supplied for impeller inspection and service. Fan assembly shall be AMCA type B spark resistant construction minimum and provided with an explosion proof motor. Fan impeller shall be mixed flow design with non-stall characteristics. The impeller shall be electronically balanced both statically and dynamically exceeding AMCA Standards. Fan impeller shall be manufactured of welded and coated steel with corrosion resistant coating. Fan impellers that are fabricated of polypropylene that have lower mechanical properties than steel, and lower maximum tip speeds are not acceptable. Mechanical shaft seals that wear out and need to be replaced or seal systems that use hoses or tubes that can leak, are not acceptable.

3. Motors shall be premium efficiency, standard NEMA frame, 1800 or 3600 RPM, TEFC with a 1.15 service factor. Motor maintenance shall be accomplished without fan or fan impeller removal or requiring maintenance personnel to access the contaminated exhaust components. Drive arrangement shall be direct mount coupling connecting the motor shaft and fan impeller shaft and sheaves shall be sized for 200% of the motor horsepower, and be readily and easily available for service. Direct drive arrangements requiring access and handling of hazardous and contaminated fan components are not acceptable. Fan shaft to be turned and polished of 1040 steel material as standard, coated with corrosion resistant coating. Fan shaft bearing shall be Air Handling Quality, ball or roller pillow block type, and sized for an L-10 life of no less than 100,000 hours. All shaft bearings and non-permanently lubricated motors shall have nylon or stainless steel braided extended lube lines with zerk fittings. Motor, coupling, and bearing shall all be outside the contaminated exhaust, and be capable of replacement without disassembling fan and accessing hazardous and contaminated fan components.

4. For multi-fan configurations designed for redundancy (N+1) a bypass air plenum shall be provided. The plenum shall be double-wall with 2” insulation and constructed of welded and coated steel, minimum 10 gauge, and provided with corrosion resistant coating. Plenum insulation shall be no less than 2 Lb. /ft^3, two inch thick foam in place polyurethane

for additional structural rigidity. The bypass air plenum shall be grade mounted on concreate equipment pad.

Where noted on the schedule integral bypass air packed acoustic attenuator fabricated of galvanized steel shall be provided by the fan manufacturer.

Fan isolation damper(s), shall be parallel-blade design, airfoil design, fabricated of steel construction for structural rigidity as standard. Metal damper(s) shall be coated up to 4 mils of chemically resistant Hi-Pro Polyester resin, electrostatically applied and baked. Isolation damper(s) shall have plated steel damper rods, stainless steel sleeved bearings, 301 stainless steel jamb seals and the blades shall have polymer edge seals. Damper model shall be equal to or exceed a heavy duty control damper, Greenheck HCD-130. Damper blade drive linkage shall be set by manufacturer and welded to eliminate linkage slippage. All damper access and service (drive actuators) shall be performed outside of the contaminated airstream. Isolation damper actuator(s) shall be factory mounted and wired to a step-down transformer, all located in a weatherproof enclosure outside of the airstream. Each fan isolation damper shall be equipped with 2-position electric actuator(s). Each actuator shall be equipped with (2) built-in SPDT auxiliary switches (one switch fixed at 10° and one adjustable from 10° to 90°). Blower / Plenum vibration isolation shall be limited to neoprene or cork vibration pads.

When properly anchored, the plenum blower assembly shall withstand wind loads of up to 125 mph without additional structural support.

5. The fan controls shall be a pre-engineered, factory programed control system capable of stand-alone operation. Refer to drawings for sequence of operations.

6. Fan units shall be Greenheck Vektor-MD, Cook QMX-VP, or Strobic Fan Tri-Stack.

2.3 Motor HP shall be sufficient to handle the full load of the fan, including drive losses, at the selected condition without exceeding the motor rating. In no case shall the motor size be less than shown without prior approval from the Engineer. All motors 1 HP and larger shall be "premium efficiency" series. Motors connect to VFD's shall comply with 23 05 13 Electrical Requirements for HVAC Equipment and shall be furnished with AEGIS SGR shaft grounding ring kit, installed by the equipment manufacturer. Refer to Section 23 05 13 Electrical Requirements for HVAC Equipment.

2.4 Motorized backdraft dampers, where specified, shall be furnished with an electronic damper actuator with voltage compatible with the fan motor voltage and electric service to the fan. If not compatible, a transformer shall be provided with the fan and damper actuator to afford the appropriate voltage. Where the fan motor is fed from a Variable Frequency Drive controller (VFD) provide a control contactor or relay and extend the control from the VFD damper control output relay to open/close the damper when associated fan motor is started/stopped.

PART 3 - EXECUTION

3.1 Install fans level and plumb, in accordance with manufacturer's written instructions. Support units as described below using the vibration control devices specified in Section 23 05 49 Vibration Control for HVAC.

A. Base mounted unit: Set unit on equipment base using vibration isolators as specified. Secure unit to equipment base.

3.2 Arrange installation of fans to provide access space around fans for service and maintenance.

3.3 Adjust damper linkages for proper damper operation. Motorized backdraft dampers are to be wired to open when the fan operates. Coordinate with Division 26.

3.4 Factory furnished devices which are not installed and wired in the factory shall be field installed and wired by Division 23, complete and ready for operation.

3.5 Perform the following operations and checks before start-up.

A. Remove shipping blocking and bracing.

B. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork and electrical are complete. Verify proper thermal overload protection is installed in motor starters and disconnects.

C. Verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation. Align belts and reinstall belt guards.

D. Lubricate bearings, pulleys, belts and other moving parts with factory-recommended lubricants.

E. Verify manual and automatic volume control, and fire and smoke dampers in connected ductwork systems are in the full-open position.

END OF SECTION

23 37 00 AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 Air outlet and inlet devices include grilles, registers, diffusers, louvers and special air diffusion devices associated with ceiling and lighting systems.

1.2 Refer to the schedule on the drawings for description, catalog numbers, materials, finishes, accessories, mounting and other details of the devices required.

1.3 Supply air devices in ceilings shall have their backsides externally insulated for condensation control. This external insulation shall be field installed, same as that specified for supply air ductwork, minimum R-4.2 mineral fiber with foil jacket.

PART 2 - PRODUCTS

2.1 Air distribution devices other than louvers and specialty products shall be Titus, Tuttle & Bailey, Kreuger, or Price. All devices of a common type shall be by the same manufacturer.

2.2 Air outlet and inlet devices shall be equal to those specified by catalog number and description in the schedule on the drawings. Dampers shall be galvanized steel, unless otherwise noted, opposed blade configuration. Damper operators shall be concealed screw type. An auxiliary mounting frame shall be furnished with each grille and register except those mounted on exposed ducts or in lay in application.

PART 3 - EXECUTION

3.1 Verify & ensure compatibility of ceiling mounted devices with the ceilings and suspension systems (lay in, concealed spline, plaster, drywall, etc.). Verify with the architectural drawings.

3.2 Carefully align square and rectangular devices with the vertical and horizontal building lines. Diffusers shall be attached rigidly to the ductwork. Where connected by flexible ducts, special supports shall be provided as required, either from the ceiling suspension system or by independent suspension wires or rods from the building structure.

3.3 Externally insulate the backsides of supply air devices that are mounted in ceilings and not internally insulated. Insulation shall comply with 23 07 13 DUCT INSULATION.

3.4 Inside of ducts behind grilles, registers and diffusers shall be painted flat black, as needed, to eliminate the sight of shiny surfaces.

END OF SECTION

23 81 19 SELF-CONTAINED AIR CONDITIONERS ROOFTOP

PART 1 - GENERAL

1.1 The heating and cooling units shall be factory packaged rooftop cooling-heating units with circulating fan, electric heating section, and air cooled refrigeration section Units shall be grade mounted.

1.2 Units shall be tested and certified by UL or ETL to conform to applicable ANSI standards.

1.3 Shop drawing submittals shall include detailed control sequences for the unit controller that are intended to comply with the specifications and drawings. A document with listed control methodologies and options with the selected ones indicated as being provided is acceptable. A document that shows control methodologies and options available without an indication of which are being provided is NOT acceptable and will be a basis for rejection.

A copy of the Approved Submittal shall be sent to the Start-up Technician and the BAS Contractor for coordination.

A copy of the Start-up report that indicates what sequences have been programmed shall be submitted for review and record purposes.

1.4 Equipment shall carry an all-inclusive manufacturer's parts and labor warranty for a period of two (2) years (5 years for compressor and related refrigerant system, and furnace heat exchangers) from date of final acceptance or date of beneficial use, as agreed to between Contractor and Nexus Engineering Group. Any materials, equipment, or controls found to be defective during this warranty period shall be made good without expense to the Owner, including any required replacement of fluids, glycol or refrigerant. The warranty shall include a delayed start-up provision such that the warranty does not begin at time of delivery. The labor for the warranty shall be performed by the manufacturer's authorized service agent.

1.5 Mechanical equipment, appliances and supports that are exposed to wind shall be designed and installed to resist the wind pressure determined in accordance with the building and mechanical code.

PART 2 - PRODUCTS

2.1 Unit shall be specifically designed for outdoor installation on grade, completely factory assembled and tested, piped, internally wired and shipped in one piece. Units are direct expansion cooling with 100 percent economizer capability (including relief air), enthalpy controller. Provide non-fused disconnect switch and all operating and safety controls, furnished factory installed. All units shall be factory run tested.

2.2 Unit casing shall be constructed of aluminum or galvanized steel, finished with two coats of weather resistant paint. The entire casing shall be internally insulated with minimum 1" thick fiberglass insulation with foil facing, no exposed edges. Provide hinged access panels for access to filters, unit control panel, supply and exhaust fans and other components needing service. Refrigeration components and compressor shall be accessible through hinged doors or removable panels. All access doors and panels shall be double wall construction with neoprene gaskets. Roof assembly curved or cross broken for natural drainage. All exterior seams shall be filled with sealant. The floor casing shall be double wall and insulated.

2.3 Units shall be grade-mounted arranged for horizontal air discharge and return and shall be set on a concrete pad.

2.4 Indoor air circulating fan shall be forwardly curved centrifugal type with resiliently mounted motor, belt drive and adjustable pulley, and meet NEMA premium efficiency for over 1 hp or an ECM for 1 hp and under. Note particularly fan duty and HP requirements listed on the drawings.

2.5 Heating section shall be electric resistance type complete with operating and safety controls. Heating elements shall be 80 percent nickel – 20 percent chromium open coil resistance wire with insulators, stainless steel terminals, support brackets and galvanized steel frame. Each stage shall be extended over the full face of the coil. An equalizing plate shall be incorporated upstream of the heating elements.

2.6 Refrigeration section shall consist of compressor(s), evaporator coil, condenser coils, condenser fans, refrigerant piping and devices. The compressor system shall be five stage scroll type with spring mounting. Coils shall be aluminum fins bonded to copper tubes, all joints brazed, and shall have a minimum of two refrigerant circuits intertwined over the full face of the coil. Coils that are face-split or row-split are not acceptable. Condenser fans shall be direct driven propeller type with wire guards.

2.7 Units shall be rated under ANSI/AHRI Standards and shall have minimum Energy Efficiency Ratings as specified below. Multiple or variable speed compressor units shall achieve this rating at high speed.

Size (cooling)	Heat Source	Rating Condition	Min Efficiency
240,000 – <760,000 Btuh	Electric	AHRI 340/360	11.4 IEER

2.8 Motors 1 HP and larger shall be "premium efficiency" series motors. Motors connected to VFD's shall be furnished with AEGIS SGR shaft grounding ring kit, installed by the equipment manufacturer. Refer to Section 23 05 13 Electrical Requirements for HVAC Equipment.

2.9 Filters shall be 2" MERV 8 and 4" MERV 13 throwaway media filters.

Furnish one complete initial set of filters and one complete set of spare filters for each filter bank in the project. This is in addition to filters used for temporary heating.

2.10 Return air and outside air dampers and modulating controls shall be arranged for minimum outside air intake and up to 100 percent outside air while in economizer cycle. Control package shall include a fully modulating return air/outside air electric damper operator, automatic enthalpy changeover control and adjustable mixed air thermostat. Also provide an Economizer Diagnostics Package that will initiate a local alarm indicating economizer malfunction. All dampers shall be neoprene or extruded vinyl edged for tight sealing. Outside air and relief air openings shall be weather protected and equipped with bird screening.

2.11 Units shall be furnished with exhaust fan and damper for powered venting up to full specified supply fan cfm, controlled in conjunction with the economizer cycle.

2.12 The unit shall be provided with an electronic system of controls for refrigeration, electric heater, relief fan/damper, and supply fan mounted in a unit control panel, wired and tested in the factory. Magnetic starters with overload protection shall be provided for each motor.

2.13 The unit shall be capable of BACnet communications interface to allow the unit to communicate directly with a generic open protocol BACnet MS/TP Network Building Automation System Controls.

2.14 Units shall be manufactured by Daikin, Trane, JCI, or Carrier .

PART 3 - EXECUTION

3.1 Provide a concrete pad for grade mounted units. The supply duct housing shall be set on the pad, caulked air-tight and the unit set on the housing.

3.2 Provide condensate drainage piping from the drain pan with a deep trap and cleanout as detailed on the drawings.

3.3 Coordinate power wiring with Division 26 thru a non-fused disconnect switch to one set of power terminals in each unit. Provide all additional power and control wiring required for the completion of the systems. All wiring shall be run in 0.50 inch and larger conduit in accordance with applicable provisions of Division 26.

END OF SECTION

23 81 25 COMPUTER ROOM AIR CONDITIONERS (CEILING AIR COOLED)

PART 1 - GENERAL

1.1 Each air conditioning system shall consist of an indoor horizontal evaporator unit and an outdoor air cooled condensing unit. The indoor unit shall be arranged for suspended mounting with ducted supply and return air. The condensing unit shall be mounted on grade per manufacturers recommendations.

1.2 Refer to the HVAC drawings for capacities and performance data.

1.3 Refer to the Division 23 and 26 drawings and specifications for electrical power feeds. Compare unit requirements to feeder sizes shown. Refer to 23 05 13 Electrical Requirements for HVAC Equipment.

1.4 Equipment shall carry an all-inclusive manufacturer's parts and labor warranty for a period of two (2) years (5 years for compressor and related refrigerant system) from date of final acceptance or date of beneficial use, as agreed to between Contractor and Nexus Engineering Group. Any materials, equipment, or controls found to be defective during this warranty period shall be made good without expense to the Owner, including any required replacement of fluids, glycol or refrigerant. The warranty shall include a delayed start-up provision such that the warranty does not begin at time of delivery. The labor for the warranty shall be performed by the manufacturer's authorized service agent.

PART 2 - PRODUCTS

2.1 Air conditioning system shall be Liebert Mini-MATE 2 or equal by Data Aire, Mitsubishi, or Daikin.

2.2 The indoor evaporator unit shall consist of:

A. Cabinet shall be heavy gauge galvanized steel designed for mounting above the ceiling with ducted supply and return air

B. Air filter shall be disposable 30 percent minimum pleated panel filter, efficiency conforming to ASHRAE 52-76.

C. Evaporator fan section shall consist of a direct drive, double inlet centrifugal fan with two-speed motor. Motor shall be permanent split capacitor, premium efficiency type, and shall have integral overload protection.

D. Evaporator coil shall be refrigerant type with copper tubes and aluminum fins, externally equalized thermostatic expansion valve, filter dryer, and a stainless steel condensate drain pan. A factory installed float switch shall be provided in drain pan to prevent overflow in high water conditions.

E. Electric reheat coil shall be finned tubular construction with thermal safeties.

F. Condensate pump, consisting of integral float switch, discharge deck valve, sump, pump, motor and automatic control shall be field mounted on the side of the unit cabinet. A secondary float switch shall be provided to shutdown the evaporator upon high water level conditions.

2.3 The air cooled condensing unit shall be designed for remote exterior mounting. The unit shall consist of:

A. Scroll compressor, pressure safety switches, sight glass, moisture indicator and service valves with charging ports.

B. Direct driven propeller fan, variable speed motor, copper tube and aluminum fin condenser coils, aluminum cabinet and wire guard on fan discharge.

C. Control panel, factory wired and tested, with transducers for fan speed head pressure control, thermostat and control circuitry. The fan speed head pressure control system shall provide positive start-up and low ambient temperature operation down to 10 degF.

2.4 Control system shall be microprocessor based with wall mounted monitor panel, to afford system control, monitoring and alarming. The panel shall have an operator interface and LCD display.

A. Controls shall include:

1. Temperature and humidity control, set-point and sensitivity adjustment and temperature and humidity anticipation.
2. Compressor short cycle control.
3. Automatic system restart after power failure with adjustable time delay.

B. Monitoring shall include:

1. On-off indication.
2. Fan speed indication.
3. Readouts of temperature, humidity, day and time.
4. Operating mode indication (cooling, heating, humidification and de-humidification).

C. Contacts for “general alarm” for monitoring by the building automatic temperature controls shall be provided. Local alarms shall be both audibly sounded and visually displayed for high and low temperatures and humidities.

2.5 Pre-charged refrigerant line set with suction line insulation shall be provided between the indoor evaporator unit and the condensing unit.

2.6 Air conditioning units shall be rated under AHRI 1360 and shall have minimum Energy Efficiency Ratings as specified below.

Condenser remote exterior mounted

Size (Ducted)	Rating Condition	Minimum Efficiency
< 29,000 Btu/h	75°F/52°F (Class 1)	2.05 COP
29,000 - <65,000 Btu/h	75°F/52°F (Class 1)	2.02 COP
65,000 Btu/h and greater	75°F/52°F (Class 1)	1.92 COP

Size (Nonducted)	Rating Condition	Minimum Efficiency
< 29,000 Btu/h	75°F/52°F (Class 1)	2.08 COP
29,000 - <65,000 Btu/h	75°F/52°F (Class 1)	2.05 COP
65,000 Btu/h and greater	75°F/52°F (Class 1)	1.94 COP

PART 3 - EXECUTION

3.1 The indoor evaporator unit, condensing unit, piping, controls and accessory items shall be installed in accordance with the manufacturer's instructions. Locate the equipment so as to afford adequate service space. Hang the unit with hanger rods, Type J1 from the structure.

3.2 Refer to the drawings for mounting of the condensing unit and routing of refrigerant piping. Refer to Section 23 23 00 Refrigerant Piping.

3.3 Provide a drain pipe with trap from the unit drain pan and extend to the condensate pump mounted on the side of the unit. Extend piping from the pump discharge to a floor drain or other point of discharge as shown on drawings.

3.4 The system shall be checked, started, tested and adjusted by a factory trained service agent of the manufacturer prior to operation.

END OF SECTION

23 81 28 DX MINI SPLIT SYSTEMS – AIR-COOLED

PART 1 - GENERAL

1.1 The heating-cooling systems shall be variable capacity, DX split heat pump systems. The systems shall consist of indoor fan coil unit(s) matched to outdoor air-cooled heat pump condensing unit(s), singularly or multiple indoor units on a single outdoor unit, and associated controls. Refer to drawings for capacities and arrangements.

1.2 The design is based on Trane / Mitsubishi equipment. The other manufacturers listed in Part 2 are acceptable manufacturers but shall include in their bid price all necessary revisions from the basis of design required to install their system, including but not limited to variations in electrical services, branch controllers, pipe sizing, quantities and arrangements.

1.3 Equipment shall be rated in accordance with ARI 210/240 and so labeled, and shall be Listed by UL or ETL and so labeled.

1.4 The condensing units shall be factory charged with R-410A refrigerant.

1.5 Provide a set of spare filters for each indoor unit.

1.6 The systems shall carry a five (5) year warranty from date of installation. In addition, the compressors shall be covered by the manufacturer's limited warranty for a period of seven (7) years from date of installation. If, during these periods, any part shall fail to function properly due to defects in workmanship or material, it shall be replaced or, at the discretion of the manufacturer, repaired. The 2nd thru 5th year and 2nd thru 7th year warranties do not include labor.

1.7 Refer to the HVAC and Electrical drawings for electrical power feeds. Compare unit requirements to feeder sizes shown. Refer to 23 05 13 Electrical Requirements for HVAC Equipment.

1.8 Installing contractor shall be factory trained and certified to install the systems. Training shall be documented by the manufacturer and certification shall be submitted for review with shop drawings, prior to the installation of the systems.

PART 2 - PRODUCTS

2.1 Each Air-Cooled Heat Pump Condensing Unit shall consist of:

A. General:

1. Each outdoor unit shall be specifically matched to the corresponding indoor unit size(s), factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of inverter scroll or rotary compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant regulator. High/low pressure gas line, liquid and suction lines, individually insulated between the outdoor and indoor units.
2. Accumulator with refrigerant level sensors and controls; high-pressure safety switch, over-current protection and DC bus protection.
3. High efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained.
4. Auto-charging feature and a refrigerant charge check function. The unit shall be capable of metering the refrigerant charge as additional refrigerant is added to the system and will calculate how much additional refrigerant is to be added to the system.

5. Oil recovery cycle shall be automatic occurring after start of operation and then at re-occurring intervals during unit operation.
6. Cooling operation down to 23 degF dry bulb ambient temperature. Provide accessories as necessary to achieve the low ambient operation.
7. Heating operation down to 5°F dry bulb ambient temperature. Manufacturers that cannot provide heating operation at 5°F shall provide supplemental electric heat or additional low ambient heating components in the condensing unit to allow for operation down to 5°F. All additional engineering, electrical, and installation costs shall be by the unit manufacturer.
8. The system shall automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for re-programming.
9. Unit shall have a sound rating no higher than 60 dB(A) measured at 3 feet from any side of the unit.

B. Cabinet shall be fabricated of galvanized or rust-proofed steel, bonderized and finished with a powder coated baked enamel. The outdoor unit shall come furnished with four (4) mounting feet, mounted across the base pan, to allow bolting to an equipment pad.

C. Condenser fans shall be statically and dynamically balanced direct drive, variable speed propeller type. Fan motor shall have inherent protection, permanently lubricated bearings, and be completely variable speed. Fan motor shall be mounted for quiet operation. Fan shall be provided with a raised guard to prevent contact with moving parts. Provide high static motors for units installed indoors.

D. Condenser coils shall be copper or other nonferrous construction with corrugated fin tube. The fins shall be aluminum or covered with an anti-corrosion acrylic resin and hydrophilic, rated for up to 500 hours salt spray. Automatic defrost shall remove any frost from the outdoor unit allowing the system to maintain heating capacity.

E. Compressor

1. Compressors shall be inverter scroll or rotary type, inverter-driven variable speed, capable of changing the speed to follow the variations in total cooling and heating load.
2. Each compressor shall be equipped with a crankcase heater (if required for specified design and operating conditions), high pressure safety switch, and internal thermal overload protector.
3. The capacity control range shall be minimum 10% to 100%.
4. Compressor assembly shall be installed on vibration isolators.
5. The following safety devices shall be included on the condensing unit: high pressure switch, control circuit fuses, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.

F. Units shall be rated under AHRI 210/240 and 340/360. Single-Phase heat pump units shall meet or exceed the DOE requirement of 14 SEER and 8.2 HSPF.

Note: Shop drawing submittals shall include AHRI ratings to show compliance with the requirements.

2.2 Fan Coil Units

A. Concealed Ducted Units:

1. General

a. Concealed indoor units shall be ducted fan coil type, suspended from structure above the ceiling utilizing neoprene isolators, with front discharge air duct collar and filtered back for supply and return ductwork as shown on the drawings.
b. Units shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, time delay mechanism, and an auto restart function.
c. Refer to drawings for required capacities

2. The cabinet exterior shall be 18 gauge galvanized steel. The interior of the cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation
3. Fan shall be an assembly with one or two fans direct driven by a single motor. The fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. Airflow rate adjustment shall be available via thermally protected 3-speed motor.
4. High-efficiency 1" MERV 13 filters in the return air, back mounted per the duct layout.
5. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing, minimum 3-rows. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed and pressure tested at the factory. A drip pan under the coil shall have an internal trap and auxiliary pan under the coil header.
6. Electrical Requirements
   a. Unit shall operate on 115 volt, 208 volt, or 230 volt, 60 Hz single-phase power supply as specified on the equipment schedule. Power and control connections shall have terminal block connections
7. Controls
   a. Controls shall consist of a microprocessor-based control system, which shall control space temperature, determine optimum fan speed, and run self-diagnostics. The space temperature control range shall be from 64F to 84F.
   b. Provide hard wired wall-mounted local programmable controller with integral space sensor for each unit, with features as specified in the "Controllers" paragraph below.
   c. Controls shall be 24 volt, and shall be easily operated by the user from the wall-mounted local controller.
8. Accessories
   a. Condensate Overflow Switch -- A level sensor on the condensate pan shall stop cooling operation and alarm if the level in the condensate pan is near overflow condition.
   b. Condensate Pump – Provide a factory-furnished UL 2043 plenum-rated condensate pump and sensing unit compatible with the fan coil voltage to remove condensate from the drain pan. Pump shall be thermally-protected (auto reset) and designed for quiet operation (less than 27 dBA) and consist of two parts: a reservoir/sensor assembly, and a remote sound-shielded pump assembly. The lift capability of the condensate pump shall be minimum 18". Pump shall be powered and wired from the fan coil unit power connection, downstream of safeties.
   c. Provide mixing boxes of physical size to match basic unit, and include equal-sized flanged openings capable of handling full air flow. Arrange openings as indicated on drawing sheets. Provide dual action parallel dampers for return air with sealing edges, arranged to operate automatically with one set of linkage. Provide parallel blade damper for outside air directed towards the return air stream for reduced stratification. Provide dampers of balanced construction, rotating in sintered bronze or nylon bearings.

2.3 Controllers:

A. Local Controllers (Room Thermostats)

1. Wall mounted local remote controllers (thermostats) shall be provided to allow the user to change on/off, temperature setting, and fan speed setting for each fan coil unit. The room

temperature shall be sensed at this wall mounted remote controller (thermostat) unless noted otherwise. The controller shall display a four-digit error code in the event of system abnormality/error.

2. The Local Controller shall be mounted into a standard 2" x 4" junction box.
3. Unit Display
   a. The Local Remote Controller shall be a backlit LCD display with contrast adjustment.
   b. The controller shall display On/Off Status, Operation Mode, Setpoint, and Fan Speed. The controller shall display temperature setpoint in one degree increments with a range of 60-90 degF. On/Off status shall be displayed with an LED.
   c. Error codes shall be displayed in the event of system abnormality/error.
   d. The following system temperatures shall be capable of being displayed to assist service personnel in troubleshooting:
      1) Return air temperature
      2) Liquid line temperature
      3) Gas line temperature
      4) Discharge air temperature (if available on the unit)
      5) Remote temperature sensor temperature (if applicable)
      6) Indoor space temperature setpoint
4. Operation
   a. The controller shall be capable of controlling a group of indoor units coupled to a common outdoor unit. Refer to drawings for groupings. The following operation groups shall be controlled:
      1) On/Off, Operation Mode (Cool, Heat, Fan, and Dry)
      2) Independent cooling and heating setpoints in the occupied mode
      3) Independent cooling setup and heating setback
      4) Fan speed
      5) Airflow direction
      6) The controller shall be able to limit the user adjustable setpoint ranges individually for cooling and heating in the occupied period
      7) Lock out key settings
5. Program Functions
   a. Controller shall support schedule settings with selectable weekly pattern options.
      1) Seven day week
      2) Weekday + weekend
      3) Weekday + Saturday + Sunday
      4) Independently settable Cooling and/or Heating setpoints when unit is on (occupied).
      5) Setup (Cooling) and Setback (Heating) setpoints when unit is off (unoccupied)
      6) A maximum of 5 operations schedulable per day
      7) Time setting in 1-minute increments.
   b. The Controller shall support auto-changeover mode allowing the optimal room temperature to be maintained by automatically switching the indoor unit's mode between Cool and Heat according to the room temperature and temperature setpoint.
      1) Changeover to cooling mode shall occur at cooling setpoint + 1oF .
      2) Changeover to heating mode shall occur at heating setpoint - 1oF .
   c. The Controller shall support an Auto-Off-Timer for temporarily enabling indoor unit operation during the unoccupied period.
      1) When the Off Timer is enabled and when the unit is manually turned on at the remote controller, the controller shall shut off the unit after a set time period.
      2) The time period shall be configurable in the controller menu with a range of 30-180 minutes in 10 minute increments.
   d. The space temperature shall be sensed at the local controller unless noted otherwise to be in the return air of the unit or as a remote temperature sensor.

2.4 Refrigerant Piping:

A. Refrigerant piping shall be copper tubing conforming to ANSI B31.5 and ASTM B280. Refrigerant piping systems and components shall be engineered, installed, tested and placed in operation in accordance with ASME B31.5, latest edition.

B. Copper tubing shall be Type ACR, hard-drawn straight lengths. Fittings shall be copper, UL or ETL tested to UL 207, and certified to a working pressure of 600 psig. All joints shall be brazed using silver brazing alloy while flowing an inert gas such as dry nitrogen through the piping. Copper tubing that is downstream of branch controllers and .625" size and smaller may be Type ACR soft annealed coils for lengths under 25 ft if approved by the equipment manufacturer. Refer to 23 23 00 for additional information.

C. Pipe arrangement, devices and sizing information shown on the drawings is limited due to variations in equipment manufacturers' requirements. The equipment supplier shall prepare project-specific drawings of each piping system showing numbers and sizes of piping, devices and accessories, coil circuitry, traps, double suction risers and other such detail required for the application shown on the drawings and as specified herein. Drawings shall be submitted to the Engineer for review with the equipment shop drawings.

D. The equipment supplier shall provide piping installation instructions to the Contractor and supervision as needed to ensure that the piping system is installed in accordance with the equipment manufacturer's recommendations.

2.5 The split systems shall be manufactured by Mitsubishi / Trane / Daikin / LG / Toshiba-Carrier / Samsung / JCI.

PART 3 - EXECUTION

3.1 Installers shall have received training by the manufacturer of the systems being supplied for the project. If they have not received training the system manufacturer shall schedule and perform required installation training.

3.2 Piping Installation

A. Pipe arrangement, devices and sizing information shown on the drawings is schematic in nature, limited due to variations in equipment manufacturers' requirements. The equipment supplier shall prepare project-specific drawings of each piping system showing numbers and sizes of piping, devices and accessories, coil circuitry, traps, double suction risers and other such detail required for the application shown on the drawings and as specified herein. Exact routing, and pipe quantities and sizing shall be per manufacturer's requirements. Refrigerant piping shall conform to ANSI B31.5 and ASTM B280. Refrigerant piping systems and components shall be engineered, installed, tested and placed in operation in accordance with ASME B31.5, latest edition. Drawings shall be submitted to the Engineer for review with the equipment shop drawings. Exact routing, and pipe quantities and sizing shall be per manufacturer's requirements.

B. At time of equipment submittal approval a piping diagram shall be provided by the equipment manufacturer to the Installing Contractor for each split system. The equipment manufacturer shall review the piping diagram with the Installing Contractor.

C. A copy of the Approved piping diagrams shall be kept at the jobsite.

D. The Installing Contractor shall update the piping diagrams with any field changes such as re-routing, shortening, lengthening or changing diameter of a pipe segment, adding or eliminating elbows and or fittings, resizing adding or eliminating indoor units, changing the mounting height, or moving the location of a device or fitting during installation. Those changes shall be

communicated to the equipment manufacturer PRIOR TO INSTALLATION. The equipment manufacturer shall review and provide written approval or required modifications prior to installation.

E. The equipment manufacturer shall update their Piping Program to an "As-Built" program. Proper refrigerant charge shall be calculated and communicated to the Commissioning/Startup Technician along with the As-Built piping program.

F. The equipment manufacturer's representative shall inspect the piping system prior to charging and start-up, and document their approval or required changes.

G. System shall be leak checked, evacuated and charged by the Installing Contractor. Refer to 23 23 00.

3.3 Control wiring shall be installed between indoor units, condensing units in strict accordance with the manufacturer's instructions. All control wiring shall be low-voltage plenum rated type.

3.4 Furnish and install all controls, wiring and accessories for a complete and operational system.

3.5 Locate equipment so as to afford adequate service space.

3.6 Condensing units shall be installed in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances. Set with Type A1 isolators and secure to a 6" reinforced concrete pad. Piping shall be connected utilizing flexible connectors.

3.7 Install fan coil units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances. For gravity drained units, provide a drain pipe with trap from fan coil drain pans and extend piping to a floor drain or other point of discharge as shown and terminated per the Code. For fan coils fitted with condensate pumps, install pump and sensing devices in evaporator condensate drain piping, and provide and/or extend power and control and safety wiring, all in strict accordance with the manufacturer's instructions. Condensate piping shall be extended to a floor drain or other point of discharge as shown and terminated per the Code.

3.8 Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26. Do not proceed with equipment start-up until wiring installation is acceptable to equipment Installer.

3.9 The system shall be checked, started, tested, adjusted and commissioned by a factory trained service agent of the manufacturer prior to operation. The unit manufacturer will be responsible for the start-up, programming, and commissioning of the entire variable refrigerant volume system. Manufacturer shall test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

3.10 Provide services of manufacturer's technical representative for 2 days to instruct Owner's personnel in operation and maintenance of units. Schedule training with Owner.

3.11 In addition to the adjustments and fine tuning, the Contractor shall include as a part of this contract the equivalent of three (3) man days of service technician time for work as may be specified by the Engineer.

3.12 The control equipment supplier shall provide 4 hours of instruction and training of the Owner's personnel regarding the hardware and software of the system. Software training shall include

programs, methods of programming, control loops, scheduling and reports. Site training classes shall not be scheduled for longer than 4 hours duration except at the discretion of the Owner. Contractor shall videotape the demonstrations and make copies available to the Owner.

END OF SECTION