DIVISION 23 – HVAC

Dayton Children’s
Home Care Pharmacy Renovation

Heapy Engineering
Mechanical Electrical Commissioning Technology
Dayton, Ohio  Project No. 2019-05025

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MAY, 2019
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 M series drawings, and as specified in Division 23 and elsewhere in the project documents.

C. The project drawings and specifications define scope of work for the various divisions. Such assignments of work are not intended to restrict the Construction Manager 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 the Architect / Construction Manager 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 the Architect / Construction Manager 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 the Architect / Construction Manager 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. The Architect / Construction Manager 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. The Architect's / Construction Manager’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 the Architect / Construction Manager. In such event, none of the trades or their suppliers shall assume that he is relieved of the work which is specified under his branch until instructions in writing are received from the Architect / Construction Manager.

1.5 Asbestos Materials

A. Abatement, removal or encapsulation of existing materials containing asbestos is not included in the Division 23 Contract. Necessary work of this nature will be arranged by the Owner / Construction Manager to be done outside of this construction and remodeling project by a company regularly engaged in asbestos abatement. Such work will be scheduled and performed in advance of work in the construction and remodeling project.

B. If, in the performance of the work, materials are observed which are suspected to contain asbestos, the Contractor shall immediately inform the Architect / Construction Manager 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.

C. 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 the Architect 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 the Architect / Construction Manager. 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 two / three copies each 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 and water balance reports and as-built automatic temperature controls drawings and specifications shall also be included.

D. These shall be assembled into three-ring loose leaf binders or other appropriate binding. An index and tabbed sheets to separate the sections shall be included. These shall be submitted to the Engineer and Construction Manager for review. Upon approval, manuals shall be turned over to the Owner.

1.10 Final Inspection and Punch List

A. As the time of work completion approaches, survey and inspect Division 23 work and develop a punch list to confirm that it is complete and finished. Then notify the Architect and Construction Manager and request that a final inspection be made. It shall not be considered the Architect's or Engineer's obligation to perform a final inspection until the Contractor has inspected his work and so states at the time of the request for the final inspection.

B. Requests to the Architect, Engineer or Construction Manager for final inspection may be accompanied by a limited list of known deficiencies in completion, with appropriate explanation and schedule for completing these; this is in the interest of expediting acceptance for beneficial occupancy.

C. The Architect and/or Engineer will inspect the work and prepare a punch list of items requiring correction, completion or verification. Corrective action shall be taken to the satisfaction of the Architect and Engineer within 30 days of receipt of the Architect/Engineer's punch list.
1.11 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 Architect or Construction Manager. 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 the Architect 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 the Architect or 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. Ductwork.
   2. Ductwork supports.
   3. Ductwork insulation.
   4. Electric heating coils.
   5. Unit heaters.
   6. Fans.
   7. Roof ventilators.
   8. Air filters.
   10. Air control terminal units / dampers
   11. Air Control Valves
   12. Variable air volume/temperature control system.
   13. Air outlets and inlets.
   14. Variable Frequency Drives
   15. Automatic Temperature Controls.
PART 3 - EXECUTION

3.1 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.

C. Test relief valves, air vents and regulating valves to ensure proper operation.

3.2 Operating Demonstration and Instructions

A. Set the various systems into operation and demonstrate to the Owner and Construction Manager 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.

3.3 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
PART 1 - GENERAL

1.1 The Engineer, at his 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
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):

Recipient Address:

Name of authorized Recipient Representative: 

Title of authorized Recipient Representative: 

E-mail address of authorized Recipient Representative: 

Signature of authorized Recipient Representative: 

Date: 

Provider (Name of Company):

Recipient (Name of Company):

Recipient Address:

Name of authorized Recipient Representative: 

Title of authorized Recipient Representative: 

E-mail address of authorized Recipient Representative: 

Signature of authorized Recipient Representative: 

Date: 

Provider (Name of Company):

Recipient (Name of Company):

Recipient Address:

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):

[ ] CD-ROM [ ] DVD-ROM [ ] Heapy FTP [ ] User’s FTP site [ ] Flash Drive

C. Delivery of Electronic Files Cost Summary:

Available electronic Revit file format:
[ ] 2018 .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 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 shall not be allowed. Provide portable spot heaters and coolers to maintain interior conditions as defined by the General Contractor / Construction Manager. Coordinate power requirements with the electrician. Provide temporary drains and ducts as needed.

   Cover all supply and return openings. When air balancing the permanent systems, all dust producing operations need to have ceased. Clean any ductwork or equipment that becomes dusty or dirty.

1.2 Continuity of Services
   A. Work shall be so planned and executed as to provide reasonably continuous service of existing systems throughout the construction period. Where necessary to disrupt services for short periods of time for connection, alteration or switch-over, the Owner and Construction Manager shall be notified in advance and outages scheduled at the Owner's reasonable convenience.
   B. Submit, on request, a written step-by-step sequence of operations proposed to accomplish the work. The outline must include tentative dates, times of day for disruption, downtime and restoration of services. Submit the outline sufficiently in advance of the proposed work to allow the Architect or Engineer and Construction Manager to review the information with the Owner. Upon approval, final planning and the work shall be done in close coordination with the Owner.
   C. Shutdown of systems and work undertaken during shutdown shall be bid as being done outside of normal working hours.

PART 2 - PRODUCTS

2.1 Access Panels
   A. Provide ceiling and wall access panels where indicated on the drawings, or where otherwise required to gain access to concealed valves, traps, devices and equipment requiring service or adjustment.
   B. Access panels shall be steel construction (except where aluminum or stainless steel is specified) with concealed hinge and door with screwdriver lock. Panels shall be 18 inches x 18 inches size unless larger panels are shown or required. Mounting frames shall be compatible with the material in which they are installed. Access panels shall be:

      1. Standard flush type with overlapping flange for masonry and tile walls, Milcor Style “M” or equal.
      2. Recessed type having the door recessed to accept a drywall panel insert, for drywall ceilings and walls, Milcor Style “ATR” or equal.
C. Access panels in fire rated shaft walls and in fire rated ceilings shall be "B" label or greater to match the rating of the wall or ceiling.

D. Materials used in plenums shall be rated for plenum use conforming to the ASTM E84 25/50 smoke development and flame spread restrictions.

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 Architect and 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 the Architect or Construction Manager.

B. The Owner's property and the property of other contractors shall be scrupulously 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 the Architect or Construction Manager. 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 and Construction Manager regarding all removal and remodeling work. Unless otherwise noted, remove existing work which is associated with Division 23 and which will be superfluous when the new work is installed and made operational.

C. Extraneous ductwork and piping which is or becomes accessible shall be removed and stubs shall be capped at the first active duct or pipe encountered. Ductwork and piping that is and remains inaccessible shall be abandoned. Ends of abandoned duct and pipe shall be capped so as to be concealed by finished surfaces. Upon completion of the work no abandoned duct, pipe, valve or stub shall extend thru finished floors, walls or ceilings.

D. When it is necessary to reroute a section of active ductwork or piping the rerouted section shall be installed before removing the existing in order to minimize system down time. Rerouted sections shall be insulated as required for new work. Patch insulation on existing ductwork and piping which has been damaged or removed in this work.

E. 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.

F. Remove, store and reinstall lay-in ceiling tile and grid as needed to perform work in areas where such removal and re-installation is not to be done by others. Damaged tile and/or grid shall be replaced with new matching tile and/or grid.

G. In areas of minor work where the space is not completely vacated, temporarily move portable equipment and furnishings within the space as required to complete the work. Coordinate this activity with Owner / Construction Manager. Protect the Owner's property by providing dust covers and temporary plastic film barriers to contain dust. Remove barriers and return equipment and furniture upon completion of the work.

H. 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 which is not factory or shop painted or galvanized and which remains exposed to view in the finished areas of the building shall be given a prime coat of paint and two finish coats of paint.

2. 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 paint.
3. 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.

4. Apply Z.R.C. Galvilite cold galvanizing compound or approved equal, for touch-up of previously galvanized surfaces.

5. Inside of ducts, behind grilles and registers, shall be painted flat black to eliminate the viewing of shiny 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 except where otherwise required under remodeling work. Refer to the Cutting and Patching paragraph in this Section for finishing requirements.

3.6 Access Panels

A. Install access panels or pay general trade to do so. Final appearance is subject to approval by the Architect or Engineer.

B. Location of access panels shall be planned to clear ceiling lights, ceiling support grids and other obstructions so as to allow, wherever possible, full shoulder clearance beside the device to be inspected, adjusted or repaired.

C. Panels with recessed doors are to be fitted with insert panels of drywall or, those for plaster, infilled with plaster. Caution the Installing Contractor to provide appropriate framing with drywall or plaster beading to ensure a finished appearance. Shim strips may be required to bring the insert panel flush with the plane of the door and wall / ceiling.

3.7 Miscellaneous Equipment Connections

A. Certain categories of fixtures and equipment, including kitchen equipment, sterilizers, washers, laundry and laboratory equipment, require piping connections and duct connections as shown on the drawings.

B. Make all final connections to these fixtures and equipment, as indicated and in accordance with the manufacturer's recommendations. All piping connections shall be valved and final connections made with unions.

C. For equipment served by steam, all steam supplies shall be dripped immediately ahead of the valves. Supply connections shall include, at a minimum, a shutoff valve, strainer, pressure and temperature gauges and a union. Factory furnished automatic valves shall also be installed. Condensate return connections shall include, at a minimum, a union, strainer, trap assembly, check valve and shutoff valve. Provide return traps in accordance with details shown on the drawings and as recommended by the equipment manufacturer. Steam pressure reducers and relief valves, where required, shall also be provided.

D. Hydronic connections to equipment shall be in accordance with manufacturers installation guidelines. Provide at each supply connection, at a minimum, a shut-off valve, strainer, pressure and temperature gauges, P/T test plug and a union. On each return connection provide a union, pressure and temperature gauges, P/T test plug and a shut-off valve. Also provide any additional accessories recommended by the equipment manufacturer.

E. Piping and devices connecting to equipment where exposed to view in the finished space shall be chrome plated, and insulation shall be omitted unless noted otherwise.
F. Roughing-in drawings shall be obtained for the various fixtures and items of equipment as the time approaches when such information is required; allow a reasonable period, from the time of notice, to obtain this information.

3.8 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
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 in OBC Chapter 1, Section 106 and Chapter 7, Section 712.

PART 2 - PRODUCTS

2.1 Firestopping materials shall be manufactured and/or supplied by Hilti.

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 05 07 Piping Materials and Methods for pipe sleeve requirements and treatment of penetrations not requiring firestopping. Refer to 23 31 13 HVAC Ductwork for duct sleeve requirements where firestopping is required.

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.

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, Square D by Spears Mechanical, 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 being provided as part of 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
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. Manual bypass
   1. Provide a manual bypass switch on motors 30 HP and above - drive and bypass shall be in a single enclosure. Provide a complete bypass of the controller to allow motor to start and stop via a bypass contactor (starter). Bypass design shall be 3 contactor arrangement, input contactor, output contactor and bypass starter. Bypass circuitry shall be supplied by the controller manufacturer as a part of the controller package. All safeties (smoke, freeze stats, motor overloads, etc.) shall remain functional in the bypass mode. Controller shall be able to start into a rotating load to facilitate transfer from bypass operation.
   2. All components, VFD, bypass, filtering shall be mounted in a common steel enclosure. Separate enclosures are not acceptable.

D. 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.

E. Serial Communications – The controller shall provide serial communication to the building automation system via one of the following protocols as coordinated with the BAS: LONWorks, BACnet, Modbus, Ethernet. The following data shall be shared between the drive and the BAS:

Analog Inputs – Speed Reference, Output Speed, Output Cement, KWH Meter, Output Power, Drive Temperature, PI Feedback, AC Output Voltage, DC Bus Voltage, Fault Code, Elapsed Time-Hours, Megawatt Horn Meter, Drive Rated Current, Communication Error Code, PI Deviation, PI Output Capacity, PI Reference, Last Fault Code, Frequency Reference @ Fault, Output Frequency @ Fault, Current and Voltage @ Fault, Operation Status @ Fault, Elapsed Operation Time @ Fault.


Provide all software and hardware necessary to complete the interface to the BAS. Provide the temperature controls installer with all necessary electronic files including XIF and object files. Provide on-site assistance to the temperature controls installer for programming, checkout, start-up and commissioning.

F. NEMA 1 Enclosure - Controllers located indoors or in a conditioned environment shall be provided in a ventilated enclosure intended for indoor use.
G. 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 ATC 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 wall mounted, unit mounted, or mounted on unistrut framing system.

3.5 Refer to “Identification” Paragraph for nameplate requirements.

3.6 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.

3.7 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 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 125 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 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 project's 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 4” 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. 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 Rooftop heating cooling units shall be roof curb mounted. Curbs shall be furnished with the equipment and meet the following requirements:

A. The roof curb shall be 24” minimum height. Gasketing shall be furnished for field installation to ensure a weather-tight condition. For sloped roofs, the roof curb shall be sloped to match the roof slope to provide a level unit support. The roof curb shall be consistent with the footprint of the unit, including the piping cabinet and other unit components.

B. Minimum 2” continuous internal insulation.

2.5 Refer to 23 34 00 HVAC Fans for roof curb 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.

END OF SECTION
23 05 31   HVAC EQUIPMENT DRIVES

PART 1 - GENERAL

1.1 Belt driven equipment shall be provided with pulleys and drive belts as specified and as required for the service.

1.2 Exposed pulleys, belts, drives and couplings shall be protected with guards in accordance with OSHA requirements.

1.3 Unless noted otherwise adjustable frequency motor controllers (VFD’s) shall be provided under Division 23. Refer to specification section 23 05 14 Adjustable Frequency Motor Controllers.

PART 2 - PRODUCTS

2.1 Drive belts shall be "V" type unless another design is standard for the equipment manufacturer. Belt drives shall have a capacity rating of at least 150 percent of the motor horsepower.

2.2 Drive pulleys shall be adjustable unless a fixed pulley is specified. Adjustable drive pulleys shall be selected near the mid-point of range.

2.3 Drive guards in the air stream of fans shall be flattened expanded metal which does not appreciably restrict air flow.

PART 3 - EXECUTION

3.1 Pulleys and belts shall be aligned, pulleys adjusted and belt tension set for proper operation and specified duty.

3.2 Provide a drive change-out (sheaves, pulleys and, if necessary, belts) when, during final air balancing, it is deemed necessary to attain the specified air quantity and/or the desired performance. The Engineer shall have final say as to whether or not a drive change-out is required.

END OF SECTION
IDENTIFICATION OF HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

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

1.2 Each item of major equipment shall be labeled. This shall include air handling units, fans, air terminal units, heating coils, air filters, 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 Each shutoff valve, other than at equipment, shall be identified with a stamped tag. Valves and tagging shall be scheduled typewritten on 8.50 inches x 11 inches paper, tabulating valve number, piping system, system abbreviation, location of valve (room or area) and service (e.g. - South wing reheat boxes).

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

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

1.8 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 1 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 Underground line marker tape shall be permanent bright-colored, plastic with continuous identification lettering. Tape over service lines that cannot be detected by a metal detector shall be multi-ply with an aluminum foil core.

2.6 Valve tags shall be polished brass or plastic laminate with solid brass S hook. Tags shall be engraved with "H" (for HVAC) and the designated number.

2.7 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. Exhaust fan labeling shall also indicate service or room or area of service.

3.5 Pipe and 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.

3.6 Refer to appropriate sections of this specification for installation of underground line marker tape.

3.7 Valve tags shall be placed on each valve except those intended for isolation of individual items of equipment. Valve tag schedules shall be prepared as specified above. Copies of one set of schedules shall be laminated in clear plastic and placed where directed by the Owner. Other sets shall be included in the Operating and Maintenance Manuals.

END OF SECTION
23 05 93  TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 Provide air and water balancing of the new systems and existing systems affected by the new work. Balancing work shall be performed by qualified personnel of a member firm of the Associated Air Balance Council (AABC), 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 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 Architect or Construction Manager for review.

1.5 When project is in phases and partial occupancy is planned, determine process to allow balancing work to be completed before occupancy.

1.6 Refer to Section 23 05 31 HVAC Equipment Drives and other Sections of Division 23 for requirements related to the balancing work.

1.7 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. Refer to SMACNA Guide 2.6.1 for items to be included in system check.

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. The balance report shall include a detailed balance report for Critical Spaces to show compliance with the latest edition of ASHRAE 170 and USP 797 and 800 with respect to pressure relationships and total air change rates. These Critical Spaces shall be balanced to within 10% of the CFM’s specified on the drawings but no less than the required Total Air Change Rate required by ASHRAE 170 and USP 797 and 800. These Critical Spaces shall include all rooms with a room pressure monitoring system, Hazardous Compounding, Non-Hazardous Compounding, Ante-Room, and Air Lock. The information provided in the report shall include:

1. Pressure difference to all adjacent spaces.
2. Diagram of the room layout with dimensions including approximate locations of air devices in the room.
3. Quantity of Total air changes achieved.
4. Ceiling Height
5. Room area
6. Room Volume

H. 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.

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

J. 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.

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

L. Total air quantities of the supply fan, and the return fan, 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 automatic volume control devices at the fans fully open / variable speed drives at full speed. Refer to item F. above for drive changeout requirements and the items below.

M. For variable-air-volume systems, develop and implement a plan to simulate diversity.

N. 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.

O. Check for airflow blockages.
P. Check for proper sealing of air-handling unit components. Report all issues in balancing report.

Q. 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 Construction Manager.

R. In balancing of variable air volume systems, the total air quantity of the devices generally exceeds the fan air quantity due to the nature of the VAV system. The fan speed shall be set to deliver the required maximum fan cfm (not the total cfm of all of the devices) with duct static pressure sufficient (and yet not excessive) for proper operation. Terminal air control units shall be repositioned for fan balancing to deliver the maximum fan cfm.

S. Balancing of terminal air control units and air devices shall be done to provide adequate but not excessive pressure in the branch ducts to air control units and air devices. Dampers incorporated in air devices shall be used only as secondary balancing means when other branch dampers are provided. Check, test and calibrate as required all terminal air control unit cfm settings (maximum, minimum). Also, record static pressure drop across the air control unit and reheat coil.

T. 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 within the unit, and static pressure readings across each item. Balance reports will be rejected without this information.

U. 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.

V. Pressurization measurements shall not start until the space has been observed to verify the integrity of the space boundaries. Test should measure, adjust and record the pressurization of each room, each zone and each building. If building is being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.

3.2 After completion of the balancing work, a full report shall be prepared in pencil and two copies (only) submitted to the Engineer for preliminary review. After review, additional balancing, adjustments, drive replacements, readings and recordings deemed necessary shall be done and the report revised. Six typed copies 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. Pump Curves.

F. Fan Curves.

G. Manufacturers’ test data.

H. System component diagrams including schematic layouts of air and hydronic equipment. Present each in single-line format with data points indicated.

3.4 Inspection after testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance reading documented in the final report. Submit random sampling percentages and results.

END OF SECTION
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. 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, duct coils, air terminal reheat box coils, air control dampers and valves, fire dampers, smoke dampers, filter housings, sound attenuators. The backside of supply air diffusers shall also be insulated to prevent condensation, except if the air device is factory insulated.

1.5 Ductwork shall not be internally lined, unless shown otherwise for return or exhaust.

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, Manson, or as listed below. 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:

<table>
<thead>
<tr>
<th>Duct System</th>
<th>Minimum Installed R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply air, return air, and outside air located outdoors</td>
<td>R-6.0</td>
</tr>
</tbody>
</table>
Supply air, outside air, and return air located above the roof insulation in both ventilated and non-vented attics

“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 Insulation on ductwork located outdoors and required to be externally insulated shall be fiberglass board insulation with factory applied “all service” jacket with vapor barrier, minimum 2 inches thick, 3 p.c.f. density, formaldehyde-free or GreenGuard Certified for low formaldehyde and VOC emissions. Insulation shall be jacketed as described below.

2.5 Protective jacketing of outdoor ductwork systems and/or insulation systems shall be VentureClad 13-ply 1579 CW self-adhesive laminate, or equal by Foster Products. Color shall be white.

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. Blanket insulation shall be wrapped tight to the duct. Insulation shall be secured to ducts 20 inches wide and greater with weld pins and fasteners, 18 inches on center maximum. Adhesive shall be applied to the duct as an aid to installation and adhesion. Vapor barrier jacket shall be lapped, stapled and sealed with adhesive and 3 inches wide FSK pressure sensitive tape.

D. 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.

E. 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.

F. 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.

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

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

END OF SECTION
23 09 23  BUILDING AUTOMATION SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 Overview

A. Furnish all labor, materials and equipment necessary for a complete and operating Building Automation System (BAS), utilizing direct digital controls and electric actuation as shown on the drawings and as described herein. Integrate into existing campus web supervisor. Drawings are diagrammatic only.

B. System software shall be based on a server/thin-client architecture, designed around the open standards of web technology. The control system server shall be accessed over the control system network, the Owner’s local area network, and remotely over the Internet (through the Owner’s LAN).

C. Performance Monitoring: The BAS will provide the specified performance monitoring functionality, including required monitoring points and performance metrics, improved through system accuracy, data acquisition and data management capabilities, and required graphical and data displays.

D. The intent and requirement of this specification and related sections is to provide a fully integrated, open, interoperable, peer-to-peer, networked, and distributed BAS. The following communication protocols are acceptable:

1. ANSI/ASHRAE Standard 135 BACnet - A Data Communication Protocol for Building Automation and Control Networks
2. MODBUS Application Protocol V1.1b (applicable to factory packaged equipment controllers only)
3. Tridium Niagara Framework Protocol
4. Internet Engineering Task Force RFC 7540 Hypertext Transfer Protocol HTTP/2

E. The BAS shall be comprised of:

1. Communications Network
2. Enterprise Network Server
3. Embedded Controller/Web Server(s)
4. Graphical User Interface
5. Equipment controllers (B-AAC, B-ASC, MEC)
6. Sensors (refer to Section 23 09 25)
7. Controlled devices (refer to Section 23 09 25)

F. Software License Agreement

1. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract, and shall give him and his authorized agent full access to all features and functions of the installed BAS. Such license shall grant use of all programs and application software to Owner and his authorized agent as defined by the manufacturer’s license agreement, but shall protect manufacturer’s rights to disclosure of trade secrets contained within such software.

2. It is the Owner’s express goal to implement an open system that will allow products from various suppliers to be integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system. The Owner shall be the named license holder of all software associated with any and all incremental work on the project. In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all
configuration and programming that is generated for a given project and/or configured for use with the Enterprise Network Server, Embedded Controller/Web Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required IDs and passwords for access to any component or software program shall be provided to the owner. The owner shall determine which organizations to be named in the SI organization ID (“orgid”) of all software licenses. Owner shall be free to direct the modification of the “orgid” in any software license, regardless of supplier, by Tridium Inc.

G. All Embedded Controller/Web Servers shall be accessed via a single connection to the Enterprise Network Server. In this configuration, each Embedded Controller/Web Server can be accessed from a PC using Remote Desktop Connection Client User Interface and from a PC using Web Browser Client User Interface.

H. Local connections shall be via an Ethernet LAN. Remote connections shall be via owner provided full-time, high-speed ISP connection for remote site access (i.e., T1, ADSL, cable modem) and IPv6 compliant. The owner shall be responsible for all monthly internet access fees and connection charges.

I. The basic control system includes all sensors, controllers, instruments, valves, actuators, devices, installation and service for a complete and functional control system. All control devices (valves, dampers, actuators, etc.) and associated power and control wiring shall be included. Refer to Section 23 09 25 Instrumentation and Control Devices for HVAC and Section 23 09 47 Control Power and Wiring for HVAC. The BAS shall be designed to allow easy field adjustment of all set points and parameters.

J. Provide for future system expansion to include monitoring of the access, intrusion detection, fire alarm, and lighting control systems.

K. Identify active or inactive pneumatic tubing, control wiring, equipment, etc., and where requested assist in the actual removal. Remove all pneumatic tubing, control wiring, and control devices not required to accommodate the new control system.

1.2 Provider Requirements

A. Manufacturer Qualifications

1. All products used in the installation shall be new, currently under manufacture, and shall be applied in standard off the shelf products. The 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 made available for at least 10 years after completion of this contract.

B. Installer Qualifications

1. Installing Contractor shall have an established working relationship with Control System Manufacturer of not less than 5 years.
2. Installing Contractor and his Sub-Contractors shall have successfully completed manufacturer’s control system training. Provide certification of completed training, including hours of instruction and course outlines, within 10 days after bid date.
3. Installing Contractor shall have an office within 75 miles of the project site and provide 24 hour response in the event of a customer call, 7-days per week, 365 days per year.

1.3 Approved Control System Manufacturers and Installing Contractors

A. Enterprise Server and Embedded Controller/Web Server products utilizing Niagara Framework by Tridium Inc. are the basis of design.
B. Any material or equipment that will fully perform the duties specified will be considered ‘equal,’ provided the bid submits proof that such material or equipment is of equivalent substance and function and is approved, in writing. Requests for the approval of ‘or equal’ shall be made in writing at least five business days prior to bid opening. During the bidding period, all approvals shall be issued by the Architect/Engineer in the form of addenda at least two business days prior to the bid opening date.

C. The following control system Manufacturers’ products that are BACnet compliant are pre-qualified:

1. Honeywell International – WEBs (N4) [BACnet]
2. Honeywell International - Spyder Controllers [BACnet]
3. Tridium – Niagara N4 [BACnet]

D. The following Installing Contractors are pre-qualified:

2. Point To Point Systems [Honeywell WEBs (N4)]

E. Any Manufacturer or Installing Contractor not pre-qualified above shall submit credentials for the Engineer’s review seven or more days prior to the bid date. Applications submitted after seven days prior to the bid date will not be considered. Credentials must attest that the manufacturer and installer meet all requirements above. The Engineer’s judgment in reviewing any manufacturer or contractor will be final.

1.4 Technical Proposal

A. Provide a technical proposal to the Engineer after bidding and before award of a contract when so requested by the Engineer. The Engineer’s review comments will be made available to the bidder two weeks after receipt of the technical proposal. The technical proposal shall contain the following:

1. Description of how the system meets and achieves the specified criteria in terms of configuration, operation and control.
2. BAS single line riser diagram, showing all major components (digital controllers, bus network, etc.).
3. Procedure and amount of time required to start up the system.
4. Bidder shall explain:
   a. How Owner programs (language, etc.) the system.
   b. Any proprietary software for which documentation is not available.
   c. Manufacturer of major components.
   d. Requirements of the off-site data terminal to access to BAS over telephone communications.

B. For all application programs supplied, bidder shall explain in the technical proposal, program constraints and limitations, and listing of all systems the program is applied to, including digital controller interface and control of:

1. Typical air handling unit.

C. An interview may be conducted and each bidder will be requested to make a presentation concerning the system proposed.

1.5 Codes and Standards
A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions of the following codes and standards:

1. National Electric Code (NEC)
2. Ohio Building Code (OBC) and Ohio Mechanical Code (OMC)
3. National Fire Protection Association (NFPA)
4. ANSI/ASHRAE Standard 55 Thermal Environmental Conditions For Human Occupancy
5. ANSI/ASHRAE Standard 62 Ventilation For Acceptable Indoor Air Quality
7. ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Networks
8. Underwriters Laboratories: Products shall be UL-916-PAZX Listed

1.6 The following sections constitute related work:

A. Section 23 09 25 – Instrumentation and Control Devices for HVAC
B. Section 23 09 47 – Control Power Wiring for HVAC
C. Section 23 09 93 – Sequence of Operation for HVAC Controls
D. Section 23 09 95 – Direct Digital Control System Points List

1.7 System Performance

A. Performance Standards. System shall conform to the following minimum standards over network connections:

1. Graphic Display. A graphic with 20 dynamic points/objects shall display with current data within 10 seconds.
2. Graphic Refresh. A graphic with 20 dynamic points/objects shall update with current data within 8 seconds.
3. Object Command. Devices shall react to command of a binary object within 2 seconds. Devices shall begin reacting to command of an analog object within 2 seconds.
4. Object Scan. Data used or displayed at a controller or user interface shall have been current within the previous 6 seconds.
5. Alarm Response Time. An object that goes into alarm shall be annunciated at the user interface within 45 seconds.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 second. Select execution times consistent with the mechanical process under control.
7. Performance. Programmable controllers shall be able to completely execute BAS PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.
8. Multiple Alarm Annunciations. Each user interface on the network shall receive alarms within 5 seconds of other user interfaces.
9. Reporting Accuracy. System shall report values with the minimum end-to-end accuracy listed in Table 1 of Section 23 09 25 Instrumentation and Control Devices.
10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2 of Section 23 09 25 Instrumentation and Control Devices.

1.8 Submittals

A. Refer to Section 23 05 01 – Basic HVAC Requirements.
B. Begin no work until submittals have been approved for conformity with design intent. Provide drawings as 11 inches x 17 inches prints of each drawing. When manufacturer's cutsheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Damper and valve schedules and data sheets may be submitted separately to improve product delivery dates. Provide submittals within 12 weeks after contract award, including the following:

1. **BAS Hardware**
   a. Complete bill of materials indicating quantity, manufacturer, model number, and other relevant technical data.
   b. Manufacturer's description and technical data, such as performance curves, product specification sheets, and installation and maintenance instructions for items listed below and for other relevant items not listed below:
      1) DDC (controller) panels
      2) Transducers and transmitters
      3) Sensors (including accuracy data)
      4) Actuators
      5) Valves
      6) Dampers
      7) Relays and switches
      8) Control panels
      9) Power supplies
      10) Batteries
      11) User interface equipment
      12) Wiring
   c. Wiring diagrams and layouts for each control panel. Show all termination numbers.
   d. Floor plan schematic diagrams indicating field sensor, controller and power supply locations.

2. **Network and User interface Hardware and Software**
   a. Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.
   b. Manufacturer's description and technical data, such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:
      1) Central Processing Unit (CPU)
      2) Monitors
      3) Keyboards
      4) Power supply
      5) Battery backup
      6) Interface equipment between CPU and control panels
      7) Routers
      8) Repeaters
      9) Operating System software
      10) User interface software
      11) Color graphic software
      12) Third-party software
   c. Schematic diagrams of control, communication, and power wiring for central system installation. Label cables and ports with computer manufacturers’ model numbers and functions. Show all interface wiring to control system.
   d. List of color graphics to be provided. Provide a conceptual layout of pictures and data for each graphic, showing or explaining which other graphics can be directly accessed.

3. **Controlled Systems**
a. Riser diagrams showing control network layout, communication protocol, and wire types.

b. Schematic diagram of each controlled system. Label control points/objects with point/object names. Graphically show all locations of control elements.

c. Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.

d. Instrumentation list for each controlled system. List each control system element in a table format. Show element name, type of device, manufacturer, model number, and product data sheet number.

e. Mounting, wiring, and routing plan view drawing in 0.25 inch scale. Take into account HVAC, electrical and other systems’ design and elevation requirements. Show locations of concrete pads and bases and special wall bracing for panels to accommodate this work.

f. Complete description of control system operation including sequences of operation. Include and reference a schematic diagram of system.

g. Point/object list for each system controller including inputs and outputs (I/O), point/object numbers, controlled device associated with each I/O point/object, and location of I/O device. Indicate alarmed and trended points/objects.

4. Description of process, report formats, and checklists to be used in Part 3: “Control System Demonstration and Acceptance.”

5. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of BACnet controller (B-BC, B-AAC, B-ASC) and user interface (B-OWS).

6. Instrumentation and Data Point Summary Table. Contractor shall submit in table format with the following information for each instrument and data point. The table is to be reviewed and approved by the owner’s representative prior to hardware and software installation and programming.

   a. Point name
   b. Point description: provide building designation, system type, equipment type, engineering units, and functionality; include a description of its physical location
   c. Expected range (upper and lower limit)
   d. Instrumentation (as applicable): manufacturer, model number, range, and accuracy specification
   e. Type
      1) AI: analog input
      2) BI: binary input
      3) NAI: network analog input
      4) NBI: network binary input
      5) P: programmed (e.g., soft or virtual point in control sequence such as a PID input or output)
      6) C: calculated value; a soft or virtual point. If calculated value, provide logic diagrams or code and any constants used in formula. If time-based integrated values are required, provide time periods: minutes, daily, weekly, monthly, and yearly. Also indicate if it is a running average.

   f. Input resolution
   g. Graphic display resolution
   h. Data trend interval
   i. Number of samples stored in local controller before transfer to host computer/server database
   j. Data point address

C. Schedules

1. Provide a Schedule of work within one month of contract award indicating:
   a. Intended sequence of work items
   b. Start date of each work item
   c. Duration of each work item
d. Planned delivery dates for ordered material and equipment, and expected lead time

2. Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.

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

1. Project Record Drawings.
   a. As-built versions of the submittal shop drawings provided as 11 inches x 17 inches prints.
   b. Submittals to include complete electrical point-to-point wiring diagrams, component layouts, system and equipment component sequences of operation, start-up and checkout procedures. Include a list of all unit default safety and control settings, whether fixed or adjustable, as shipped from the factory. Where field modifications are required to meet the specification, provide all modification labor and materials, and submit a complete, detailed, step-by-step procedure for the modifications.

2. Testing and Commissioning Reports and Checklists. Completed versions checklists and trend logs used to meet requirements of Part 3: “Control System Demonstration and Acceptance.”

   a. As-built versions of the submittal product data.
   b. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
   c. User’s manual with procedures for operating control systems: logging on and off, handling alarms, producing point/object reports, trending data, overriding computer control, and changing setpoints and variables.
   d. Programming manual or set of manuals with description of the programming language and syntax of statements for algorithms and calculations used of point/object database creation and modification, of program creation and modification, and editor use.
   e. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points/objects, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
   f. Documentation of all programs created using custom programming language including setpoints, tuning parameters, and object database.
   g. Graphic files, programs and database on magnetic or optical media.
   h. List of recommended spare parts with part numbers and suppliers.
   i. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware, including computer equipment and sensors.
   j. Complete original-issue copies of furnished software, including operating systems, custom programming language, user interface software, and graphics software.
   k. Licenses, guarantee, and warranty documents for equipment and systems.
   l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

4. Training Materials: Provide course outline and manuals for each class at least six weeks before the first class. Engineer will modify course outlines and manuals if necessary to meet Owner’s needs. Engineer will review and approve course outlines and manuals at least three weeks before first class.

1.9 Warranty

A. Warrant all work as follows:
1. Warrant labor and materials for specified BAS free from defects for a period of 18 months after final acceptance. BAS failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. Respond during Owner’s business hours within 24 hours of Owner’s warranty service request.

2. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.

3. If Engineer determines that equipment and systems operate satisfactorily at the end of the final start-up, testing, and commissioning phase, Engineer will certify in writing that BAS operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.

4. Provide updates to user interface software, project-specific software, graphic software, database software, and firmware which resolve Contractor identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above mentioned items. Do not install updates or upgrades without Owner’s written authorization.

5. Exception: Reused devices shall not be required to be warranted except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer’s acceptance.

1.10 Ownership Of Proprietary Material

A. Project specific software and documentation shall become Owner’s property. This includes, but is not limited to:

1. Graphics
2. Record drawings
3. Database
4. Application programming code
5. Documentation

PART 2 - PRODUCTS

2.1 Materials

A. The equipment specified shall be provided as defined herein, shown on the drawings and as required to accomplish the sequences of control.

B. Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 25 installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner or Owner’s Representative. Spare parts shall be available for at least five-years after completion of this contract.

2.2 BACnet Communications

A. Control products, communication media, connectors, repeaters, hubs and routers shall comprise a BACnet BAS. Controllers and user interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.

B. Each controller shall have a communication port for connections to an user interface.

C. Project drawings indicating remote buildings or sites to be connected to the Enterprise network shall allow for communication with each controller on the network as specified in Paragraph D.

D. Network user interface and value passing shall be transparent to network architecture.
1. A user interface connected to the BAS shall allow the user to interface with networked controllers as if directly connected. BAS information such as data, status, reports, system software, and custom programs, shall be viewable and editable from the user interface.

2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be available on the network. Program and test all cross-controller links required to execute specified BAS operation. An authorized user shall be able to manage, maintain, and access the BAS network of controllers.

E. Workstations, Building Control Panels and Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clock daily from an user designated device via the network. The system shall automatically adjust for daylight saving and standard time as applicable.

F. System shall be expandable to at least twice the required data points with additional controllers, associated devices, and wiring. Expansion shall not require user interface hardware additions or software revisions.

2.3 Enterprise Network Server

A. The Enterprise Network Server shall support all Embedded Controller/Web Servers connected to the owner’s network whether local or remote.

B. The Enterprise Network Server Software shall provide the following functions, at a minimum:

1. Global Data Access: The Enterprise Network Server shall provide complete access to distributed data defined anywhere in the system.

2. Distributed Control: The Enterprise Network Server shall provide the ability to execute global control strategies based on control and data objects in any Embedded Controller/Web Server in the network, local or remote.

3. The Enterprise Network Server shall include a master clock service for its subsystems and provide time synchronization for all Embedded Controller/Web Servers.

4. The Enterprise Network Server shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.

5. The Enterprise Network Server shall provide scheduling for all Embedded Controller/Web Servers and their underlying field control devices.

6. The Enterprise Network Server shall provide demand limiting that operates across all Embedded Controller/Web Servers. The Enterprise Network Server must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.

7. The Enterprise Network Server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to Embedded Controller/Web Servers. Systems not employing this prioritization shall not be accepted.

8. Each Embedded Controller/Web Server supported by the Enterprise Network Server shall have the ability to archive its log data, alarm data and database to the Enterprise Network Server, automatically. Archiving options shall be user-defined including archive time and archive frequency. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. The server software shall utilize a Java Database Connectivity (JDBC) compatible database such as: MS SQL 8.0, Oracle 8i or IBM DB2 and HTTP/HTML/XML, CSV or text formats. BAS systems written to Non-Standard and/or Proprietary databases are NOT acceptable.

9. The Enterprise Network Server shall provide central alarm management for all Embedded Controller/Web Servers supported by the Enterprise Network Server. Alarm management shall include:
   a. Routing of alarms to display, email, and pagers
b. View and acknowledge alarms
c. Query alarm logs based on user-defined parameters

10. The Enterprise Network Server shall provide central management of log data for all Embedded Controller/Web Servers supported by the Enterprise Network Server. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:
   a. Viewing and printing log data
   b. Exporting log data to other software applications
   c. Query log data based on user-defined parameters

C. The Enterprise Network Server hardware platform shall have the following minimum requirements:

1. Processor: Intel Xeon x64 (or better), compatible with dual- and quad-core processors
3. Memory: 8 GB
4. Hard Drive: 1 TB
5. Display: Video card capable of displaying 1024 x 768 pixel resolution or greater
6. Network Support: NIC card rated for at least 1 Gigabit or 10 Gigabit Ethernet

2.4 Embedded Controller/Web Server

A. Embedded Controller/Web Server(s) shall manage communications between the BACnet Advanced Application Controllers (B-AAC) and BACnet Application Specific Controllers (B-ASC) which are connected to its communications trunks, manage communications between itself and other Embedded Controller/Web Servers and with Enterprise Network Server that are part of the BAS, and perform control and operating strategies for the system based on information from any controller connected to the BAS.

2.5 Graphical User Interface

A. All Embedded Controller/Web Servers shall be accessed via a single connection to the Enterprise Network Server. In this configuration, each Embedded Controller/Web Server can be accessed from a PC using Thin-Client Remote Desktop Connection User Interface and/or a PC using Thin-Client Web Browser User Interface.

B. The Thin-Client Remote Desktop Connection User Interface shall use any of the current versions of Windows Server with Remote Desktop Services and shall allow the Enterprise Server to host multiple, simultaneous client sessions. Remote Desktop shall use Remote Desktop Services technology to allow a single session to run remotely. A user shall connect to a Remote Desktop Session Host (RD Session Host) server by using Remote Desktop Connection (RDC) client software. Thin-client hardware devices running an embedded Windows-based operating system shall run the RDC client software to connect to the RD Session Host Enterprise Server.

C. The Thin-Client Web Browser User Interface shall use any of the current versions of Microsoft Internet Explorer, Microsoft Edge, Mozilla Firefox, or Google Chrome browsers from any computer. The thin-client web browser shall be operating system agnostic, meaning it will support HTML5 enabled browsers without requiring proprietary user interface and configuration programs or browser plug-ins. Communication between the Thin-Client Web Browser User Interface and the Enterprise Network Server shall offer, at a minimum, encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol (HTTP).

D. Software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system.
E. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.

1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.

2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote connected user interfaces.

F. The user interface shall be completely interactive and shall provide a HTML5 experience that supports the following features as a minimum:

1. Trending.
2. Scheduling.
3. Electrical demand limiting.
5. Downloading Memory to field devices.
6. Real time 'live' Graphic Programs.
8. Parameter change of properties.
9. Set point adjustments.
10. Alarm / event information.
11. Configuration of users.
12. Execution of global commands.
13. Add, delete, and modify graphics and displayed data.

G. Software Components: All software shall be the most current version. All software components of the BAS software shall be provided and installed as part of this project. BAS software components shall include:

2. 5 Year Software Maintenance Agreement. Labor to implement shall be included.
3. Embedded System Configuration Utilities for future modifications to the system and controllers.
5. Embedded Direct Digital Control software.
6. Embedded Application Software.
7. Embedded Native Function-block programming software and all controller “Setup Wizards”.

H. Login: On launching the user interface and selecting the appropriate domain name or IP address, the user shall be presented with a login page that will require a login name and strong password. Navigation in the system shall be dependent on the user's role-based application control privileges.

I. Web Page Navigation: Using a collection of web pages, it shall be constructed to "feel" like a single application, and provide a complete and intuitive mouse/menu driven user interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic set point controls, configuration menus for user access, reports and reporting actions for events.

J. Tree Navigation: Navigation through the GUI shall be accomplished by clicking on the appropriate level of a navigation tree (consisting of an expandable and collapsible tree control
like Microsoft's Explorer program) and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the user to select a specific system or equipment and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.

1. Geographic View shall display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and objects.
2. Groups View shall display Scheduled Groups and custom reports.
3. Configuration View shall display all the configuration categories (Users, Schedule, Event, Reporting and Roles).

K. Action Pane: The Action Pane shall provide several functional views for each subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

1. Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic set point controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.
2. Dashboards: User customizable data using drag and drop HTML5 elements. Shall include Web Charts, Gauges, and other custom developed widgets for web-browser. User shall have ability to save custom dashboards.
3. Search: User shall have multiple options for searching data based upon Tags. Associated equipment, real time data, Properties, and Trends shall be available in result.
4. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the user to depress an 'accept/cancel' button.
5. Schedules: Shall be used to create, modify/edit and view schedules based on the systems hierarchy (using the navigation tree).
6. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
7. Charting: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling. User shall have ability to create HTML charts through web browser without utilizing chart builder. User shall be able to drag and drop single or multiple data points, including schedules, and apply status colors for analysis.
8. Logic - Live Graphic Programs: Shall be used to display 'live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.
9. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

L. Color Graphics: The GUI shall make extensive use of color in the graphic pane to communicate information related to set points and comfort. Animated .gifs or .jpg, vector scalable, active set point graphic controls shall be used to enhance usability. Graphics tools used to create graphics shall be non-proprietary and conform to the following basic criteria:

1. Display Size: The GUI user interface software shall graphically display in a minimum of 1024 by 768 pixels 24 bit True Color.
2. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.
3. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set points. The colors shall be updated dynamically as a zone's actual comfort condition changes.
4. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of
equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.

5. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
   a. Each piece of equipment monitored or controlled including each terminal unit.
   b. Each building.
   c. Each floor and zone controlled.

M. Hierarchical Schedules: Utilizing the Navigation Tree displayed in the GUI, a user (with proper access credentials) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room, or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day 'Holiday' for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further user intervention would be required and every control module in the system with would be automatically downloaded with the 'Independence Day' Holiday. All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.

1. Schedules: Schedules shall comply with the BACnet standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
   a. Types of schedule shall be Normal, Holiday or Override.
   b. A specific date.
   c. A range of dates.
   d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
   e. Wildcard (example, allow combinations like second Tuesday of every month).

2. Schedule Categories: The system shall allow users to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.

3. Schedule Groups: In addition to hierarchical scheduling, users shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the user shall be able to define an 'individual tenant' group - who may occupy different areas within a building or buildings. Schedules applied to the 'tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the 'tenant group'.

4. Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the user schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.

5. Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the user (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).

6. Schedule Summary Graph: The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.

N. Alarms: Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an 'Alarms' view. Alarms, and reporting actions shall have the following capabilities:
1. Alarms View: Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address and other pertinent information. An user shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.

2. Alarm Categories: The user shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the user to easily sort through multiple events displayed.

3. Alarm Templates: Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.

4. Alarm Areas: Alarm Areas enable an user to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an user to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.

5. Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.

6. Alarm Configuration: Users shall be able to define the type of Alarm generated per object. A ‘network’ view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.

7. Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement and total number of Alarms in the BAS Server database.

8. Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an user defined period.

9. Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Users shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:
   a. Print: Alarm information shall be printed to the BAS server’s PC or a networked printer.
   b. Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts. Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.
   c. File Write: The ASCII File write reporting action shall enable the user to append user defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the user. The user may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
   d. Write Property: The write property reporting action updates a property value in a hardware module.
   e. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.
   f. Run External Program: The Run External Program reporting action launches specified program in response to an event.

O. Trends: As system is engineered, all points shall be enabled to trend. Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.
1. Viewing Trends: The user shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.

2. Local Trends: Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and periodically uploaded to the BAS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.

3. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis.

4. Dynamic Update. Trends shall be able to dynamically update at user-defined intervals.

5. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.

6. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.

7. Copy/Paste. The user shall have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).

P. Reports and Logs. Provide a reporting package that allows the operator to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date. Report data shall be archivable on the hard disk for historical reporting. Provide the ability for the operator to obtain real-time logs of all objects by type or status (e.g., alarm, lockout, normal). Reports and logs shall be stored on the Enterprise Server hard disk in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.

Q. Custom Reports. Provide the capability for the operator to easily define any system data into a daily, weekly, monthly, or annual report. Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. These reports shall be time and date stamped and shall contain a report title and the name of the facility.

R. Security Access: Systems that access from the web browser GUI to BAS server shall require a Login Name and Strong Password. Access to different areas of the BAS system shall be defined in terms of Role-Based Access Control privileges as specified:

1. Roles: Roles shall reflect the actual roles of different types of users. Each role shall comprise a set of 'easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function Privileges.
   b. Edit Privileges shall comprise: Set point, Tuning and Logic, Manual Override, and Point Assignment Parameters.

S. Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same user defined HVAC Role) to different areas of the system.

T. The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in all control modules. Any system that does not use a drag and
drop method of graphical icon programming shall not be accepted. All systems shall use a GPL method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

U. Graphic programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

V. Graphic Sequence: The clarity of the graphic sequence shall be such that the user has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer’s unique programming language. The graphic programming shall be self-documenting and provide the user with an understandable and exact representation of each sequence of operation.

W. GPL Capabilities: The following is a minimum definition of the capabilities of the Graphic Programming software:

1. Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
2. Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
3. Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors bid.
4. Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O.
5. Reference Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.
6. Parameter: A parameter shall be a value that may be tied to the input of a microblock.
7. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields, and shall contain 'push buttons' for the purpose of selecting default parameter settings.
8. Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes its function.
9. Menu-bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.

X. Live Graphical Programs: The Graphic Programming software shall support a ‘live’ mode, where all input/output data, calculated data and set points shall be displayed in a ‘live’ real-time mode.

2.6 BACnet Advanced Application Controller (B-AAC)
A. General. Provide an adequate number of BACnet Advanced Application Controllers (B-AAC) to achieve the performance specified in the Part 1 Article on “System Performance”. B-AAC shall provide microprocessor based self-contained stand-alone fully programmable operation of local process control loops. The controller platform shall provide options and advanced system functions, programmable and configurable, that allow standard and customizable control solutions required in executing the "Sequence of Operation". All local level application programs shall be installed on individual controllers in non-volatile memory. Control systems that utilize ‘canned’ programs or programmable read only memory (PROM) level application programming are not acceptable. Each of these panels shall meet the following requirements.

1. The B-AAC shall have sufficient memory to support its operating system, database, and programming requirements.
2. Data shall be shared between networked B-AACs.
3. The operating system of the controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information, and allow central monitoring and alarms.
4. Controllers that perform scheduling shall have a real-time clock.
5. The B-AAC shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall
   a. Assume a predetermined failure mode,
   b. Generate an alarm notification.
6. The B-AAC shall communicate with other BACnet devices on the network using protocol specific services.
7. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals.
8. Provide documentation for each device, with the following information:
   a. BACnet Device; MAC address, name, type and instance number,
   b. BACnet Objects; name, type and instance number.

B. Communication

1. Each B-AAC shall reside on a BACnet network using the MS/TP or Ethernet Data Link/Physical layer protocol.
2. The controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable user’s terminal.

C. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at 32 degrees F to 150 degrees F and 10 to 90 percent RH.
2. Controllers used in conditioned space shall be mounted in dust proof enclosures, and shall be rated for operation at 32 degrees F to 120 degrees F.

D. Keypad. A local keypad and display shall be provided for each controller. The keypad shall be provided for interrogating and editing data. An optional system security password shall be available to prevent unauthorized use of the keypad and display. If the manufacturer does not provide this keypad and display, provide a portable user terminal.

E. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

F. Memory. The B-AAC shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
G. Immunity to power and noise. Controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.

2.7 BACnet Application Specific Controller (B-ASC)

A. General. BACnet Application Specific Controllers (B-ASCs) are microprocessor-based BAS controllers which through hardware or firmware design are dedicated to control a specific piece of equipment. They are not fully user-programmable, but are customized for operation within the confines of the equipment they are designed to serve. B-ASCs may not be used for complex sequences of operation. B-ASCs shall communicate with other BACnet devices on the network using the Read (Execute) Property service as defined in Clause 15.5 of ASHRAE Standard 135. Each B-ASCs shall be certified or listed for compliance to the BACnet standards.

1. Each B-ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
2. Each B-ASC will contain sufficient I/O capacity to control the target system.
3. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals.
4. Provide documentation for each device, with the following information:
   a. BACnet Device; MAC address, name, type and instance number,
   b. BACnet Objects; name, type and instance number.

B. Communication

1. Each controller shall reside on a BACnet network using the MS/TP or Ethernet Data Link/Physical layer protocol. Each network of controllers shall be connected to one building controller.
2. Each controller shall have a BACnet Data Link/Physical layer compatible connection for a laptop computer or a portable user’s tool. This connection shall be extended to a space temperature sensor port where shown and allow access to the entire network.
3. Each controller shall have a secondary sub network for communicating sensors or I/O expansion modules.

C. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at 32 degrees F to 150 degrees F and 10 to 90 percent RH.
2. Controllers used in conditioned space shall be mounted in dust proof enclosures, and shall be rated for operation at 32 degrees F to 120 degrees F.

D. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

E. Memory. The application specific controller shall use nonvolatile memory and maintain all BIOS and programming information in the event of a power loss.

F. Immunity to power and noise. Controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.
G. Transformer. Power supply for the ASC must be rated at a minimum of 125 percent of ASC power consumption and shall be of the fused or current limiting type.

2.8 MODBUS System Integration

A. The BAS shall support the integration of device data from MODBUS RTU, ACSII, or TCP control system devices. The connection to the MODBUS system shall be via an RS-232, RS485, or Ethernet IP as required by the device.

1. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the MODBUS system data into the FPMS. Objects provided shall include at a minimum:
2. Read/Write MODBUS AI Registers
3. Read/Write MODBUS AO Registers
4. Read/Write MODBUS BI Registers
5. Read/Write MODBUS BO Registers

B. All scheduling, alarming, logging and global supervisory control functions, of the MODBUS system devices, shall be performed by the Network Area Controller.

C. The BAS supplier shall provide a MODBUS system communications driver. The equipment system vendor that provided the equipment utilizing MODBUS shall provide documentation of the system’s MODBUS interface and shall provide factory support at no charge during system commissioning.

2.9 Input/Output Interface

A. Hardwired inputs and outputs may tie into the BAS through building, advanced application, or application specific controllers.

B. All input and output points shall be protected such that shorting of the point to itself, to another point, or to ground, shall cause no damage to the controller. All input and output points shall be protected from voltage up to 24 volts of any duration, such that contact with this voltage will cause no damage to the controller.

C. Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

D. Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.

E. Analog inputs shall allow the monitoring of low-voltage (0-10 VDC), current (4-20 mA), or resistance signals (thermistors, RTD). Analog inputs shall be compatible with – and field configurable to – commonly available sensing devices.

F. Binary outputs shall provide for ON/OFF operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and advanced application controllers shall have three-position (On/Off/Auto) override switches, and status lights. Outputs shall be selectable for either normally open or normally closed operation.

G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC signal or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building or advanced application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable
potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4 percent of range per year.

H. Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct mounted heating coils, zone dampers, radiation, etc.) Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of user tracking.

I. Input/Output points shall be universal type, i.e., controller input or output may be designated (in software) as either a binary or analog type point with appropriate properties. Application specific controllers are exempted from this requirement.

J. System Capacity. The system size shall be expandable to at least twice the number of input/output objects/points required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The user interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

K. Each controlled device or function shall be a separate output of the digital controller (i.e., Economizer, Heating Valve, Cooling Valve are three (3) separate output points). When a points' list is provided the greater number of points and their configuration shall govern. Multiplexers or programmable logic controllers utilized with digital controller input and output points to expend the digital controller I/O capabilities will not be allowed.

PART 3 - EXECUTION

3.1 Pre-Installation Sequences of Operations Meeting

A. Prior to shop drawings submittals and any hardware installation, set-up and conduct a “Sequences of Operations” meeting to review the specified sequences to confirm an understanding of intent. Invited attendees shall include the BAS software programming technicians, Owner’s representative(s), Construction Manager, and Engineer of Record. Coordinate with Construction Manager.

3.2 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 drawings and specifications for other parts of the work. If head room or space conditions appear inadequate or if any discrepancies occur between the plans and the Contractor’s 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 control work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect to report such discrepancies shall be made by and the costs borne by this Contractor.

3.3 Protection

A. Protect all work and material from damage by his work or employees, and shall be liable for all damage thus caused.
B. The installing contractor shall be responsible for his work and equipment until finally inspected, tested, and accepted. Protect any material that is not immediately installed. Close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.4 Coordination

A. Site

1. Where the temperature control work will be installed in close proximity to, or will interfere with work of other trades, assist in working out space conditions to make a satisfactory adjustment. If temperature control work is installed before coordinating with other trades, so as to cause any interference with work of other trades, the temperature control work shall be re-worked to correct the condition without extra charge.
2. Coordinate and schedule work with all other work in the same area, or with work which is dependent upon other work, to facilitate mutual progress.

B. Test and Balance

1. Furnish all tools necessary to interface to the control system for test and balance purposes.
2. Provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
3. In addition provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.

C. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated as follows:

1. All communication media and equipment shall be provided as specified in Part 2: “Communication” of this specification.
2. Each supplier of controls product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequences of operation described in this section.
3. Coordinate and resolve any incompatibility issues that arise between the control products provided under this Section and those provided under other sections or divisions of this specification.

D. Revise equipment tagging and nomenclature, room numbering, etc. to reflect as-built conditions or an Owner’s preference for integration into his existing naming numbering convention.

3.5 Field Quality Control

A. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this specification.

B. Continually monitor the field installation for code compliance and quality of workmanship.

C. Have work inspected by authorities having jurisdiction over the work.

3.6 Controllers
A. Provide a separate controller for each AHU, terminal unit, fan coil, and other unitary equipment and HVAC systems. A DDC controller may control more than one system provided that all points/objects associated with the system are assigned to the same DDC controller. Points/objects used for control loop reset such as outside air or space temperature are exempt from this requirement.

B. Building Controllers and Custom Application Controllers shall be selected to provide a minimum of 15 percent spare I/O point/object capacity for each point/object type found at each location. If input/objects are not universal, 15 percent of each type is required. If outputs are not universal, 15 percent of each type is required. A minimum of one spare is required for each type of point/object used.

1. Future use of spare capacity shall require providing the field device, field wiring, point/object database definition, and custom software. No additional controller boards or point/object modules shall be required to implement use of these spare points.

3.7 Programming

A. Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25 percent of available memory free for future use.

B. Point/object Naming: System point/object names shall be modular in design, allowing easy user interface without the use of a written point/object index. Use the following naming convention:

AAABBBCCCDDDEEE where:

AAA is used to designate the location of the point/object within the building such as mechanical room, wing, or level, or the building itself in a multi-building environment.

BBB is used to designate the mechanical system with which the point/object is associated (e.g., A01, HTG, CLG, LTG).

CCC represents the equipment or material referenced (e.g., SAF for supply air fan, EXF for exhaust fan, RAF for return air fan).

D or DD or DDD may be used for clarification or for identification if more than one of CCC exists (e.g., SAF10, EXF121).

EE represents the action or state of the equipment or medium (e.g., T for temperature, RH for humidity, CO for control, S for status, D for damper control, I for current).

C. Software Programming

1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:

   a. Text-based:
      1) must provide actions for all possible situations
      2) must be modular and structured
      3) must be commented

   b. Graphic-based
      1) must provide actions for all possible situations
      2) must be documented

   c. Parameter-based
1) must provide actions for all possible situations
2) must be documented

2. After submittal and review of control software, offer to schedule a meeting with the Engineer and Commissioning Agent (CxA) to review system function.

D. Graphical User Interface

1. Standard Graphics. Provide graphics for all controlled systems and floor plans of the building. Point/object information on the graphic displays shall dynamically update. Show on each graphic all input and output points/objects for the system. Also show relevant calculated points/objects such as setpoints.

2. Show terminal equipment information on a “graphic” summary table. Provide dynamic information for each point/object show.

3. Provide all the labor necessary to install, initialize, start up, and troubleshoot all user interface software and their functions as described in this section. This includes any operating system software, the user interface database, and any third-party software installation and integration required for successful operation of the user interface.

4. Provide graphic representation of each system. Graphic shall have a link to its respective approved as-built sequence of operation in portable document format (pdf) or hypertext markup language format (html).

5. Provide graphic representation of each control device component (sensor, controller, controlled device). Each control device component graphic representation shall have a cursor-hover-over pull-down box with links to the manufacturer’s data sheet, installation instructions, maintenance instructions, and programming instructions literature in portable document format (pdf) or hypertext markup language format (html). Also, provide a link to an active trend of sensor and controlled device components.

6. Provide graphic representation of each equipment component (pump, boiler, chiller, air handling unit, etc.). Each equipment component shall have a cursor-hover-over pull-down box with links to the manufacturer’s data sheet, installation, maintenance, and programming literature in portable document format (pdf) or hypertext markup language format (html). For equipment components with factory mounted controllers provide an additional link to a graphic representation of all equipment controller data available via the respective communication protocol interface in tabular format.

7. The ATC Contractor shall initially prepare and be responsible for a Graphical User Interface Development Plan. The plan shall describe the process for the development of the GUI.

8. GUI Scope Meeting: Within 45 days from execution of the Contract, participate in a scope meeting with the GUI Development Team chaired by the ATC Contractor. The purpose of the meeting includes a review of the GUI Development Plan with discussions of development schedule, graphical requirements, and assignments of responsibilities.

9. GUI Coordination Meetings: The GUI Development Team members will meet on a predetermined and approved basis (by the Owner) to review progress on the GUI work, coordinate scheduling conflicts, and to discuss strategies and processes for upcoming tasks. The meetings will be chaired by the ATC Contractor. Allow for 80 hours of meeting time.

10. GUI Development Meeting Minutes: The ATC Contractor shall prepare minutes of the initial scope and progress meetings, and shall include a copy of the agenda, and identify location and date of the meeting, and individuals in attendance. Minutes shall be distributed to members of the GUI Development Team.

11. GUI Development Team: Members of the GUI Development Team shall include, but not be limited to the Owner, ATC Contractor, and such parties designated by the Owner or ATC Contractor.

3.8 Control System Checkout And Testing
A. Start-up Testing: All testing listed in this article shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Owner’s Representative is notified of the system demonstration.

1. Upon completion of the control system, adjust all components of the system. Make all adjustments in the control system required and as directed by the balancer to achieve the desired air balance quantities. All instruments shall be carefully calibrated and each control function shall be demonstrated to function properly, to the satisfaction of the Engineer and the Owner. Provide a complete instruction manual covering the function and operation of all components. At the time of demonstration, each function shall be simulated to ensure that controls respond properly to all signals, and the Owner shall be instructed in the proper operation of the system.

2. Furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.

3. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

4. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures per manufacturers’ recommendations.

5. Verify that all binary output devices (relays, solenoid valves, two position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

6. Verify that all analog output devices (transducers, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. Check all control valves and automatic dampers to ensure proper action and closure. Make any necessary adjustments to valve stem and damper blade travel.

7. Verify that the system operation adheres to the Sequences of Operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum Start/Stop routines.

8. Alarms and Interlocks
   a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
   b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
   c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

9. Each unit and associated controls, safeties and wiring shall be checked out, started and adjusted by a factory trained service technician. Submit a startup report including a list of all unit safety and control settings, whether fixed or adjustable, as field checked and setup per the specified design conditions five days after unit startup. Submit service technician certification upon request.

3.9 Control System Demonstration And Acceptance

A. Demonstration

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the temperature controls have been completed, started up and performed its own tests.

2. The tests described in this section are to be performed in addition to the tests that are performed as a necessary part of the installation, startup, and debugging process and as specified in the “Control System Checkout and Testing” Article in Part 3 of this specification. The Engineer may be present to observe and review these tests. The Engineer shall be notified at least 10 days in advance of the start of the testing procedures.

3. The demonstration process shall follow that approved in Part 1: “Submittals.” The approved checklists and forms shall be completed for all systems as part of the demonstration.
4. Provide at least two persons equipped with two way communication, and demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point/object and system. Provide and operate any test equipment required to prove the proper operation.

5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.


7. Demonstrate compliance with Sequences of Operation through all modes of operation.

8. Demonstrate complete operation of User Interface.

9. Additionally, the following items shall be demonstrated:
   a. Optimum Start. Supply a trend data output showing the capability of the algorithm. The hour by hour trends shall include the output status of all optimally started equipment, as well as temperature sensor inputs of affected areas.
   b. Interface to the building fire alarm system.
   c. Operational logs for each system that indicate all setpoints, operating points, valve positions, mode, and equipment status shall be submitted to the Engineer. These logs shall cover three 48 hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.

10. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date, and any necessary repairs or revisions to the hardware or software to successfully complete all tests shall be made.

B. Acceptance

1. All tests described in this specification shall have been performed to the satisfaction of both the Engineer and Owner prior to the acceptance of the control system as meeting the requirements of Completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the Completion requirements if stated as such in writing by the Engineer. Such tests shall then be performed as part of the warranty.

2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1: Submittals.

C. During the first year of operation, after acceptance by the Owner, provide complete service to adjust or assist the Owner in adjusting the equipment to obtain optimum performance from the control equipment and from the heating and air conditioning systems in general. This shall be done without additional expense to the Owner. This work shall include revisions to DDC software programs and controller, and all PC front end software upgrades. All software shall be provided to the Owner in disk form, including back-ups of final field programs.

3.10 Cleaning

A. Clean up all debris resulting from its activities daily. Remove all cartons, containers, crates, etc., under its control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.11 Training
A. Provide a minimum of three onsite training classes 8 hours in length during the construction period for personnel designated by the owner.

B. Provide two additional training sessions at 6 and 12 months following building’s turnover. Each session shall be 8 hrs. in length and must be coordinated with the building Owner.

C. Train the designated staff of Owner’s Representative and Owner to enable them to:

1. Day-to-day Users:
   a. Proficiently operate the system
   b. Understand control system architecture and configuration
   c. Understand DDC system components
   d. Understand system operation, including DDC system control and optimizing routines (algorithms)
   e. Operate the user interface and peripherals
   f. Log on and off the system
   g. Access graphics, point/object reports, and logs
   h. Adjust and change system setpoints, time schedules, and holiday schedules
   i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
   j. Understand system drawings, and Operation and Maintenance manual
   k. Understand the job layout and location of control components
   l. Access data from DDC controllers
   m. Operate portable user's terminals

2. Advanced Users:
   a. Make and change graphics on the user interface
   b. Create, delete, and modify alarms, including annunciation and routing of these
   c. Create, delete, and modify point/object trend logs, and graph or print these
   d. Create, delete, and modify reports
   e. Add, remove, and modify system’s physical points/objects
   f. Create, modify, and delete programming
   g. Add panels when required
   h. Add user interface stations
   i. Create, delete, and modify system displays — both graphical and otherwise
   j. Perform BAS system field checkout procedures
   k. Perform DDC controller unit operation and maintenance procedures
   l. Perform user interface and peripheral operation and maintenance procedures
   m. Perform BAS system diagnostic procedures
   n. Configure hardware including PC boards, switches, communication, and I/O points/objects
   o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware
   p. Adjust, calibrate, and replace system components

3. System Managers/Administrators:
   a. Maintain software and prepare backups
   b. Interface with job-specific, third-party user software
   c. Add new users and understand password security procedures

D. Provide course outline and materials as per “Submittals” Article in Part 1 of this specification. The instructor(s) shall provide one copy of training material per student.

E. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

F. Classroom training shall be done using a network of working controllers representative of the installed hardware.

3.12 Outdoor temperature and humidity sensors shall be mounted on the north face of the building unless otherwise approved by the Engineer. Exact location shall be approved by the Architect.
3.13 In addition to the adjustments and fine tuning, include as a part of this contract the equivalent of five (5) man days of service technician and/or programming time for work as may be specified by the Engineer.

END OF SECTION
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, Section 23 09 23 Building Automation System (BAS) for HVAC, Section 23 09 93 Sequences of Operations, Section 23 09 95 BAS Points List, 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**

<table>
<thead>
<tr>
<th>Measured Variable</th>
<th>Reported Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Temperature</td>
<td>±0.5°C [±1°F]</td>
</tr>
<tr>
<td>Ducted Air</td>
<td>±0.5°C [±1°F]</td>
</tr>
<tr>
<td>Outside Air</td>
<td>±1.0°C [±2°F]</td>
</tr>
<tr>
<td>Dewpoint</td>
<td>±1.5°C [±3°F] (-76 to 176°F scale)</td>
</tr>
<tr>
<td>Water Temperature</td>
<td>±0.5°C [±1°F]</td>
</tr>
<tr>
<td>Delta-T</td>
<td>±0.15°C [±0.25°F]</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>±5% RH (0 – 90% scale)</td>
</tr>
<tr>
<td>Water Flow</td>
<td>±2% of full scale</td>
</tr>
<tr>
<td>Airflow (terminal)</td>
<td>±10% of full scale (see Note 1)</td>
</tr>
<tr>
<td>Airflow (measuring stations)</td>
<td>±5% of full scale</td>
</tr>
<tr>
<td>Airflow (pressurized space)</td>
<td>±3% of full scale</td>
</tr>
<tr>
<td>Air Pressure (ducts)</td>
<td>±25 Pa [±0.1” w.g.]</td>
</tr>
<tr>
<td>Air Pressure (space)</td>
<td>±3 Pa [±0.01” w.g.]</td>
</tr>
<tr>
<td>Water Pressure</td>
<td>±2% of full scale (see Note 2)</td>
</tr>
<tr>
<td>Electrical (A, V, W, Power factor)</td>
<td>±1% of reading (see Note 3)</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>±5% of reading</td>
</tr>
<tr>
<td>Carbon Dioxide (CO2)</td>
<td>±50 ppm</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Controlled Variable</th>
<th>Control Accuracy</th>
<th>Range of Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Pressure</td>
<td>±50 Pa [±0.2” w.g.]</td>
<td>0-1.5 kPa [0-6” w.g.]</td>
</tr>
<tr>
<td></td>
<td>±3 Pa [±0.01” w.g.]</td>
<td>-25 to 25 Pa [-0.1 to 0.1” w.g.]</td>
</tr>
<tr>
<td>Airflow</td>
<td>±10% of full scale</td>
<td></td>
</tr>
<tr>
<td>Space Temperature</td>
<td>±1.0°C [±2.0°F]</td>
<td></td>
</tr>
<tr>
<td>Duct Temperature</td>
<td>±1.5°C [±3.0°F]</td>
<td></td>
</tr>
<tr>
<td>Humidity</td>
<td>±5% RH</td>
<td></td>
</tr>
<tr>
<td>Fluid Pressure</td>
<td>±10 kPa [±1.5 psi]</td>
<td>0-1 MPa [1-150 psi]</td>
</tr>
<tr>
<td></td>
<td>±250 Pa [±1.0” w.g.]</td>
<td>0-12.5 kPa [0-50” w.g.] differential</td>
</tr>
<tr>
<td>Differential Enthalpy</td>
<td>±5 kJ/kg [±3 Btu/lb]</td>
<td>35 – 63 kJ/kg [20-36 Btu/lb]</td>
</tr>
</tbody>
</table>

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 counterclockwise 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. For outdoor units and for indoor units where the freezestat controller is mounted more than 6 ft. above the floor, the low-limit thermostat shall be auto reset type with manual reset of its electrical circuit. 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 or Resistance Temperature Device (RTD), and be suitable for the application. Where feasible, provide the same sensor type throughout the project. Avoid using transmitters unless absolutely necessary.

2. Precision thermistors may be used in applications below 200 degrees F. 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.

3. Provide RTD sensors with platinum elements compatible with the digital controllers. Encapsulate sensors in epoxy, series 300 stainless steel, anodized aluminum, or copper. Temperature sensor accuracy shall be 0.1 percent (1 ohm) of expected ohms (1000 ohms) at 32 degrees F. Temperature sensor stability error over five years shall not exceed 0.25 degree F cumulative. Direct connection of RTDs to digital controllers without transmitters is preferred. When RTDs are connected directly, lead resistance error shall be less than 0.25 degrees F. The total error for a RTD circuit shall not exceed 0.5 degree F.
4. 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.
5. 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.
6. 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.
7. Provide matched temperature sensors for differential temperature measurement.
8. 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 ± 3 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 170 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. Flow Switches

1. Flow-proving switches shall be either paddle or differential pressure type, as specified or as appropriate for the application.
2. Paddle type switches (water service only) shall be UL Listed, SPDT snap-acting with pilot duty rating (125 VA minimum). Adjustable sensitivity with NEMA enclosure suitable for location.
3. Differential pressure type switches (air or water service) shall be UL Listed, SPDT snap act, pilot duty rated (125 VA minimum), NEMA enclosure suitable for location, with scale range and differential suitable for intended application, or as specified.

F. 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.

G. 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.

H. 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.

I. 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 at 500 ohm maximum burden.
3. Transmitters shall be UL/CSA recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1 requirements.

J. Voltage Transformers
1. AC voltage transformers shall be UL/CSA recognized, 600 VAC rated, complete with built-in fuse protection.
2. Transformers shall be suitable for ambient temperatures of 4 to 55 degrees C [40 to 130 degrees F] and shall provide ±0.5 percent accuracy at 24 VAC and a 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic material.

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 Switches and Relays

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the BAS.
2. Current relays for fan or pump proof shall be fully adjustable from 1.5 amps to 150 amps and shall have L.E.D. indicators. Form "A" (normally open) relays shall not be polarity sensitive. Current relays shall accommodate variable frequency drive outputs down to 6 HZ without contact chatter. Motor loads of less than 1.5 amps shall be multi-wound around current relay to increase "sensed" amperage to minimum setpoint for activation.

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. Carbon Dioxide Sensors - Sensors shall be infrared type CO2 measuring device with a 4-20 ma linear output from 0 - 2000 ppm. Sensor shall be designed and provided with all necessary accessories for duct or space mounting, as shown on drawings. Sensors shall be manufactured by MSA or approved equal.

P. Airflow measuring stations shall be provided on outside air of air handling units, as shown on the drawings and specified herein, utilizing electronic air flow traverse probes and transmitters designed to continuously monitor duct airflow volume or fan inlet volume as dictated by the application. Each airflow measurement system shall consist of single or multiple probes with velocity measuring sensors and elements designed and built to comply with accepted practice for traversing as defined in the most current ASHRAE Handbook of Fundamentals. The minimum number of sensing points on each element, and the quantity of elements utilized at each installation, shall comply with ASHRAE Standard 111 for equal area traversing. Sensors
may utilize the principles of thermistor technology with temperature compensation, high precision pitot tube technology, or vortex shedding provided that the performance specified below can be achieved. Signal amplifying sensors requiring flow corrections for field calibration are not acceptable.

Outside air airflow stations shall include flow transducers with minimum 0.25 percent full-scale accuracy signal processors, with an auto zeroing function, temperature compensation, and a digital cfm readout on the face. Minimum accuracy shall be 2.0 percent of reading with a field installed system accuracy of 3.0 percent or better, through a velocity range of 150 to 2500 fpm. Provide linearization function to compensate for installations where non-minimum duct conditions are encountered.

Duct insertion probes shall be provided with a gasketed duct mounting plate and threaded end support. Each airflow measurement probe shall connect to the companion transmitter through a manufacturer supplied, shielded connection cable. Stations shall be capable of field recalibration, with interchangeable electronics and be field repairable. Transmitters shall provide an analog electronic output linear to air flow reading for input into the BAS.

Technology shall utilize EEPROM's or 48 hr. battery back-up to accommodate power outages with no loss of setpoints, parameters, or programming.

Airflow measuring stations shall be manufactured by Paragon Controls (Microtrans transducers with FE-1000 probes, and FT-1005 transducers with FE-1050 fan inlet probes), or equivalent Ebtron Gold Series. Warranty of equipment including parts and labor shall be for a period of two years. The manufacturer’s representative shall field verify duct configurations prior to ordering airflow stations. Documentation showing compliance with specified system accuracies shall be included with the shop drawings.

Q. 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 and face and bypass (F&BP) 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 louvered). 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 CDTI-50, 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.

M. Smoke dampers and operators are specified in Section 23 33 00 Air Duct Accessories.

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. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells. All duct mounted sensors in externally insulated ducts shall be installed in insulated J-boxes (or J-boxes with 1 inch thick ductboard between it and duct) to afford access (and not be covered with insulation).

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

J. 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.

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 Flow Switch Installation

A. Use correct paddle for pipe diameter.

B. Adjust flow switch in accordance with manufacturer’s instructions.

3.4 Control Valves

A. Control valves shall be installed in strict accordance with the valve manufacturer’s instructions and recommendations.

B. Steam valves shall have their stems and actuators horizontal or 45 degrees upright to promote cooling of the assembly.

3.5 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.

3.6 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.

3.7 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 (except as stated below) shall be run in conduit. 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. Cable trays installed by other trades may only
be used when approved by Owner and Technology Installer. 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 “Legally Required” or “Owner Optional” emergency 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.

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23 09 93  SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 Implemented Sequences of Operation shall be in compliance with ASHRAE 90.1-2013, unless deviated by the sequences with-in. Any additional deviations must be reviewed with the Engineer prior to implementation.

1.2 Provide all equipment (valves, dampers, actuators, controllers, etc.) required to perform the functions specified unless noted herein or elsewhere in these contract documents. Electric motor driven equipment (pumps, chillers, compressors, cooling towers, etc.) shall be provided with minimum on (run) and minimum off timers to prevent short cycling of the equipment (coordinate with equipment manufacturer's).

1.3 All DDC system control points shall have a default value in case of sensor failure or logic error. All controlled devices shall fail safe on loss of control. All setpoints and parameters shall be fully adjustable from the end user / owner interface.

1.4 Refer to Section 23 09 23 for Sequences of Operations meeting.

PART 2 - PRODUCTS

2.1 Refer to Section 23 09 23 and 23 09 25 for applicable products.

PART 3 - EXECUTION

3.1 “Occupied”, “Unoccupied” and Override Modes

A. Each air-side system shall be scheduled (independently) for “Occupied” and “Unoccupied” modes of operation, unless stated otherwise in the specific system sequences of operations with-in.

B. Automatic controls shall be capable of retaining programming and time settings during loss of power for a period of at least ten hours, and shall include an accessible override that allows temporary operation of each system for up to two hours.

C. The “Occupied” mode of operation shall be scheduled through a time and date calendar function at the DDC system operator workstation. The initial “Occupied” mode schedule shall be in effect Monday through Friday, 7:00 a.m. to 5:00 p.m. unless noted otherwise in the specific system sequences with-in. Coordinate time of day scheduling with Owner. Scheduling software shall be capable of seven different day-types per week.

D. The “Unoccupied” mode shall be in effect whenever the zone or system is not in “Occupied” mode.

E. “Override” mode shall put the zone or system into “Occupied” mode when any of the following occurs:

1. “Occupied” mode initiated through manual override of the “Unoccupied” mode at the operator workstation.

2. “Occupied” mode initiated by a zone override device. A zone override device shall be a manually operated switch as defined with-in or on the drawings.

Whenever the zone or system occupancy sensor detects movement and heat changes, the “Occupied” mode shall be enabled. If movement and heat changes are not detected for 20 minutes (adjustable), the zone or system “Occupied” mode shall be disabled.
Whenever the zone vacancy sensor detects movement and heat changes, and the zone light switch is turned on, the “Occupied” mode shall be enabled. If movement and heat changes are not detected for 30 minutes (adjustable), or the zone light switch is turned off, the zone “Occupied” mode shall be disabled.

3.2 Adaptive Optimal Start Mode

A. For each air-side system, the DDC System shall utilize space temperature, outdoor air temperature, applicable “Occupied” heating and cooling setpoints and occupancy schedule to continuously adapt itself using a "learning" process to calculate the most optimal start time, up to 4 hours (adjustable) prior to scheduled occupancy time, to allow the average building space temperature to reach the “Occupied” space temperature setpoint determined by the heating or cooling mode. Programs which require manual fine-tuning of each fan system’s algorithms shall not be acceptable.

3.3 Zone Heating and Cooling Setpoints

A. Zone heating and cooling setpoints shall be as follows except as specified otherwise. All setpoints shall be adjustable.

“Occupied” Zone Cooling Setpoint: 72 deg F / As Defined on the drawings

“Occupied” Zone Heating Setpoint: 2 deg F below “Occupied” Zone Cooling Setpoint

“Unoccupied” Zone Cooling Setpoint: 7 deg F above “Occupied” Zone Cooling Setpoint but no warmer than 82 deg F

“Unoccupied” Zone Heating Setpoint: 7 deg F below “Occupied” Zone Heating Setpoint but no lower than 60 deg F. For radiant systems, the “Unoccupied” Zone Heating Setpoint shall be 4 degrees below the “Occupied” Zone Heating Setpoint.

3.4 Electric Air Curtains

B. System Description:

1. Electric heat air curtains are being installed to provide supplemental heating at exterior doors.

C. Run Conditions:

1. For units with dedicated thermostats, the units shall be programmed for ““Occupied” and “Unoccupied”” modes and Adaptive Optimal Start per paragraphs 3.1 and 3.2.

2. For units controlled from associated room temperature controls, the units shall be programmed in sequence with the associated air terminal unit.

D. Space Temperature Control

1. For units with dedicated thermostats, modulate the stages of electric heat to maintain space heating setpoints per paragraph 3.3. Electric heat shall be “Off” when outside air temperature is above 55 deg F.

2. For units controlled from associated room temperature controls, modulate the electric heat in sequence with the associated air terminal unit to maintain space heating setpoints per paragraph 3.3. Electric heat shall be “Off” when terminal unit is in cooling mode, or when the outside air temperature is above 55 deg F. Refer to Air Terminal Units controls.
3.5 VAV Boxes (Air Terminal Units)

A. The VAV box manufacturer shall provide the box with velocity sensor and air flow taps for use in the temperature controls. Provide all other control components. Reheat boxes shall be provided with a SCR controlled electric reheat coils as indicated on the drawings. Also refer to drawings for listed cfm set points and listed discharge air temperature set points as described below. Provide Auto Zeroing function to adjust the zero calibration point of the pressure or velocity transducer. VAV box control sequences shall be active when the associated AHU supply fan is “on”.

B. VAV Shutoff (cooling-only) Control - If the space temperature is below setpoint, the box damper shall be at the listed Dead Band Minimum CFM. If space temperature rises above the cooling setpoint, the control shall modulate the box damper between the listed Dead Band Minimum CFM and the listed Cooling Maximum CFM to satisfy the space cooling setpoint. Box controls shall reverse action during “warm-up” cycles.

C. VAV Electric Reheat and Heating Control

1. Reheat Mode -- If mechanical cooling is active or if economizer is active (outside air damper open beyond minimum setting), the following sequence shall be implemented:
   If the space temperature is in the dead band between heating and cooling set points, the box damper shall be positioned to the listed Dead Band Minimum CFM. (Note: Unless noted otherwise on the drawings Dead Band Minimum CFM shall be set to the scheduled value even if below manufacturer’s minimum box CFM.) If space temperature rises above the cooling setpoint, the control shall modulate the box damper between the listed Dead Band Minimum CFM and the listed Cooling Maximum CFM to satisfy the space cooling setpoint. When the room temperature is below setpoint, the box damper and hot water valve shall be sequenced to maintain the space heating set point as follows:
   a. 1st stage of heating shall be to position the box damper at its listed Dead Band Minimum CFM and modulate the SCR electric reheat control to maintain space temperature, with a high limit discharge air temperature of 20 degrees above the space heating set point (except during warm-up cycles).
   b. If after 10 minutes the space heating set point cannot be maintained for 5 minutes, 2nd stage of heating shall be to modulate the box damper from the listed Dead Band Minimum CFM to the listed Reheat Maximum CFM while maintaining a discharge air temperature of 20 degrees above the space heating set point.
   c. Reverse the sequence when space heating setpoint is reached. When in a “warm up” cycle, the box damper shall go to the listed Heating Maximum CFM and SCR electric reheat control shall be modulated to maintain the space heating set point (and supply air temperature not limited to 20 degrees above room set point).
   d. If electric reheat is not available the boxes shall act as Shutoff (cooling only) boxes.

2. Heating Mode -- If the outdoor air temperature is below 50 deg F and mechanical cooling is not active and economizer is not active (outside air damper being controlled to minimum cfm), the following sequence shall be implemented:

   If the space temperature is in the dead band between heating and cooling set points, the box damper shall be positioned to the listed Dead Band Minimum CFM. If space temperature rises above the cooling setpoint, the control shall modulate the box damper between the listed Dead Band Minimum CFM and the listed Cooling Maximum CFM to satisfy the space cooling setpoint. When the room temperature is below setpoint, the box damper and SCR electric reheat control shall be sequenced to maintain the space heating set point as follows:
   a. 1st stage of heating shall be to position the box damper at its listed Dead Band Minimum CFM and modulate the SCR electric reheat control to maintain space temperature, with a high limit discharge air temperature of 95 deg F (except during warm-up cycles).
b. If after 10 minutes the space heating set point cannot be maintained for 5 minutes, 2nd stage of heating shall be to modulate the box damper from the listed Dead Band Minimum CFM to the listed Heating Maximum CFM to maintain space temperature while maintaining a discharge air temperature of 95 deg F.

c. Reverse the sequence when space heating setpoint is reached. When in a “warm up” cycle, the box damper shall go to the listed Heating Maximum CFM and the SCR electric reheat control shall be modulated to maintain the space heating set point (and supply air temperature not limited to 95 deg F).

d. If electric reheat is not available the boxes shall act as Shutoff (cooling only) boxes.

D. Constant Volume Electric Reheat Control – The box damper shall be controlled to maintain the listed constant volume CFM, and the SCR electric reheat control shall be modulated to maintain the space temperature set point.

E. Energy Management - Each VAV box shall have its own time of day schedule for “Occupied” and “Unoccupied” control. An override pushbutton shall be provided at each sensor thermostat to override the “Unoccupied” schedule for a fixed (programmable) time. The DDC system shall track, log and report on the amount of time each box was overridden as well as VAV box discharge air temperature.

3.6 Air Control Valves

A. Refer to section 23 36 24

3.7 Air Handling Unit

A. System Description

1. The air handling system consists of a supply fan VFD, exhaust fan array with VFD, outside air dampers with airflow measuring station, relief air dampers, prefilters, final filters, gas fired pre-heat section, DX cooling coil. Refer to the drawings for details.

B. System Enable Conditions:

1. Refer to paragraph 3.1 for definitions of “Occupied”, “Unoccupied”, and Override Modes.
2. The “Occupied” mode of operation for this air handling system shall be as defined in paragraph 3.1. Verify and coordinate time of day scheduling with Owner. During the “Occupied” mode, the temperature controls shall function as specified. Refer to below for “Unoccupied” mode and “Override” mode.
3. When a zone thermostat override button is energized, the air handling system shall be enabled to run in the “Occupied” mode for the duration of the override.
4. Provide start-stop interlock between supply and return fans. Schedule exhaust fans to run when the AHU is in the “Occupied” mode.

C. “Unoccupied” Night Setback Heating Mode

1. When the air handling unit is in the “Unoccupied” mode and any zone temperature falls 3 degrees below the zone “Unoccupied” heating setpoint (refer to paragraph 3.3 above), the air handling unit system shall cycle on, except that the outside air dampers shall remain closed and the interlocked exhaust fans shall remain off. When all zone temperatures are at or above their zone “Unoccupied” heating setpoint the air handling system shall cycle off.

D. “Unoccupied” Night Setup Cool-Down Mode

1. When the air handling unit is in the “Unoccupied” mode and any zone temperature rises 3 degrees above the zone “Unoccupied” cooling setpoint (refer to paragraph 3.3 above), or
when space RH rises above 60%, the air handling unit system shall be cycled on for cool-
down, except that and the interlocked general exhaust fans shall remain off. Provide wall
mounted RH sensor as shown on drawings.

2. During cool-down, outside air shall be used for cooling first unless the economizer is locked
out. If the economizer is inactive, the associated relief and economizer exhaust fans shall
remain off, and outside air dampers shall remain closed, and mechanical cooling shall be
made available. When all zone temperatures are at or below their zone “Unoccupied”
cooling setpoint the air handling system shall cycle off.

E. Adaptive Optimal Start

1. An optimal start program shall start the unit in advance of the scheduled “Occupied” time
to ensure proper space temperatures at occupancy time. Refer to paragraph 3.2 above.
The control learning algorithm at a minimum shall be a function of the difference between
zone temperatures and occupied set points and the amount of time prior to scheduled
occupancy. The algorithm shall adjust start times based on past histories and times to
obtain occupied setpoints at similar outside air temperatures.

2. During an optimal start warm-up cycle (“morning warm-up”) the outside air dampers shall
remain closed, return air dampers full open, economizer exhaust fan off and relief dampers
full closed, and associated general exhaust fans off. Gas heat shall be made available.
During warm-up the VAV shut-off boxes shall open. This mode shall continue until the
exterior zones (only) reach their “Occupied” heating setpoints. If the system is still in its
warm-up cycle 30 minutes after the scheduled occupied start time, end the warm-up cycle
and alarm the BAS of the zone(s) that did not hit their occupied heating set point. When
the warm-up cycle ends, the economizer dampers shall be positioned to minimum and the
respective exhaust fans shall be enabled. Economizer damper control shall be delayed
two minutes during start-up to prevent cabinet heat from false loading the system.

3. During an optimal start cool-down cycle, outside air shall be used for cooling first unless
the economizer is locked out. If the economizer is inactive, the associated relief and
economizer exhaust fans shall remain off, and outside air dampers shall remain closed,
and mechanical cooling shall be made available. This mode shall continue until all zones
reach their “Occupied” cooling setpoints. If the system is still in its cool-down cycle 30
minutes after the scheduled occupied start time, end the cool-down cycle and alarm the
BAS of the zone(s) that did not hit their occupied cooling set point. When the cool-down
cycle ends, the economizer dampers shall be positioned to minimum and the respective
exhaust fans shall be enabled.

F. Safeties

1. The following safeties shall be provided to stop the air handling unit system and position
associated control devices to their “fail safe” position, i.e., outside and relief dampers
closed, return dampers open, heating valves open and humidifier valves closed. Safeties
shall be wired into the fan starter circuit such that the safety shall function whether the
starter selector switch is in the hand on or automatic position, and whether or not the VFD
is in Bypass.
   a. Low Temperature Limit Cutout “Freezestats” –Auto reset type with remote manual
      reset. Shall be provided and installed on the leaving air face of the first coil in the air
      stream (unless otherwise noted) and shall stop the air handling unit system if a
temperature below 34 deg F is detected. Refer to detailed installation requirements
      in 23 09 25 Instrumentation and Control Devices for HVAC.
   b. Unit Smoke Detectors – Upon sensing smoke or products of combustion the air
      handling system shall be disabled. Smoke detectors shall be provided per Division
      26 unless otherwise noted, installed in the return duct system and wired to the fan
      safety circuits to stop the air handling unit system upon smoke detection. Refer to the
drawings for detector locations and coordinate their installation.
c. Supply Duct High Static Pressure Cutout - Provide a manually reset type duct static pressure switch, set at the maximum working pressure of the ductwork, to stop the fan system (supply, return, exhaust) on a rise in duct static above setpoint.

d. Return Duct High Negative Pressure Cutout - Provide a manual reset type duct static pressure switch, set at the maximum negative working pressure of the ductwork, to stop the fan system (supply, return, exhaust) on a fall in duct static below setpoint.

G. Minimum Outside Air Control

1. This paragraph defines the operation of outside air, relief air and return air dampers (economizer dampers) to provide minimum outside air for ventilation. The phrase “Minimum” in the sequences of operation shall invoke this paragraph. Simple outside air damper sections (all damper blades operating in unison) shall open to a fixed position as determined by air balance and airflow station monitoring to provide the specified minimum ventilation cfm set point. Return air dampers shall remain full open until the point in which the minimum outside air damper is full open and minimum outside air flow is not being maintained. In this scenario the return air dampers shall start to modulate closed until the minimum outside air is met. Once minimum outside airflow rises above setpoint, return air damper shall modulate to the full open position prior to outside air damper modulating closed to meet minimum outside airflow setpoint. Relief dampers shall remain closed unless building pressure sensor rises above setpoint. Refer to Relief Damper control section for further detail. At no point shall the return air dampers and the relief air dampers be simultaneously closed.

H. Differential Dry Bulb Economizer Control

1. During “Occupied” mode or “Cool-Down” mode, outside air temperature and return air temperature shall be measured. If the temperature of the outside air is less than the temperature of the return air, the economizer shall be enabled.

2. When the unit operates in the “Occupied” mode, the minimum outside air shall be provided, the return air dampers shall open full and relief air dampers shall remain closed. This condition is the normal position and shall be maintained during the “Occupied” mode except during the "economizer" cycle. During the “economizer” cycle, the amount of outside air and relief air shall be increased as required to maintain the unit discharge air temperature setpoint. Provide a mixed air sensor and low limit control set at 45 degrees F. to prevent over-opening of the outside air dampers. If the mixed air temperature falls below 45 deg F for 10 minutes and the outside air dampers are at minimum position, economizer shall be considered “inactive”. All control setpoints shall be fully adjustable to meet job conditions. Economizer Mode shall be delayed two minutes during start-up to prevent cabinet heat from false loading the system.

I. Outside Air Auto Damper Control

1. When the supply air fan is off for any reason or the unit is operating in the “Unoccupied” mode, warm-up mode, or cool-down mode the outside air damper shall be closed unless economizer is enabled.

J. Return Air Auto Damper Control

1. The return air damper shall modulate inversely to the outdoor air damper when the economizer mode is enabled. When the economizer mode is disabled the return air damper shall be fully open. Provide interlock so that the return air dampers and outside air dampers cannot be closed at the same time, under normal operation and off or failed operation.

K. Relief Air Auto Damper Control

1. Relief air is controlled by an economizer exhaust fan. Refer to paragraph M below.
L. Supply Fan System Control

1. The supply fan system consists of a fan and associated VFD. Refer to 23 05 14 Adjustable Frequency Motor Controllers for VFD requirements. Each VFD has a manual bypass.

2. A manual “Hand-Off-Auto” switch on the face of the VFD shall select mode of operation. When the selector switch is indexed to the “off” position, the associated fan system shall stop. When the selector switch is indexed to the “on” position and all safeties are normal, the associated fan system shall start and run continuously. When the selector switch is indexed to the “auto” position and all safeties are normal, the BAS shall start and stop the associated fan system.

3. A manual “Manual-Auto” switch (control pad feature) on the face of the VFD shall select control signal source for motor speed. When the motor is enabled and is indexed to the “Manual” position, the manual speed adjustor of the VFD shall provide the control signal for motor speed. When the motor is enabled and is indexed to the “Auto” position, the BAS shall provide a proportional plus integral control signal to modulate motor speed to maintain the supply air static pressure setpoint.

4. Supply Fan System Speed Control - The variable speed drives on the supply fan system shall be modulated by a duct-mounted static pressure sensor located two-thirds down the main supply duct as shown on the drawings, and a proportional plus integral control shall provide a signal thru the BAS to modulate the VFD speed to maintain the duct static pressure setpoint (initially set to 1.0” w.c.).

M. Economizer Exhaust Fan System Control

1. The economizer exhaust fan system consists of fan and associated VFD, integral with the AHU. Refer to 23 05 14 Adjustable Frequency Motor Controllers for VFD requirements. Each VFD has a manual bypass.

2. A manual “Hand-Off-Auto” switch on the face of the VFD shall select mode of operation. When the selector switch is indexed to the “off” position, the associated fan system shall stop. When the selector switch is indexed to the “on” position and all safeties are normal, the associated fan system shall start and run continuously. When the selector switch is indexed to the “auto” position and all safeties are normal, the BAS shall start and stop the associated fan system.

3. A manual “Manual-Auto” switch (control pad feature) on the face of the VFD shall select control signal source for motor speed. When the motor is enabled and is indexed to the “Manual” position, the manual speed adjustor of the VFD shall provide the control signal for motor speed. When the motor is enabled and is indexed to the “Auto” position, the BAS shall provide a proportional plus integral control signal to modulate motor speed to maintain setpoint.

4. Economizer Exhaust Fan System Speed Control – When the air handling unit is on economizer cycle, the isolation auto dampers on the economizer exhaust fans shall open fully and the variable speed drive on the economizer exhaust fan system shall be modulated by a wall-mounted Dp sensor-transmitter to maintain a building pressure of +0.05” w.c., referenced to outdoors. Refer to drawings for Dp sensor location. Economizer exhaust fan and associated isolation dampers shall be closed when not on economizer.

N. Supply Air Temperature Set Point and Reset

1. The air handling unit components shall be sequenced to provide a supply air temperature of 70 deg F during “warm-up” cycles, and 46 deg F during “cool down” cycles. During “occupied” mode, the supply air temperature set point shall be 46 deg F except reset as follows:
   a. Supply Air Temperature Reset Based on Zone Temperature: Poll all zones associated with this air handling unit every 15 minutes and the zone furthest from its cooling setpoint shall govern. As the worst-case zone deviation from its cooling setpoint decreases, the discharge air shall be reset upwards towards an upper limit of 55 deg F. If all zones are in heating and/or in dead band, the supply air set point shall
be reset to the upper limit of 55 deg F. Automatically detect those zones that may be excessively driving the reset logic and generate an alarm to the system operator. Readily allow operator removal of zone(s) from the reset algorithm. If return air relative humidity rises above 58 percent RH the reset schedule shall be deactivated. After 60 minutes, re-activate reset schedule if building RH falls below 55 percent. Provide return duct RH sensor for monitoring and reset control.

O. Heating/Cooling Control

1. If the AHU fan system is “on” and mechanical cooling is off and economizer is “off” and the ahu supply air temperature falls 2 degrees below setpoint, the gas-fired preheat shall modulate to maintain the supply air at 2 degrees below setpoint.

2. DX Coil – If the AHU fan system is “on” and the economizer is active and at 100 percent (outside air dampers full open) and the ahu supply air temperature is above set point, the solenoid valves and compressor stepping shall be sequenced to satisfy the setpoint. If the AHU fan system is “on” and the economizer is NOT active and the ahu supply air temperature is above set point, the solenoid valves and compressor stepping shall be sequenced to satisfy the setpoint. Provide on and off time delays between steps. Provide air flow switch for interlock thru software to keep cooling off unless the fan is operating.

P. Air Filter Monitoring

1. The BAS system shall monitor the differential pressure across each filter bank. When the filter bank pressure drop exceeds the manufacturer’s filter load limit generate an alarm to the BAS.

3.8 Exhaust Fans

Each exhaust fan (and its respective automatic damper) where indicated on the Electric Drawing Starter Schedule shall be a separate start/stop point of the digital control system.

3.9 VFD Bypass Operation Sequence

The air handling units supply and return fans are powered through VFDs. When either VFD is switched to the bypass position, that air handling system shall automatically enter a constant volume reheat operating mode and an alarm shall be indicated at the monitoring console. The DDCS system shall monitor a set of contactors on the VFD indicating bypass contactor. When a VFD is switched to bypass, all air control terminal units on that air handling system shall position to cooling maximum cfm. Reheat coils shall modulate to maintain space setpoint.

3.10 Monitoring and Alarms

The following points shall be monitored and alarmed at the monitoring console and as otherwise specified hereinafter:

A. Point Descriptions:

1. Current Sensing Relays – Provide for all air handling unit supply and return/exhaust fans; all general exhaust fans.
2. High/Low Temperature Alarms on all DDCS temperature sensors with off normal messages.
3. Fire Alarm System Inputs – Fire alarm shall be input into the DDCS for information and smoke control mode. Provide wiring from the DDCS inputs to the Fire Alarm System outputs. Coordinate connection points with the Electrical Contractor.
B. When interfacing with equipment providing remote analog inputs or receiving analog outputs to the DDCS or when monitoring requires the installation of external relays at the equipment being monitored, coordinate all requirements such as range, signal condition, grounding, wiring and input impedance with the supplier of the equipment being monitored.

C. Dial Out Alarms – DDCS shall initiate a phone call and print an alarm message at a remote printer, digital pager, or PC operating in terminal mode whenever the system detects a critical alarm. These alarms shall include but not be limited to: AHU freezestat alarm, chiller trouble, boiler or heating failure.

END OF SECTION
23 09 95  DIRECT DIGITAL CONTROL SYSTEM POINTS LIST

PART 1 - GENERAL

1.1 The following list and those shown on the drawings shall be the minimum points required of the Direct Digital Control System (DDCS). It is not the intent to show all required points. If or when additional points are required to accomplish the sequences of control specified, these points shall also be provided. The point types are identified as follows:

- DI  Contact Input (NO or NC)
- DO  Contact Output (NO or NC)
- AI  Analog Input
- AO  Analog Output
- PI  Pulsed Input

1.2 Air Handling Unit Points List:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>Return Air Temperature</td>
<td>1</td>
</tr>
<tr>
<td>AI</td>
<td>Mixed Air Temperature</td>
<td>1</td>
</tr>
<tr>
<td>AI</td>
<td>Supply Air Temperature</td>
<td>1</td>
</tr>
<tr>
<td>AI</td>
<td>Supply Air Static Pressure</td>
<td>1</td>
</tr>
<tr>
<td>AI</td>
<td>Leaving Heating Section Temperature</td>
<td>1</td>
</tr>
<tr>
<td>DI</td>
<td>Supply Fan Status</td>
<td>1</td>
</tr>
<tr>
<td>DI</td>
<td>Exhaust Fan Status</td>
<td>1</td>
</tr>
<tr>
<td>AO</td>
<td>Economizer Dampers</td>
<td>1</td>
</tr>
<tr>
<td>AO</td>
<td>Heating Status</td>
<td>1</td>
</tr>
<tr>
<td>AO</td>
<td>Cooling Status</td>
<td>1</td>
</tr>
<tr>
<td>AO</td>
<td>Supply Fan Volume Control</td>
<td>1</td>
</tr>
<tr>
<td>AO</td>
<td>Exhaust Fan Volume Control</td>
<td>1</td>
</tr>
<tr>
<td>AI</td>
<td>Air Filter Pressure Drop</td>
<td>1</td>
</tr>
<tr>
<td>DI</td>
<td>Freezestat</td>
<td>1</td>
</tr>
<tr>
<td>DO</td>
<td>Fan System Start/Stop</td>
<td>1</td>
</tr>
<tr>
<td>AI</td>
<td>Space Temperature</td>
<td>*</td>
</tr>
<tr>
<td>AI</td>
<td>Return Air Humidity</td>
<td>1</td>
</tr>
<tr>
<td>DI</td>
<td>Smoke Alarm</td>
<td>**</td>
</tr>
</tbody>
</table>

*One sensor for unoccupied control, additional space sensor as shown on drawings. When DDC zone control is specified all zone thermostats shall be DDC inputs.
**For notice of smoke detection at the B.A.S. (in addition to hardwired starter interlock for unit shutdown) and smoke damper control.

1.3 VAV Air Terminal Unit Points List (per each unit):

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>Space Temperature</td>
<td>1</td>
</tr>
<tr>
<td>AI</td>
<td>Space Temperature Setpoint</td>
<td>1</td>
</tr>
<tr>
<td>AI</td>
<td>Discharge Air Temperature</td>
<td>1</td>
</tr>
<tr>
<td>AI</td>
<td>Air Volume (CFM)</td>
<td>1</td>
</tr>
<tr>
<td>DI</td>
<td>Occupancy Override</td>
<td>1</td>
</tr>
<tr>
<td>AO</td>
<td>Air Damper</td>
<td>1</td>
</tr>
<tr>
<td>AO</td>
<td>Electric SCR value</td>
<td>1</td>
</tr>
</tbody>
</table>

1.4 Exhaust Fan Systems
**DIRECT DIGITAL CONTROL SYSTEM POINTS LIST**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>Exhaust Fan Start/Stop</td>
<td>*</td>
</tr>
<tr>
<td>DI</td>
<td>Exhaust Fan Status</td>
<td>*</td>
</tr>
<tr>
<td>DI</td>
<td>Low Static Safety</td>
<td>*</td>
</tr>
</tbody>
</table>

*One for each fan system.
**For notice of smoke detection at the B.A.S., shutdown of fan, and closure of associated smoke dampers.

1.5 General or Global Points:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>Outside Air Humidity</td>
<td>1</td>
</tr>
<tr>
<td>AI</td>
<td>Outdoor Air Temperature</td>
<td>1</td>
</tr>
</tbody>
</table>

**PART 2 - PRODUCTS - NOT USED**

**PART 3 - EXECUTION - NOT USED**

END OF SECTION
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 Ductwork shall not be internally lined, unless shown otherwise for return or exhaust.

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, G60 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 / and / (wet environment) 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 and / on the roof 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. Length shall be limited to 7 feet unless noted otherwise.

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. 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 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 30 degrees on converging transitions and 15 degrees on diverging transitions.

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, whichever is more stringent. Connector components shall be constructed from same material as the duct section being connected.

2.5 Fan Transitions

A. Fan inlet – Maximum 7 degrees diverging and 15 degrees converging, and first duct elbow shall be minimum 2.5 fan inlet diameters away unless shown otherwise on plans.

B. Fan Discharge -- Maximum 7 degrees diverging and 15 degrees converging, and first duct elbow shall be minimum 2.5 fan inlet diameters away unless shown otherwise on plans

2.6 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. In lieu of the above, round duct, fittings and connectors may be 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-values and liner types shall be as specified above.

C. 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 conicals 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 30 degrees on converging transitions and 20 degrees on diverging transitions. Divided flow branches shall conform to SMACNA. Bull head tees without vanes are not permitted.

D. Construction, reinforcing, supports, etc. shall either conform to SMACNA or to the duct manufacturer’s standards, whichever is more stringent.

2.7 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 which is not internally lined.

2.8 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.

2.9 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.

2.10 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.

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. 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. Side beam bracket in wood construction, secured to the wood joist with lag screws set in drilled pilot holes.

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

F. 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.

G. Attachment to manufactured trusses, purlins and other engineered structural members and supports shall be done in strict accordance with the structural 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 manufacturer. Provide additional supports with supplemental steel shapes when spacing between structural members exceeds specified distances.

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 contaminants 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 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". Duct connections to Type I grease duct fans shall be flanged and gasketed with material rated for no less than 1500 degF.

3.9 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.

3.10 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.

3.11 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.

3.12 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.

3.13 Sheet metal sleeves in conjunction with fire dampers shall be placed in walls and floors to pass ductwork.
3.14 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. Refer to 23 05 05 Firestopping.

3.15 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.

3.16 Due to the high level of cleanliness required in the clean rooms, take extreme care in erecting and maintaining a clean duct system. Each duct section shall be wiped out with a wet cloth and dried with a clean, dry cloth immediately before installation. Before the end of each day’s work, open ducts and air devices shall be sealed with heavy visqueen plastic and completely taped around all edges. Just prior to starting the air system, the visqueen barriers shall be removed and a temporary filter shall be placed over all return air openings or registers. Secure the filter firmly in place.

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 The duct system shall be free of construction debris and new ductwork shall comply with level “B”, the Intermediate Level of the latest edition of the SMACNA Duct Cleanliness for New Construction Guidelines.

3.19 Where duct surfaces can be seen thru grilles, registers and diffusers, the inside of the duct shall be coated with flat black paint before the device is installed, to eliminate obtrusive appearances.

3.20 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.

3.21 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.

3.22 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.

3.23 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) and the Construction Manager / Owner’s Representative.

END OF SECTION
PART 1 - GENERAL

1.1 Work includes plenum casings for central air supply, return and exhaust systems, including such related items as doors, baffles, air blending devices, coil supports and drain pans, and concrete or steel curbs.

1.2 SMACNA standards for plenum construction and reinforcing shall be applicable except where specific requirements exceed these standards.

PART 2 - PRODUCTS

2.1 Types

A. TYPE B.

1. Double wall acoustic type "Uni Housing" by United Sheet Metal or equivalent by Koppers, Airflex, Industrial Acoustics, Keene or Tempmaster.

2. Construction for return and mixed air plenums shall be for medium pressure, 2 inches thickness, to withstand 4 inches pressure.

3. Construction for supply side plenums shall be for high pressure, 4 inches thickness to withstand 8 inches pressure.

4. Construction shall consist of double wall galvanized sheet metal. Inside sheet of metal shall be perforated for sound absorption and the thickness between two layers of metal shall be filled with 4 lb. density fibrous glass insulation for sound absorption and thermal insulation. Provide septum partitions to divide compartments.

5. Construction shall be manufacturer's standard design as regards to gauge thickness, reinforcing, etc., however no deflection in excess of 0.50 inch will be allowed.

6. Construction shall be arranged to form an air tight joint at all attachments to walls, floors, etc., and all joints shall be made air tight by the use of non-shrinking high velocity duct sealer.

7. Ceiling panels shall be supported by prime coated structural steel beams and columns. Reinforcing and attachment angles, sheet metal baffles and other accessory elements shall be installed to complete the installation.

8. Doors shall be triple hinged hollow construction with 12 inches x 12 inches wire reinforced double glass inspection window, "Ventlock" No. 310 latches and tight sealing No. 390 gaskets. Latches shall have handles on both sides. Doors shall be 24 inches wide x 60 inches high unless otherwise noted. All shall be hinged to close due to air pressure.

9. All piping and conduit piercing the casing shall be sleeved and made air tight with oakum packing.

10. Provide 6 inches x 6 inches longitudinally reinforced concrete curbs which are doweled to the concrete floor for each casing. Cast in anchor bolts and bolt to bottom angle of casing.

11. Furnish complete dimensional drawings of all housing assemblies for approval before commencement of fabrication. Standard drawing details along will not be considered as compliance with this requirement. Drawings shall show equipment in place, structural supports, baffles, ducts, curbs and bases.

PART 3 - EXECUTION

3.1 All casings shall be insulated on the interior with not less than 1 inch thickness neoprene coated semi-rigid acoustic fiberglass board. This provision not applicable for acoustic housing where insulation is an integral part of the construction.
3.2 Plenums shall be constructed air tight. Plenums constructed outside shall be water tight. Basic construction shall be to minimize possible paths of leakage. Permanently pliable caulking shall be used in cracks, edges and joining surfaces to ensure tightness.

3.3 Assemble panels carefully to ensure air tight joints. Provide gaskets at all bolted connections. Caulk all incidental cracks and points of leakage. Braze in sleeve thru all points of pipe or duct passage to make air tight. Pack and caulk sleeve.

Pitch coil pans to drain; extend pipe drain thru casing and provide deep seal trap and extension to floor drain.

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, filter pressure differential gauges, and sound attenuators. 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 A pressure differential gauge shall be provided at air filters in each air handling unit for pressure drop indication. Where pre-filter panels and higher efficiency filters are back-to-back, one gauge is to be provided.

1.5 Provide sound attenuation for duct systems, including duct insertion type units, attenuation type double wall ducts and lead mass muffling. Where attenuator type air terminal boxes have inadequate sound absorption, provide insertion type attenuators to supplement noise reduction.

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 Pressure differential gauges for air filter application shall be Dwyer "Magnehelic" Series 2000 dial type gauges. Range shall be appropriate for the application. Each gauge shall be furnished with vent valves, aluminum or plastic tubing, static pressure tips and mounting bracket or flange.

2.5 Duct mounted sound attenuators shall be “hospital grade” constructed of minimum 22 gauge galvanized sheet metal outer casing with minimum 26 gauge galvanized sheet metal perforated inner lining and baffles backed with sound absorbing media completely wrapped in an impervious protective cover. The sound-absorbing media may consist of fiberglass or natural cotton fibers treated with an EPA registered, non-toxic borate solution, “flash dried” to actively inhibit the growth of mold, mildew bacteria and fungi. Media shall not contain any formaldehydes, phenolic resins or Volatile Organic Compounds (VOC's) that can off-gas and/or cause health concerns. Media shall comply with UL181 and NFPA 90A. Media shall be packed with a minimum of 15% compression during silencer assembly. Media shall not cause or accelerate corrosion of aluminum or steel. The
wrapped acoustic media shall be separated from the perforated metal by a factory-installed ½” thick acoustically transparent spacer. The spacer shall be flame retardant and erosion resistant. Units shall be Vibro-Acoustics RFMB series or equal by Industrial Acoustics (Quiet Duct Clean Flow series). All silencers shall be factory fabricated and by the same manufacturer. Silencer inlet and outlet connection dimensions must be as indicated on the drawings. Transitions at the inlets and outlets are not permitted. All pressure drop requirements must be calculated to include “system effect” for non-ideal installations. An “ideal installation” shall be defined as “four (4) duct diameters of straight duct at inlet and five (5) duct diameters of straight duct on outlet”. None of the proposed locations for sound attenuators will meet “ideal installation” requirements. Sound attenuators at the VAV boxes shall also meet the following requirements.

Dynamic insertion loss in Decibels for a 3 ft. rectangular unit shall be:

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**PART 3 - EXECUTION**

3.1 Install air filter pressure differential gauges in a readable location on or near the air handling unit, filter housing or as otherwise indicated on the drawings.

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. 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 and Section 23 05 31 HVAC Equipment Drives 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 Architect or Construction Manager. 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 Utility Blower
   Centrifugal utility blower shall be single inlet with flat blade backwardly inclined centrifugal wheel, motor, adjustable "V" belt drive, weather protective cover to enclose motor and drive.

   Housing and bearing support shall be constructed of welded structural steel members to prevent vibration and rigidly support the shaft and bearings. Housing shall include discharge stack of
same material as fan housing to increase the overall discharge height of the unit. Minimum overall unit height with stack to be 10 feet from the roof deck.

Stack material to be a minimum of 18 gauge. Stack discharge shall have tapered design increasing exit velocity and not adding additional static pressure drop to the exhaust fan. No discharge rain caps or flapper caps are permitted as to interfere with exhaust airflow. Threaded drain connection with plug shall be located at lowest part of scroll housing to prevent moisture build-up in the interior of fan. An OSHA compliant weatherhood shall be included to completely cover the motor pulley and belt(s). Fan assembly shall be AMCA type C spark resistant construction minimum or as noted on the schedule.

Fan shall be provided with integral inlet box and curb cap constructed of same material, with access panel for inspection of fan wheel and duct. Units with integral inlet box shall be provided with matching roof curb. Roof curb shall be constructed of 14 ga. galvanized steel, include one inch of insulation and be provided with adjustable duct support bar for connecting building duct to roof curb. Units with integral inlet box shall be provided with gravity, back draft damper to prevent airflow back into the building when exhaust fan is not in operation. Damper sized to match inlet area of inlet box and mounted in the roof curb. Back draft damper shall be constructed with aluminum frame, extruded aluminum blades and vinyl seals on closing edge.

All interior and exterior surface steel shall be coated with a minimum of 2-4 mils of Permatector (Polyester Urethane), electrostatically applied and baked. Coating shall allow for field painting. Color to be selected by Architect.

Fans shall be Greenheck FJI or approved equal.

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 Belt drive units shall have adjustable motor base, “V” belts and pulleys. Provide 1.5 times the number of required belts for critical application fans (chemo exhaust). Refer to Section 23 05 31 HVAC Equipment Drives.

2.5 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.

2.6 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.

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

B. Roof curb mounted units: Set unit on the curb and fasten the fan base to the curb. 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.

C. Suspended unit: Suspend unit from structural steel support frame using threaded steel rods and vibration isolation as specified here-in or indicated in the fan schedule.

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 33  AIR CURTAIN

PART 1 - GENERAL

1.1 Air curtain unit shall be electric heat type having capacities as shown on drawings.

1.2 Air curtains shall be licensed to bear the AMCA certified rating seal.

1.3 Coils shall be rated in accordance with ARI Standard 410-72.

1.4 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 Architect or Construction Manager. 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 Unit shall be factory assembled with a rigid 16 gauge welded steel base frame. Fans shall be forward curved centrifugal type, double width, double inlet design with 2-speed open drip-proof split capacitor double shafted motor(s) with built-in thermal overload protection.

2.2 Air curtain shall produce a strong, low turbulent air stream with an average air velocity at the nozzle of 1600 fpm on low speed and 2100 fpm on high speed. Cover housing shall be .050 inch satin anodized aluminum with satin anodized aluminum inlet grille.

2.3 Unit shall be equipped with a helical coil prewired electric heater assembly with fuse links, two automatic reset thermal overloads, magnetic contactor, built-in selector switch for heater operation and shall be UL listed.

2.4 Unit shall be internally wired to a junction box on top and shall be operated by a high/low/off switch. Provide internally wired relay and automatic door switch. Control of unit thru door switch. Thermostat and control wiring is included in the Automatic Control Sequence Section 23 09 93.

2.5 Sound power level measured 10 feet away from unit in free field shall be no more than 54 dba on low speed and 59 dba on high speed.

2.6 Air curtains shall be Berner Miniveil or equal by Mars or Dynaforce.

PART 3 - EXECUTION

3.1 Units shall be installed in locations shown on the drawings. Units shall be suspended from building structure with steel hanger rods and auxiliary angles and fastening devices.

3.2 Provide all interlock wiring between door switch, thermostat and unit, all in conduit.

END OF SECTION
23 36 16 AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 Air control terminal units shall be pressure independent electric reheat variable air volume with control damper and velocity sensors. Constant volume units shall be same as variable volume units except with a singular setpoint. Units shall be as specified below and shown on the drawings.

1.2 Control devices furnished with the automatic temperature controls are to be sent to the terminal unit manufacturer for factory mounting on the unit. Refer to the Instrumentation and Control for HVAC sections for controls and coordinate to provide a complete and operational system.

1.3 Unit sizes (inlet duct size) listed on the drawings shall be considered minimum. Where a larger size is required to meet noise or operational requirements, those shall be provided and noted as such on the shop drawing submittal. Resultant noise level from the control unit, ductwork and diffusers, as a system, shall not exceed a room NC level of 35 from both airborne and radiated noise, based on AHRI 885, with 2.0 inches static pressure at the inlet of unit at maximum cfm setting. Allowance for internally lined ductwork shall only be used when acoustic lining has been specified for ductwork downstream of the air terminal unit. When this noise level cannot be met, a double-wall sound attenuator, shall be provided in the discharge ductwork to attain the specified noise level, maximum .05 inch additional air pressure drop. Shop drawing submittals shall include NC ratings based on the specified inlet static pressure, and any corrective measures being taken / provided to comply with the NC level requirements. NC levels shall be calculated in compliance with AHRI 885 latest edition and all addendums.

1.4 Shop drawings shall include specific sound level calculations and necessary installation instructions (added acoustical treatment for ductwork, etc.) where added acoustical treatment is required to meet the specified room sound level.

1.5 Pressure drop thru the terminal unit and hot water reheat coil shall not exceed the maximum drop listed on the drawings. The coil face area shall be upsized if necessary to meet this requirement. The terminal unit casing shall be correspondingly upsized or the larger coil furnished separately. For a separately furnished coil an intervening duct transition, with internal insulation same as that in the terminal unit casing, shall be provided.

1.6 Because certain units may be sized for future duty, smaller inlet sizes shall not be acceptable unless approved by the Engineer.

1.7 Terminal unit performance shall be certified to comply with AHRI Standards 880 and 885.

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 Architect or Construction Manager. 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 Unit components and accessories shall consist of:

A. Unit casing shall be 22 gauge minimum galvanized or galvanealed sheet metal designed for low temperature applications. Unless specified otherwise below, casing shall be lined with minimum R-4.0 insulation, fiber free or dual density fiberglass with neoprene facing. Lining shall meet UL 181 erosion standards and ASTM E84 (25/50) fire and smoke requirements. Edges, joints and other exposures shall be additionally coated or protected with metal edging.
Unit shall also include thermally isolated inlet duct and damper assembly, insulated damper blade, and insulated inlet panel with shielded, caulked and insulated inlet duct sleeve.

B. Interior lining of units shall be minimum R-3.5, 4.0 lb. density insulation, fiberglass with non-porous reinforced aluminum foil facing, all under a galvanized sheet metal liner equal to Titus UltraLoc. Insulation and facing shall meet biological standards of ASTM C665. Edges, joints and other exposures shall be sealed and protected with metal edging. Mylar, Tedlar or similar facing materials are not acceptable. Acoustical considerations must be fully addressed. Refer to Part 1 above.

C. Electrical reheat coil shall be UL approved with open coil heater elements of high grade 80/20 resistance wire, 45 watts per square inch maximum density. Safety and control devices shall be mounted in a NEMA 1 control panel attached to the coil. Devices shall include a power disconnect switch with “dead front” feature associated with the hinged cabinet door, power fusing, magnetic contactor(s), primary automatic reset high temperature limit switch, a secondary manual reset high temperature limit cutout, minimum air flow switch, fused control transformer and terminal strips for power and control wiring. The coil and devices shall be factory wired. Control wiring shall be arranged to ensure that the damper actuator and contactor(s) are properly sequenced for control.

D. Airflow control damper or valve shall have linear control characteristics and shall be 16 gauge galvanized steel or extruded or cast aluminum with gasketing and nylon bearings.

E. Velocity sensor shall be multi-point averaging crossflow type. The velocity sensor shall be mounted in the inlet air stream and shall amplify the airflow signal to provide accurate control at low, as well as high, inlet static pressure conditions. Required minimum static pressure of the volume regulator shall not exceed 0.25 inch w.g. for proper operation.

F. Airflow taps shall be provided to enable direct reading of total and static pressures. A conversion chart attached to each unit to convert pressure readings to airflow quantities. Caps for airflow taps shall not be directly mounted on hard tees. Provide 3” of poly tubing for each tap and place cap at end of tubing.

G. Casing leakage and damper leakage shall each not exceed 2 percent of maximum airflow cfm at 3.0 inches s.p. differential across the unit, when tested in accordance with ASHRAE 130.

2.2 Units shall be manufactured by Price, Krueger, Titus, Nailor, Trane, or JCI.

2.3 Digital controller, damper operator and linkage, and room thermostatic sensor are to be furnished with the automatic temperature controls. Controller, damper operator and linkage are to be sent to the terminal unit manufacturer for factory mounting.

PART 3 - EXECUTION

3.1 Support the units from the building structure with steel hanger rods or sheet metal strap hangers from corner points of unit, minimum 4, such that unit is self-supporting. Units shall not be supported from the duct system or piping system or ceiling suspension system.

3.2 The air control terminal box locations must be coordinated with all elements that may be in or above the ceiling. This includes but is not limited to piping, conduit, wiring, junction boxes, pull boxes, lighting fixtures, sprinkler heads, cable tray, speakers, smoke detectors air devices, etc. In no case shall an air control terminal be mounted above a lighting fixture, speaker, diffuser or any other device mounted on the ceiling without written permission from the Engineer or Architect. Provide ceiling access panels where the ceiling system does not afford ready access.

3.3 Caps for airflow taps shall not be directly mounted on hard tees. Provide 3” of poly tubing for each tap and place cap at end of tubing.
3.4 Air control terminal unit supplier shall coordinate closely with the automatic temperature controls installer to ensure a complete, compatible and coordinated system of controls is provided. Furnish to the automatic temperature controls installer a complete job specific control diagram.

END OF SECTION
Part 1 - General

1.1 Airflow control valves shall be venturi type with control damper, actuator and control sensors. Units shall be as specified below and shown on the drawings. A direct digital control systems shall be furnished and installed to control airflow and pressure to the space.

1.2 Unit sizes (inlet duct size) listed on the drawings shall be considered minimum. Where a larger size is required to meet operational requirements, those shall be provided and noted as such on the shop drawing submittal and coordinated with ductwork.

1.3 Minimum pressure drop thru the airflow control valve and associated reheat coil shall not exceed the maximum drop listed on the drawings.

1.4 All airflow control valves shall include discharge, exhaust and radiated sound power level performance obtained from testing in accordance with ASHRAE 130-2008. Resultant noise level from the control valve, ductwork and diffusers, as a system, shall not exceed a room NC level of 35 from both airborne and radiated noise, with 2.0 inches static pressure at the inlet of unit at maximum cfm setting.

1.5 Electric duct heating coils for each supply airflow control valve shall be provided to meet the capacities indicated on the drawings. Heating coils may be provided by the airflow control valve manufacturer or from an independent coil manufacturer, refer to specification 82 17 Electric Duct Heating Coils for requirements.

1.6 Equipment shall carry an all-inclusive manufacturer’s parts and labor warranty for a period of five (5) year(s) (three (3) years for system controls components) from date of final acceptance or date of beneficial use, as agreed to between Contractor and Architect or Construction Manager. 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.

1.7 System Controls

   A. An airflow and room pressure control system shall be furnished and installed to control space temperature and room pressure by means of airflow into and out of rooms as indicated in this specification and on the drawings. The control system shall be capable of operating as a standalone system or as a system integrated with the Building Automation System (BAS). The control system shall include fume hood controls, airflow control valve controllers, supply air, return air, and exhaust airflow control valves, system programming, checkout commissioning, air balance support, reheat coils and control valves, and space and duct sensors and controllers, including all interconnecting wiring to result in a complete and operational system.

   B. All control components shall be electronic. Use of pneumatic actuators and sensors shall be provided only as specifically noted on the drawings and specifications.

   C. Provide all equipment required to perform the functions specified unless noted herein or elsewhere in these contract documents.

   D. All system control points shall have a default value in case of sensor failure or logic error. All controlled devices shall fail safe on loss of control. All set points and parameters shall be fully adjustable from the end user / owner interface.

   E. All wiring shall be installed in conduit per Division 26.
PART 2 - PRODUCTS

2.1 Mechanically Pressure Independent (MPI) Airflow Control Valves

A. MPI airflow control valve shall be venturi type utilizing a venturi section into which a cone shaped element slides to create a smoothly varying ring shaped orifice that is mechanically pressure independent over its specified differential static pressure operating range. The MPI airflow control valve shall provide stable and accurate control at low airflow. The integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifolded system. The MPI airflow control valve shall maintain pressure independence regardless of loss of power. The MPI airflow control valve shall maintain accuracy within ±5% of signal over an airflow turndown range of no less than 12:1 for standard and 8:1 for shutoff medium pressure valves and 7:1 for standard and 5:1 for shutoff low pressure valves. The valve shall be capable of full shutoff as noted on the schedule.

B. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.

C. MPI airflow control valves shall be calibrated for the intended installation i.e. vertical or horizontal. The Contractor shall coordinate required orientation with the manufacturer.

D. A change in pressure above or below operating set point shall be sensed and alarmed by a static pressure switch pre-mounted to the valve. The alarm shall notify the operator that an airflow situation exists. The switch shall operate by measuring the pressure drop across the MPI airflow control valve’s variable orifice. MPI airflow control valve differential pressure information shall be communicated with the BAS system to allow for duct static pressure reset sequence.

E. MPI airflow control valve pressure differential operating range shall be low pressure 0.3” to 3.0” / medium pressure 0.6” to 3.0”. While MPI airflow control valve pressure drop is in this operating range airflow accuracy shall be within ±5% of set point.

F. The MPI airflow control valve shall be constructed to one of the following two types. Refer to sequences of operation below

1. Class A—The MPI airflow control valve for non-corrosive airstreams, such as supply, return and general exhaust, shall be constructed of minimum 16-gauge aluminum. The device’s shaft and internal “S” link shall be made of 316 stainless steel. The shaft support brackets shall be made of galvanal or 316 stainless steel, except shutoff valves shall be stainless steel only. The pivot arm shall be made of aluminum or 303/304 stainless, except shutoff valves shall be stainless steel only. The pressure independent springs shall be a spring-grade stainless steel. All shaft bearing surfaces shall be made of a PP (polypropylene) or PPS (polyphenylene sulfide) composite. Sound attenuating devices used in conjunction with general exhaust or supply MPI airflow control valves shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. No sound absorptive materials of any kind shall be used.

2. Class B—The MPI airflow control valve for corrosive airstreams, such as fume hoods and biosafety cabinets, shall have a baked-on, corrosion-resistant phenolic coating. The device’s shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring-grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of PP (polypropylene) or PPS (polyphenylene sulfide) composite.

G. NIST Accreditation
1. Each MPI airflow control valve shall be factory characterized on air stations NIST Accredited to ISO/IEC 17025:2005 standards.

2. Each MPI airflow control valve shall be factory characterized to the job specific airflows as detailed on the plans and specifications using NIST accredited air stations and instrumentation having a combined accuracy of no more than ±1% of signal (5,000 to 250cfm), ±2% of signal (249 to 100cfm) and ±3% of signal (199 to 35cfm). Electronic MPI airflow control valves shall be further characterized and their accuracy verified to ±5% of signal at a minimum of 48 different airflows across the full operating range of the device.

3. Each MPI airflow control valve shall be marked with device-specific factory characterization data. At a minimum, it should include the room number, tag number, serial number, model number, date of manufacture and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation.

4. The eight-point characterization information (for electronic devices) for each MPI airflow control valve shall be provided to the owner.

H. MPI airflow control valves may be provided in lieu of high accuracy variable air volume control valves.

I. MPI airflow control valve and control system components shall be as manufactured by Phoenix Controls Corporation, Siemens, or Antec Controls by Price.

2.2 Controls components.

A. Airflow Control Valve Controller

1. Internal power supply shall be included to power the complete airflow control system from one (1) 120 volt, single-phase line connection. Provide transformer as required for low voltage.

2. The airflow control valve shall be a microprocessor-based design and shall use closed loop control of the actuator position or measured airflow to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.

3. The airflow control valve shall store its control algorithms in non-volatile, re-writeable memory. The device shall be able to stand-alone or to be networked with other room-level digital airflow control valves using an industry standard protocol.

4. Room-level control functions shall be embedded in and carried out by the airflow device controller using distributed or centralized control architecture. Critical control functions shall be implemented locally; no control signals from outside the room shall be required.

5. The airflow control valve shall use industry standard 24 VAC power.

6. The airflow control valve shall have provisions to connect a notebook PC commissioning tool.

7. The airflow control valve shall have built-in integral input/output connections that address fume hood control, temperature control, humidity control, occupancy control, emergency control, and non-network sensors switches and control valves. At a minimum, the airflow controller shall have:

   a. Three universal inputs capable of accepting any of the following:
      1) 0 to 10 VAC
      2) 4 to 20 mA
      3) 0 to 65 K ohms
      4) Type 2 or Type 3 10 K ohm @ 25 degree C thermistor temperature sensors.

   b. One digital input capable of accepting a dry contact or logic level signal input.
      1) Analog outputs capable of developing either a 0 to 10 VAC or 4 to 20 mA linear control signal.
      2) One Form C (SPDT) relay output capable of driving up to 1 A @ 24 VAC/VAC.

B. Room Environment Controls
1. Provide room pressure monitoring to the corridor or adjacent space. Room pressure monitoring shall be complete with wall mounted room monitor, room pressure display, room status, password protection, red alarm light with mutable audible alarm, green “safe” light, adjustable time delay for alarm. Other equipment shall include the thru-the-wall bi-directional room pressure sensor. Each door to the space shall be provided with a door switch tied into the room pressure monitoring system. Room pressure monitoring system shall be provided with a BACnet or LONworks interface option.

2. Provide thermostat equal to those specified in 23 09 25 Instrumentation and Control Devices for HVAC. Devices shall be duct mounted or wall mounted as indicated on the drawings and specifications. Room temperature shall be available to the BAS system and room temperature set point shall be adjustable through the BAS system.

3. Provide humidistat equal to those specified in 23 09 25 Instrumentation and Control Devices for HVAC. Devices shall be duct mounted or wall mounted as indicated on the drawings and specifications. Room humidity shall be available to the BAS system and room humidity set point shall be adjustable through the BAS system.

C. Actuation

1. For electrically actuated VAV operation, a CE certified electronic actuator shall be factory mounted to the airflow control valve. Loss of main power shall cause the airflow control valve to position itself in an appropriate failsafe state. Options for these failsafe states include: normally open-maximum position, and normally closed-minimum position and last position. This position shall be maintained constantly without external influence, regardless of external conditions on the airflow control valve (within product specifications).

2. Constant volume MPI airflow control valves do not require actuators. The airflow control valve shall maintain a constant volume pressure independent, manually adjustable, volume airflow set point. It shall be factory calibrated and set for desired airflow rate. It shall be capable of field adjustment for future changes of desired airflow rate. Valve airflow and pressure feedback is not required for constant volume airflow control valves.

PART 3 - EXECUTION

3.1 Installation

A. All equipment items shall be furnished and installed as recommended by the manufacturer.

B. Support the units from the building structure with steel hanger rods or sheet metal strap hangers from corner points of unit, minimum 4, such that unit is self-supporting. Units shall not be supported from the duct system or piping system or ceiling suspension system.

C. Install sash sensor, interface boxes, presence\motion sensor and monitor on fume hood. Reel-type sash sensors and their stainless steel cables shall be hidden from view. Bar-type sash sensors shall be affixed to the individual sash panels. Sash interface boxes with interface cards shall be mounted in an accessible location.

D. Install all linearized supply, return, fume hood exhaust and general exhaust airflow control valves in the ductwork. Airflow control valves shall be mounted in the orientation calibrated at the factory. The Contractor shall install all reheat coils and transitions.

E. Install airflow control valve control panel in an accessible location within the corresponding space\as indicated on the drawings. Coordinate 110 volt, single-phase power supply to the control panel with Division 26.

F. Terminate or connect all cables, wires and/or tubing as required to make the system fully operational. The contractor shall provide cables specifically recommended by the airflow control valve manufacturer.
3.2 Start Up, Calibration and Closeout

A. System start-up shall be provided by a factory-authorized representative of the airflow control valve manufacturer. Start-up shall include calibrating the fume hood monitor and any combination sash sensing equipment, as required and setting of supply/make-up, return and/or general exhaust flow including required room offsets. Start-up shall also provide electronic verification of airflow (fume hood exhaust, supply, make-up, general exhaust or return), system programming and integration to BAS (when applicable).

B. A factory-authorized representative shall be onsite to assist during all certifications of fume hoods, biosafety cabinets, etc.

C. The airflow control valve manufacturer shall furnish a minimum of eight hours of owner training by factory trained and certified personnel. The training will provide an overview of the job specific airflow control components, verification of initial fume hood monitor calibration, general procedures for verifying airflows of air valves and general troubleshooting procedures.

D. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided for each training attendee.

3.3 Controls and Sequences

A. The airflow control valves shall utilize, distributed or centralized room control architecture to perform room-level control functions. Control functions shall include, at a minimum, volumetric offset pressurization, temperature, humidity control, as well as respond to occupancy and emergency control commands. Centralized control systems shall have all required control architecture located in the room served.

B. The airflow control system network shall have the capability of digitally interfacing with the BAS. The required software interface drivers shall be developed and housed in a dedicated interface device furnished by the airflow control system supplier.

C. All room-level points shall be available to the BAS for monitoring or trending.

D. The airflow control system shall be connected to the building level network utilizing BACnet IP or BACnet MS/TP communications, as required by the Contractor.

E. Positive Pressure Room Control

1. All airflow control valves for these spaces shall be class A.

2. Reheat coils shall be provided with SCR modulating electric heat unless indicated otherwise on the drawings or specifications. Refer to drawings for listed CFM set points.

3. CFM Set point Control
   a. Constant Volume Control:
      1) Supply CFM set point shall be based on occupied/unoccupied schedule with adjustable temporary override determined by manual override switch located in the space. During the occupied mode supply CFM set point shall be occupied CFM indicated on the schedule. During the unoccupied mode it shall be as required to maintain room temperature set point. The airflow control valve shall control to maintain set point.
      2) Return/Exhaust CFM set point shall be as required to maintain volumetric offset pressurization control. The airflow control valve shall control to maintain set point.

4. Room Temperature Control
   a. System shall control to maintain space temperature setpoint in this mode.
   b. Variable Volume Occupied Reheat Mode – Provide occupied CFM set point. If the space temperature is in the dead band between heating and cooling set points, the...
supply CFM required to maintain temperature set point shall be the listed occupied Minimum CFM and the electric reheat shall be off. If space temperature rises above the space cooling temperature set point, the control shall increase supply CFM set point between the listed occupied Minimum CFM and the listed occupied Maximum CFM to satisfy the space cooling set point. If space temperature drops below heating temperature set point the control shall modulate the electric heat to maintain space heating set point as follows:

1) 1st stage of heating supply CFM set point shall be occupied Minimum CFM and modulate the electric heat to maintain space temperature, with a high limit discharge air temperature of 20 degrees above the space heating set point (except during warm-up cycles).
2) If space heating set point cannot be maintained, 2nd stage of heating shall be to increase supply CFM set point from the occupied CFM to 50% of the listed occupied Maximum CFM while maintaining a discharge air temperature of 20 degrees above the space heating set point. Reverse the sequence when space heating set point is reached. When in a “warm up” cycle, the unoccupied CFM set point shall go to the listed occupied Maximum CFM and the electric heat shall be modulated to maintain the space heating set point (and supply air temperature not limited to 20 degrees above room set point).

Variable Volume Unoccupied Reheat Mode – Control shall be the same as stated above in variable volume occupied reheat mode except unoccupied CFM shall be used in lieu of occupied Minimum CFM.

c. Constant Volume Occupied Reheat Mode – Provide occupied CFM set point and modulate the electric heat to maintain space temperature, with a high limit discharge air temperature of 20 degrees above the space heating set point (except during warm-up cycles).
Constant Volume Unoccupied Reheat Mode – Provide unoccupied CFM set point. If the space temperature is in the dead band between heating and cooling set points, the supply CFM required to maintain temperature set point shall be the listed unoccupied CFM and the electric heat shall be off. If space temperature rises above the space cooling temperature set point, the control shall increase supply CFM set point between the listed unoccupied CFM and the listed occupied Maximum CFM to satisfy the space cooling set point. If space temperature drops below heating temperature set point the control shall modulate the electric heat to maintain space heating set point as follows:

1) 1st stage of heating supply CFM set point shall be unoccupied CFM and modulate the electric heat to maintain space temperature, with a high limit discharge air temperature of 20 degrees above the space heating set point (except during warm-up cycles).
2) If space heating set point cannot be maintained, 2nd stage of heating shall be to increase supply CFM set point from the unoccupied CFM to 50% of the listed occupied Maximum CFM while maintaining a discharge air temperature of 20 degrees above the space heating set point.
3) Reverse the sequence when space heating set point is reached. When in a “warm up” cycle, the unoccupied CFM set point shall go to the listed occupied Maximum CFM and the electric heat shall be modulated to maintain the space heating set point (and supply air temperature not limited to 20 degrees above room set point).

F. Negative Pressure Room Control

1. All airflow control valves for these spaces shall be class A.
2. Reheat coils shall be provided with SCR modulating electric heat unless indicated otherwise on the drawings or specifications. Refer to drawings for listed CFM set points.
3. CFM Set point Control
   a. Constant Volume Control:
1) Exhaust CFM set point shall be based on occupied/unoccupied schedule with adjustable temporary override determined by manual override switch located in the space. During the occupied mode the set point shall be the occupied setpoint indicated on the schedule. During the unoccupied mode the set point shall be as required to maintain volumetric offset pressurization control. During the unoccupied mode set point shall not be lower than unoccupied minimum CFM. The airflow control valve shall control to maintain set point.

2) During the occupied mode supply CFM set point shall be as required to maintain volumetric offset pressurization control. During the unoccupied mode it shall be as required to maintain room temperature set point. The airflow control valve shall control to maintain set point.

4. Room Temperature Control

   a. System shall control to maintain space heating setpoint in this mode.

   b. Variable Volume Occupied Reheat Mode – Provide occupied CFM set point. If the space temperature is in the dead band between heating and cooling set points, the supply CFM required to maintain temperature set point shall be the listed occupied Minimum CFM and the electric heat shall be off. If space temperature rises above the space cooling temperature set point, the control shall increase supply CFM set point between the listed occupied Minimum CFM and the listed occupied Maximum CFM to satisfy the space cooling set point. If space temperature drops below heating temperature set point the control shall modulate the electric heat to maintain space heating set point as follows:

      1) 1st stage of heating supply CFM set point shall be occupied Minimum CFM and modulate the electric heat to maintain space temperature, with a high limit discharge air temperature of 20 degrees above the space heating set point (except during warm-up cycles).

      2) If space heating set point cannot be maintained, 2nd stage of heating shall be to increase supply CFM set point from the occupied CFM to 50% of the listed occupied Maximum CFM while maintaining a discharge air temperature of 20 degrees above the space heating set point.

      3) Reverse the sequence when space heating set point is reached. When in a “warm up” cycle, the unoccupied CFM set point shall go to the listed occupied Maximum CFM and the electric heat shall be modulated to maintain the space heating set point (and supply air temperature not limited to 20 degrees above room set point).

   c. Variable Volume Unoccupied Reheat Mode – Control shall be the same as stated above in variable volume occupied reheat mode except unoccupied CFM shall be used in lieu of occupied Minimum CFM.

   d. Constant Volume Occupied Reheat Mode – Provide supply CFM set point and modulate the electric heat to maintain space temperature, with a high limit discharge air temperature of 20 degrees above the space heating set point (except during warm-up cycles).

   Constant Volume Unoccupied Reheat Mode – Provide unoccupied CFM set point. If the space temperature is in the dead band between heating and cooling set points, the supply CFM required to maintain temperature set point shall be the listed unoccupied CFM and the electric heat shall be off. If space temperature rises above the space cooling temperature set point, the control shall increase supply CFM set point between the listed unoccupied CFM and the listed occupied Maximum CFM to satisfy the space cooling set point. If space temperature drops below heating temperature set point the control shall modulate the electric heat to maintain space heating set point as follows:

      1) 1st stage of heating supply CFM set point shall be unoccupied CFM and modulate the electric heat to maintain space temperature, with a high limit discharge air temperature of 20 degrees above the space heating set point (except during warm-up cycles).

      2) If space heating set point cannot be maintained, 2nd stage of heating shall be to increase supply CFM set point from the unoccupied CFM to 50% of the listed
occupied Maximum CFM while maintaining a discharge air temperature of 20 degrees above the space heating set point.

3) Reverse the sequence when space heating set point is reached. When in a “warm up” cycle, the unoccupied CFM set point shall go to the listed occupied Maximum CFM and the electric heat shall be modulated to maintain the space heating set point (and supply air temperature not limited to 20 degrees above room set point).

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 or factory installed, 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, 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. Lay-in devices shall be designed to fit in the grid.

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. Insulation shall comply with 23 07 13 DUCT INSULATION.

3.4 Factory insulation on supply diffusers that is damaged prior to or during installing shall be repaired.

3.5 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
AIR FILTERS

PART 1 - GENERAL

1.1 Air filters, housings and framework shall be provided as shown on the drawings and as specified herein. Refer to the drawings for air filter types, service and mounting.

1.2 Air filters specified in air handling equipment sections shall be furnished with that equipment as accessory items, factory installed. Air filters supplied in the filter manufacturer’s housing shall be provided through the local authorized filter representative, and filters installed by the local authorized filter representative.

1.3 Efficiency standards herein refer to ASHRAE Standard 52.2 Minimum Efficiency Reporting Values (MERV). Filters shall be UL Class 2.

1.4 Refer to Section 23 33 00 Air Duct Accessories for air filter pressure differential gauges.

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. Refer to specification 23 05 30 Bases and Supports for HVAC Equipment for additional requirements.

PART 2 - PRODUCTS

2.1 Air filters, housings and framing systems shall be manufactured by Camfil Farr, American Air Filter, Flanders, or TriDim equal to that listed below. All filters and filter holding frames shall be standard sizes; 12 inches x 24 inches, 20 inches x 24 inches, or 24 inches x 24 inches.

2.2 Air Filters

A. Type B2 - Pleated Panel.
4 inches thick extended surface pleated panel type with non-woven cotton and synthetic fabric media in a beverage board frame chemically bonded to the media, with welded wire support grid. Rated as a MERV 8 filter. 4.4 / 7.0 to 1 gross media area to face area. 0.30 inch w.g. maximum initial pressure drop at 500 fpm face velocity. Camfil Farr 30/30.

B. Type D1. Deep Pleated Cartridge.
12 inches deep cartridge with rigid high density microfine glass fibers laminated to a reinforcing backing, welded wire support grid bonded to the media and contour stabilizers on both sides set in a galvanized steel enclosing frame mechanical and chemically bonded to the media. Rated as a MERV 14 filter. 14 to 1 gross media area to face area. 0.30 inch w.g. maximum initial pressure drop at 500 fpm face velocity. Equal to Camfil Farr Riga-Flo.

C. Type J2 - High Capacity HEPA Filter.
12 inches deep high capacity HEPA filter consisting of minipleated microfiber glass media, gasket seal and extruded aluminum channels and supports, arranged in a V-configuration. Media shall be totally rigid and self-supporting with no separators. Rated as a MERV 18 filter and constructed to meet leak-free scan requirements outlined in IES-RP-CC001.3. 0.80 inch w.g. maximum initial pressure drop at 500 fpm face velocity. Camfil Farr Filtra 2000.

2.3 Filter holding frames for field erected filter banks shall be factory fabricated of 16 gauge galvanized steel with gaskets and spring type fasteners, equal to Camfil Farr Type 8.

2.4 Side-access housing for HEPA filters shall be designed to accommodate 4 inches deep pre-filters and 12 inches deep HEPA filters and to facilitate upstream and downstream duct connections. Housing shall consist of:
A. Factory fabricated 14-gauge galvanized steel with filter slide rails and hinged and closed cell neoprene gasketed door on each end. Housing and doors shall be 1 inch thick double wall sheet metal with 1 inch thick, 1-1/2 lb. density fiberglass insulation between.

B. Anodized extruded aluminum slide rails for pre-filters, with reinforced nylon pile seals.

C. Bolt-lock or crank-lock filter sealing mechanism exerting pressure on the HEPA filter.

D. Static pressure taps across and between the two sets of filters for individual and total pressure drop gauging.

E. Housing shall be designed to pass an in-service efficiency test complying with the filter efficiency requirements.

F. Housing shall be of the same manufacturer as the filters, equal to Camfil Farr “Magna/Pack” (bolt-lock) or Sidelock HEPA Housing.

PART 3 - EXECUTION

3.1 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.

3.2 Install filter components, housings and holding frames in strict accordance with the manufacturer’s instructions, supervised by the local authorized filter representative. Install necessary airtight baffles between duct plenums and filter frames. Arrange access and clearance for removal and servicing of air filters. The air filters themselves shall be installed by the local authorized filter representative. The Owner or his representative shall be invited to witness the install.

3.3 Filter media included herein shall not be used for temporary heating and ventilation operation of the central air systems.

3.4 Place spare filter media for storage where directed by the Owner.

END OF SECTION
23 41 33 HEPA FILTER/FAN CEILING MODULES

PART 1 - GENERAL

1.1 Low velocity air diffuser units with HEPA air filters shall be provided as shown on the drawings and as specified herein.

PART 2 - PRODUCTS

2.1 Filter-diffuser modules shall be nominal 24 inches x 48 inches and 24 inches x 24 inches, as shown, with replaceable HEPA filter units, permanently set housing and trim frame, designed for mounting in drywall ceiling.

2.2 Filter media shall be replaceable type, 99.99 percent scanned DOP efficiency, with knife edge and gel seal, face screen and access ports for testing and diffuser adjustment.

2.3 Housing shall be sheet metal with inlet collar, adjustable diffuser/damper, foil backed fiberglass insulation and perimeter finishing flange.

2.4 Unit shall include integral air distribution diffuser, designed to provide laminar, downward supply of airflow. Diffuser face shall be removable from room to permit replacement of filter media.

2.5 Unit shall include integral supply air blower to overcome filter resistance. Blower shall be centrifugal type, factory-wired to solid-state speed controller. Single controller shall be provided to control all units within the pharmacy.

2.6 Furnish one complete initial set of filters and one replacement filter for each filter unit.

2.7 Filter/fan modules shall be Camfil Pharmaseal FFU or approved equal.

PART 3 - EXECUTION

3.1 Suspend filter housings with hanger rods from the building structure, flush with the drywall ceiling.

3.2 Installation of all filter components shall be in strict accordance with the manufacturer’s instructions.

3.3 Filter media included herein shall not be used for temporary heating and ventilation operation of the air system.

3.4 Install filter media into housings when so directed. Store replacement filter media where directed by the Owner.

END OF SECTION
PART 1 - GENERAL

1.1 The heating and cooling units shall be factory packaged cooling-heating units with circulating fan, gas fired heating section and air cooled refrigeration section. Units shall be mounted on grade as shown on drawings.

1.2 Units shall be rated in accordance with ARI Standard 270 and 360 and tested and certified by UL or ETL to conform to applicable ANSI standards.

1.3 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 Architect or Construction Manager. 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.

1.4 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 Unit shall be specifically designed for outdoor installation on a concrete pad. Completely factory assembled and tested, piped, internally wired and shipped in one piece. Units are direct expansion cooling only 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 factory run tested.

2.2 Unit casing shall be constructed of aluminum or galvanized steel, finished with two coats of weather resistant paint. Casing shall be minimum 2” thick double wall R-13 insulated type. Provide hinged access panels for access to filters, unit control panel, supply and return 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. Unit base shall have formed recess with factory installed flexible base to match roof curb assembly.

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

2.4 Unit shall be provided with UV lights.

2.5 Indoor air circulating fan shall be forwardly curved centrifugal type with resiliently mounted motor, belt drive and adjustable pulley. Note particularly fan duty and HP requirements listed on the drawings.

2.6 Heating section shall be natural gas fired with powered burner, corrosion resistant stainless steel heat exchanger, spark igniting pilot, gas piping, manual and automatic gas valves on main and pilot piping, combustion safety controls and operating controls. The heating section shall have a minimum of a 9 to 1 turndown.

2.7 Refrigeration section shall consist of compressor(s), evaporator coil, condenser coils, condenser fans, refrigerant piping and devices. The compressor shall be digital 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.

2.8 Units shall be rated under AHRI 210/240 and 340/360 and shall have minimum Energy Efficiency Ratings as specified below. Multiple or variable speed compressor units shall achieve this rating at high speed.

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<td>&lt;65,000 Btuh</td>
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<td>AHRI 340/360</td>
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<td>240,000 – &lt;760,000 Btuh</td>
<td>Gas</td>
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<td>11.4 IEER, 3.40 ICOPc</td>
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<td>760,000 Btuh and greater</td>
<td>Gas</td>
<td>AHRI 340/360</td>
<td>11.0 IEER, 3.22 ICOPc</td>
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2.9 Motors 1 HP and larger shall be "premium efficiency" series motors. 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.

2.10 Pre-filters shall be 2” Merv 8 throwaway media filters. Final filter shall be 4” Merv 14 cartridge 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.

2.11 Return air and outside air dampers and modulating controls shall be arranged for minimum outside air intake up to 100 percent outside air 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 an alarm at the BAS indicating economizer malfunction. All dampers shall be neoprene or extruded vinyl edged for tight sealing. Outside air and vent air openings shall be weather protected and equipped with bird screening.

2.12 Supply air and return air duct housings with duct connections on the side of the unit, for grade mounted units, shall be furnished with the unit, fabricated of steel and insulated on the interior.

2.13 The unit shall be provided with an electrical system of controls for refrigeration, furnace 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.

2.14 Packaged controls shall be provided with the unit as follows:

   A. DDC based controller(s) with network communication and interoperability with the BACnet / LON Building Automation System (BAS). Controller(s) shall be BACnet / LON compliant.

   B. Refer to section 23 09 95 - Sequence of Operations

2.15 Units shall be manufactured by AAON or approved equal by Carrier, Trane, Daikin, Engineered Air, JCI or Sure Comfort. The refrigeration system and furnace heat exchangers shall carry a five-year warranty.
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 fused disconnect switch to one set of power terminals in each unit. Provide all required 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
PART 1 - GENERAL

1.1 Duct heating coils shall be electric resistance type complete with operating and safety controls. Refer to the drawings for capacities, sizes and electrical characteristics.

1.2 The coil, control panel and components shall be UL 1996 listed as an assembly or assemblies and so labeled.

PART 2 - PRODUCTS

2.1 Each heating coil shall be electric resistance type arranged for insertion mounting or flange mounting in the duct. The control panel shall be end mounted on the exterior of the duct or remote mounted as indicated.

2.2 Heating elements shall be 80 percent nickel – 20 percent chromium open coil resistance wire, 45 watts per sq. in. maximum density, 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.

2.3 Control panel shall consist of a NEMA 1 enclosure with power, safety and control devices and a hinged door. Devices shall include a power disconnect switch with "dead front" feature associated with the door, magnetic contactor(s), primary automatic reset high temperature limit switch, secondary manual reset high temperature cutout, air flow switch, fused control transformer and terminal strips for power and control wiring. Fuses, time delay type, shall be incorporated in the power wiring if required by NEC and UL. Coil and devices shall be factory wired.

2.4 Heating coils shall be manufactured by Tutco, Indeeco or Brasch.

PART 3 - EXECUTION

3.1 Install coils in accordance with manufacturer's instructions.

3.2 Coil and control panel shall be arranged and located to ensure adequacy of space for the control panel, panel door swing and service activity.

3.3 Provide all required power and control wiring between the remote mounted control panel and the coil. Coordinate all wiring requirements with Division 26.

END OF SECTION
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**MAY, 2019**
26 05 01  BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1  Special Note

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

B.  The scope of the Division 26 work includes furnishing, installing, testing and warranty of all Division 26 work and complete systems as shown on the Division 26 drawings and as specified in Division 26 and elsewhere in the project documents.

C.  The project drawings and specifications define scope of work for the various divisions. Such assignments of work are not intended to restrict the Construction Manager 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 work in this Division. Furnish for the Owner certificates of approval from the governing inspection agencies, as a condition for final payment.

B.  Work must conform to the National Electrical Code, National Electrical Safety Code and other 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.

C.  All electrical work shall be inspected and approved by the local jurisdictional authority.

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 the Architect Construction Manager 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 the Construction Manager 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 the Construction Manager 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 bus duct, wireways 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 bus duct, wireways, fittings and equipment.

D. The Construction Manager shall reserve the right to make minor adjustment in locations of system runs and components where he considers such adjustments desirable in the interest of protecting and 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 and 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 NEC 110.26 Spaces about Electrical Equipment – 600 Volts Nominal or Less. For equipment rated over 600 volts nominal – 110.32 Work Space About Equipment – 110.33 Entrance to Enclosures and Access to Work Space – 110.34 Work Space and Guarding. Caution other trades to comply with this stipulation.

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. The Construction Manager’s decision shall be final in regard to the arrangement of bus duct, conduit, etc., where conflict arises.

G. Provide offsets in system runs, additional fittings, necessary conduit, pull boxes, conductors, switches 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 the Construction Manager. In such event, none of the trades or their suppliers shall assume that he is relieved of the work which is specified under his branch until instructions in writing are received from the Construction Manager.

1.5 Asbestos Materials

A. Abatement, removal or encapsulation of existing materials containing asbestos is not included in the Division 26 Contract. Necessary work of this nature will be arranged by the Construction Manager to be done outside of this construction and remodeling project by a company regularly engaged in asbestos abatement. Such work will be scheduled and performed in advance of work in the construction and remodeling project.

B. If, in the performance of the work, materials are observed which are suspected to contain asbestos, the Contractor shall immediately inform the Construction Manager 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.

1.6 Coordination Drawings

A. Refer to Divisions 00 and 01 for requirements.

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. Upon completion of the work and within 90 days of system acceptance, these hand marked drawings shall be turned over to the Construction Manager. 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 electronic copies each of operating and maintenance manuals for the Electrical 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. Major items of equipment shall consist of not less than the following:

1. Panelboards.
3. Specialty equipment.
4. Fire alarm.
5. Lighting equipment and lighting controls.

C. Standard NEMA publications on the operation and care of equipment may be furnished in lieu of manufacturer's data where the manufacturer's instructions are not available.

D. Original purchase order number; date of purchase; name, address, and phone number of the vendor; warranty information.

E. Copy of required test reports.

F. These shall be assembled into three-ring loose leaf binders or other appropriate binding. An index and tabbed sheets to separate the sections shall be included. These shall be submitted to the Engineer and Construction Manager for review. Upon approval and within 90 days of system acceptance, manuals shall be turned over to the Owner.

1.10 Final Inspection and Punch List

A. As the time of work completion approaches, survey and inspect Division 26 work and develop a punch list to confirm that it is complete and finished. Then notify the Construction Manager and request that a final inspection be made. It shall not be considered the Architect's or Engineer's obligation to perform a final inspection until the Contractor has inspected the work and so states at the time of the request for the final inspection.

B. Requests to the Architect, Engineer or Construction Manager for final inspection may be accompanied by a limited list of known deficiencies in completion, with appropriate explanation and schedule for completing these; this is in the interest of expediting acceptance for beneficial occupancy.

C. The Architect and/or Engineer will inspect the work and prepare a punch list of items requiring correction, completion or verification. Corrective action shall be taken by the Contractor to the
satisfaction of Architect and Engineer within 30 days of receipt of the Architect/Engineer's punch list.

1.11 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 Architect or Construction Manager. 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 electric is not the start of the warranty period.

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. These items include, but are not limited to, motor controller malfunction, heater element changes required for motor controller, fuse replacement where fuses blow due to abnormal shorts, adjustments and/or replacement of malfunctioning equipment and adjusting special equipment and communication systems to obtain optimum performance.

C. This provision shall not be construed to include maintenance items such as making normally anticipated adjustments or correcting adjustment errors on the part of the Owner's personnel.

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.

B. All electrical equipment and wiring shall bear the Underwriters Laboratories, Inc. label where UL labeled items are available, and shall comply with NEC (NFPA-70) and NFPA requirements.

2.2 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.

2.3 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 accessories. Also verify that adequate space is available for servicing of the equipment and that required NEC clearances are met.

D. If extensive changes in conduit, equipment layout or electrical wiring and 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.

2.4 Shop Drawings

A. Electronic copies of shop drawings and descriptive information of equipment and materials shall be furnished. Submit to the Architect 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 the Architect or 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 equipment and materials shall be submitted:

1. Wireway.
2. Cable trays and firestopping.
3. Wiring devices and coverplates.
4. Overcurrent protective device coordination study.
5. Panelboards.
6. Fuses.
7. Motor controllers and disconnects.
8. Lighting fixtures.
9. Lighting controls/contactor and photocell.
10. Fire alarm system.

PART 3 - EXECUTION

3.1 Testing

A. As each wiring system is completed, it shall be tested for continuity and freedom from grounds.
B. As each electrically operated system is energized, it shall be tested for function.

C. On all electric services including change-outs, backfeeds, etc. the Contractor shall verify phase rotation and voltage readings to ensure the final installation is proper. Submit to the Engineer in writing a record of voltage readings and current readings taken at no-load and fully loaded conditions.

D. The Contractor shall perform megger and resistance tests and special tests on any circuits or equipment when an authorized inspection agency suspects the system's integrity or when requested by the Architect or Engineer.

E. All signaling and communications systems shall be inspected and tested by a qualified representative of the manufacturer or equipment vendor. Submit four (4) copies of reports indicating results.

F. Tests shall be witnessed by field representatives of the Architect or Engineer or shall be monitored by a recorder. Furnish a written record of each system test indicating date, system, test conditions, duration and results of tests. Copies of all test reports shall be included in the O&M manuals.

G. Instruments required for tests shall be furnished by the Contractor.

3.2 Equipment Cleaning

A. Before placing each system in operation, the equipment shall be thoroughly cleaned; cleaning shall be performed in accordance with equipment manufacturer's recommendations.

B. Refer to appropriate Sections for cleaning of other equipment and systems for normal operation.

3.3 Operation and Adjustment of Equipment

A. As each system is put into operation, all items of equipment included therein shall be adjusted to proper working order. This shall include balancing and adjusting voltages and currents; verifying phase rotation; setting breakers, ground fault and other relays, controllers, meters and timers; and adjusting all operating equipment.

B. Caution: Verify that all bearings of equipment furnished 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 other trades judgment in these matters. Follow specific instructions in regard to lubrication of equipment furnished under this Contract.

3.4 Operating Demonstration and Instructions

A. Set the various systems into operation and demonstrate to the Owner Construction Manager 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.

D. A minimum of 8 hours shall be allowed for instructions to personnel selected by the Owner. Instructions shall include not less than the following:
1. Show location of items of equipment and their purpose.
2. Review binder containing instructions and equipment and systems data.
3. Coordinate written and verbal instructions so that each is understood by personnel.
4. Separate instructions shall be given by manufacturer's representatives for the various special and communications systems.

E. A minimum of 48 hours continuous trouble-free operating time shall be acceptable to prove that the systems function properly.

END OF SECTION
26 05 02 AGREEMENT AND WAIVER FOR USE OF ELECTRONIC FILES

PART 1 - GENERAL

1.1 The Engineer, at his 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
Project: Homecare Renovation  
1 Childrens Plaza  
Dayton, Ohio 45404

Owner: Dayton Children’s Hospital

Heapy Engineering Project Number: 2019-05025

Heapy Engineering Project Manager: Brian Arbogast

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): ____________________________________________

Recipient Address: ______________________________________________________

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):

□ CD-ROM □ DVD-ROM □ Heapy FTP □ User’s FTP site □ Flash Drive

C. Delivery of Electronic Files Cost Summary:

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 26 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:
□ 2018 .RVT

Cost of Preparation of Division 26 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.) $ ________
26 05 04 BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 Temporary Electric Services

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

B. The Contractor is cautioned to carefully consider the possible sources of temporary electric service and the probable location of the General Contractor's office.

C. The General Contractor will make application to the local utility company for the temporary electric service and will pay for all electric power used during construction, including electric heating.

D. The Contractor shall furnish, install and pay for all necessary conduit, wire, metering, poles, switches, receptacles, lights and accessories to provide a 200 amp, 120/208 volt, 3 phase, 4 wire temporary electric service with the main disconnect switch, meter, and a 42 circuit load center at a location specified by the General Contractor.

E. Consult the utility company for fees required and include same in Electrical Contract.

F. Labor, receptacles, boxes, fixtures, wire, etc. required by the various Contractors inside their offices shall be paid for by the respective Contractors.

G. Lighting fixtures shall be placed every 40 ft. along each corridor or, where corridors do not occur, along the long axis of all rooms and areas greater than 25 ft. in length. Provide a 200 watt (or LED equivalent) lamp in a rubber coated socket with wire guard, spliced into branch feeder conductor at every 20 ft. The branch circuit wiring may be 3 wire type "NMC" and the wire guard shall be bonded to the ground conductor. Receptacle circuits shall consist of 1 gang handy box with grounded duplex receptacles a maximum of 50 ft. on center with a maximum of 4 per circuit. All receptacle circuits shall be protected by its own overcurrent device in a panelboard. Install wiring and equipment above 6 feet 6 inches and below the finished ceiling. Extend circuits as required and protect in an appropriate panelboard on each floor level. Provide GFCI protected receptacles and circuits as required by NEC and OSHA.

H. Contractors requiring extension cords shall provide their own cords and plugs up to capacity of 20 amperes. For services to larger items of equipment and welders, this Contractor shall extend proper feeders as requested at the expense of the Contractors requiring the service.

I. The Contractor shall maintain the temporary light and power system for the duration of the work and shall remove it from the site when directed or no longer required as coordinated with the construction team. Temporary wiring and equipment shall remain the property of the Contractor.

J. The use of the permanent electrical system for temporary services during the latter stages of construction shall be allowed. Expedite completion of system as practicable to this end. Maintain the system during this period.

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

L. The complete temporary service shall comply with Power Company, OSHA, and all Code requirements.
1.2 Continuity of Service

A. Work shall be so planned and executed as to provide reasonable continuous service of existing systems throughout the construction period. Where necessary to disrupt services for short periods of time for connection, alteration or switch over, the Owner and Construction Manager shall be notified in advance and outages scheduled at the Owner's reasonable convenience.

B. Submit, on request, a written step-by-step sequence of operations proposed to accomplish the work. The outline must include tentative dates, times of day for disruption, downtime and restoration of services. Submit the outline sufficiently in advance of the proposed work to allow the Architect or Engineer and Construction Manager to review the information with the Owner. Upon approval, final planning and the work shall be done in close coordination with the Owner.

C. Shutdown of systems and work undertaken during shutdown shall be bid as being done outside of normal working hours.

PART 2 - PRODUCTS

2.1 Access Panels

A. Provide ceiling and wall access panels where indicated on the drawings, or where otherwise required to gain access to concealed junction boxes, valves, traps, devices and equipment requiring service or adjustment.

B. Access panels (refer to paragraph C. below for more specialized drywall ceiling access panels) shall be steel construction (except where aluminum or stainless steel is specified) with concealed hinge and door with industrial grade lock set. Locks in "secured" areas of the building shall have tamperproof screws. Panels shall be 18 inches x 18 inches size unless larger panels are shown or required. Mounting frames shall be compatible with the material in which they are installed. Access panels shall be:

1. Standard flush type with overlapping flange for masonry and tile walls, Milcor Style "M" or equal.
2. Standard flush type for drywall ceilings and walls, Milcor Style "M" or equal.

C. Access panels in fire rated shaft walls and in fire rated ceilings shall be "B" label or greater to match the rating of the wall or ceiling.

D. Materials used in plenums shall be rated for plenum use conforming to the ASTM E84 25/50 smoke development and flame spread restrictions.

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 Architect and Engineer shall have the right to stop the work if highest quality workmanship is not maintained.

B. Electrical work shall be performed by a licensed Contractor in accordance with requirements of the jurisdiction.
3.2 Protection

A. The Contractor shall be entirely responsible for all material and equipment furnished in connection with his 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 the Architect, or Construction Manager.

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

3.3 Infection Control and Interim Life Safety Measures (ILSM)

A. The construction work which involves disturbing the clean environment and the safe access of patient and pedestrian traffic routes shall require an approved process. The contractor is to make provisions to comply with the Owner's infection control plan and any interim life safety measures (as determined to comply with Joint Commission Interim Life Safety Measures (ILSM) and Infection Control Risk Assessment (ICRA) standards.). The contractor shall work with the Owner to develop and then comply for airborne contaminant control in Containment and Protection Areas plus transporting construction debris and materials. The plan is shall be documented in writing for review and approval by Owner's Representative and Architect. The measures as required shall be provided and may include Multi-Stage Filtering, Negative Pressure Machine, Portable Air Scrubber, HEPA vacuum, airlocks, pass throughs, and equipment rooms, contamination control mats, block off and sealing air vents, portable enclosures, air pressure monitor, other approved environmental control methods.

B. Provide and maintain all dustproof enclosures, measurement devices, warning signs and warning lighting to protect the patients, Hospital staff and public. Contractor shall remain responsible for compliance with all contamination control requirements.

C. Owner will monitor conditions in the vicinity of project in Protection Areas.

D. Field Quality Control

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections of air quality and pressure for compliance with requirements for performance and test methods.

E. Cleaning

1. Provide thorough cleaning of existing surfaces that become exposed to dust each day. Thoroughly clean each temporary access when work is completed or at the end of each work shift, using approved methods.

2. Provide a final thorough construction cleaning of area before turning space over to Owner for final cleaning.

3. Final cleaning of construction area (to medically clean standards) shall be performed by the Owner's own housekeeping forces.

3.4 Cutting and Patching

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

B. Plan the work well ahead of the general construction. Where conduits, cable trays, bus ducts and wireways are to pass thru new walls, partitions, floors, roof or ceilings, place sleeves in these elements or arrange with the General Contractor 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 the Architect or Construction Manager. Any damage caused to the building shall be repaired or rectified.

C. Where conduits, cable trays, bus ducts and wireways are to pass thru, above or behind existing walls, partitions, floors, roof or ceiling, cutting, patching, refinishing and painting 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.

D. 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.

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

F. 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.

G. 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.

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

3.5 Removals, Alterations and Reuse

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

B. Cooperate with the General Contractor and Construction Manager regarding all removal and remodeling work. The Contractor shall remove existing work which is associated with his trade, and which will be superfluous when the new system is installed and made operational. Void unused conduit behind walls or below floors as necessary or as directed. No wire or conduit shall be removed which will impair the functioning of the remaining work unless first replaced with a rerouted section of wire or conduit to ensure continuity. Remove inactive wiring back to the last active junction box, panelboard or piece of equipment.

C. Upon completion, no unused conduit or stub shall extend thru floors, walls or ceilings in finished areas. Abandoned conduit where remaining in place shall have any unused wiring removed. All accessible unused conduit shall be removed.

D. When it is necessary to reroute a section of an active circuit, the rerouted section shall be installed before removing the existing in order to minimize system down time. Rerouted sections shall be installed as required for new work.

E. 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 after a reasonable time frame
shall become the property of the Contractor responsible for removal and shall be removed from the premises.

F. Remove, store and reinstall lay-in ceiling tile and grid as needed to perform work in areas where such removal and re-installation is not to be done by the General Contractor. Damaged tile and/or grid shall be replaced with new matching tile and/or grid.

G. In areas of minor work where the space is not completely vacated, temporarily move portable equipment and furnishings within the space as required to complete the work. Coordinate this activity with Owner. Protect the Owner's property by providing dust covers and temporary plastic film barriers to contain dust. Remove barriers and return equipment and furniture upon completion of the work.

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

3.6 Painting

A. In addition to any painting specified for various individual items of equipment, the following painting shall be included in Division 26:

1. Ferrous metal which is not factory or shop painted or galvanized and which remains exposed to view in the finished areas of the building shall be given a prime coat of paint and two finish coats of paint.
2. 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 paint.
3. 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.
4. Apply Z.R.C. Galvilite cold galvanizing compound, or approved equal, for touch-up and repair of previously galvanized surfaces.
5. Each backboard shall be painted with a minimum of two coats of flame retardant paint, all sides; gray enamel primer with gray matte enamel finish.

B. Paint, surface preparation and application shall conform to applicable portions of the Painting section of Division 09 of the Specifications. All rust must be removed before application of paint.

C. Finish painting is included in the General Contract except where otherwise required under remodeling work. Refer to the Cutting and Patching paragraph in this Section for finishing requirements.

3.7 Access Panels

A. Install access panels or pay general trade to do so. Final appearance is subject to approval by the Architect or Engineer.

B. Access locations thru HVAC ductwork must be coordinated with the ductwork installer. Location of the hinged access door with latch must be coordinated in advance with the HVAC Contractor.

C. Location of access panels shall be planned to clear ceiling lights, ceiling support grids and other obstructions so as to allow, wherever possible, full shoulder clearance beside the device to be inspected, adjusted or repaired.
D. Panels with recessed doors are to be fitted with insert panels of drywall or, those for plaster, infilled with plaster. Caution the Installing Contractor to provide appropriate framing with drywall or plaster beading to ensure a finished appearance. Shim strips may be required to bring the insert panel flush with the plane of the door and wall / ceiling.

3.8 Backboards

A. Where shown on the drawings, backboards shall be provided for wall mounting of disconnect switches, devices and communications equipment. The Contractor may opt to mount additional groups of disconnect switches on backboards.

B. General

1. Backboard shall be 0.75 inch thick waterproof flame retardant plywood secured to structure.
2. Each board shall be painted.
3. Telephone backboards shall be normally 4 ft. x 8 ft. mounted 6 inches above floor where located on drawings. Where other sizes are required, they will be noted on the drawings.

C. Each terminal cabinet for communication systems, relays, etc., shall be fitted with a full size 0.50 inch thick backboard for mounting terminal strips, equipment, etc.

END OF SECTION
26 05 05  FIRESTOPPING

PART 1 - GENERAL

1.1 Firestopping assemblies shall be provided at penetrations of conduits, bus ducts, cables, cable trays and other electrical items thru fire rated floors, fire rated floor-ceiling and roof ceiling assemblies, fire rated walls and partitions and fire rated shaft walls and partitions and smoke barriers. In addition, firestopping assemblies shall be provided at penetrations thru 0-hour rated floors. Refer to the drawings for fire rated building elements.

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

1.3 Firestopping materials, assemblies and installation shall conform to requirements of the OBC / Chapter 1, Section 106 and Chapter 7, Section 714 and the Authority Having Jurisdiction.

1.4 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 shall be submitted to local authorities having jurisdiction for their review and approval prior to installation. Engineering judgment drawings must follow requirements set forth by the International Firestop Council.

1.5 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 in OBC Chapter 1, Section 106 and Chapter 7, Section 714.

PART 2 - PRODUCTS

2.1 Firestopping materials shall be manufactured and/or supplied by Hilti or other approved manufacturer.

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 Refer to 26 05 33 Raceway and Boxes for Electrical Systems for sleeve requirements and treatment of penetrations not requiring firestopping.

END OF SECTION
PART 1 - GENERAL

1.1 This section pertains to the use of copper conductors, 600V insulation class.

PART 2 - PRODUCTS

2.1 All conductors shall be copper: conductors shall be insulated for 600 volts.

2.2 Insulation types referenced are those of NEC. All conductors shall be UL labeled and shall be marked for size and type at regular intervals on its length. Conductors #8 and larger shall be stranded; #10 and smaller may be stranded provided approved terminations are used.

2.3 Types of conductor insulation for general use may be any of the following, subject to limitations listed, in addition to those in the NEC:

A. Type THHN - restrictions - do not use for conductors in slab. Do not use in wet locations.

B. Type THWN - no restrictions.

C. Type XHHW - no restrictions.

2.4 Use shielded VFD cables for feeds from VFD to motor where conductor length is longer than 25 feet. VFD cable shall be 3 conductor XHHW low capacitance copper, full size insulated copper ground, 1.5 mil AL foil and 85 percent tinned copper woven braid shield with PVC oil and sunlight resistant jacket. UL TC-ER, 90 degrees C., 600V wet/dry. Manufactured by Belden, AWC, Lutze or equal.

2.5 Use only Type XHHW for isolated ungrounded branch circuit wiring such as monitored wiring in hospital operating and special procedures and X ray rooms. Refer to Section "Hospital Specialty Equipment".

2.6 Use Type THHN or XHHW, (90 degrees C. rated) types for connecting luminaires and for running thru fixture housings.

2.7 Use conductors such as type FEP with high temperature insulation as identified in the NEC for connections to resistance heating elements or in other areas subject to temperature exceeding the rating of THWN, XHHW or THHN.

2.8 Color Coding – The use of colored commercial building wire is encouraged.

A. On 208/120 volt, three phase and 240/120 volt, single phase grounded systems, wires colored black, red and blue shall be used for phase conductors. Neutral wires on these systems shall be white. Three- and four-way switch travelers shall be pink. If conductors No. 4 AWG or larger are not available in white or white stripes, the neutral may be a black wire identified with white tape, minimum size 0.50 inch wrapped twice around at the following points:

1. At each terminal.
2. At each conduit entrance.
3. At intervals not more than 12 inches apart in all accessible enclosures.

B. On 480/277 volt, three phase system, wires colored brown, orange and yellow shall be used for phase conductors. Neutral wires on these systems shall be gray or other NEC acceptable means for distinguishing each system grounded conductor from another. Three- and four-way switch travelers shall be purple. If conductors No. 4 AWG or larger are not available in the
proper colors, black wire may be used with 0.50 inch tape bands of the proper color at the following points:

1. At each terminal.
2. At each conduit entrance.
3. At intervals not more than 12 inches apart in all accessible enclosures.

C. Equipment grounding conductors shall be green, or for 4 AWG and larger may be completely taped green, at all accessible points.

D. All control circuits shall be red with individual wire identification on each conductor.

E. Where existing wiring systems (remodel work or building additions) have different color coding, consult the Engineer concerning matching existing wire color coding and phasing.

2.9 Wire size ampacity shall equal or exceed its overload protective device. Where wire sizes shown on the drawings are greater than the apparent ampacity requirements, the size shown shall prevail to compensate for voltage drop. In no instance shall conductors be installed that are less than required by N.E.C. Minimum conductor size shall be No. 12 AWG except No. 14 AWG may be used only for control wiring or where otherwise specifically shown.

2.10 When necessary to use a lubricant for pulling wires, lubricant must be listed by Underwriters’ Laboratories, Inc. Only cable lubricants approved for the type of jacket material or insulation shall be used, and must be of such consistency that it will dry completely when exposed to air. Lubricant must leave no obstruction or tackiness that will prevent pulling out old wires or pulling in new wires or additional wires, and, after drying, must leave a film of lubrication which will promote easy movement of the wires. The lubricant shall contain no waxes, greases, silicones, or polyalkylene glycol oils or waxes. Lubricant shall be Ideal "Yellow 190", 3M "WL" Wire Pulling Lubricant, or approved equal.

2.11 Splices No. 10 AWG and smaller shall be made using the following:

A. Preinsulated spring pressure connectors as follows: ITT Holub "Freespring", with metal grip threads 3M "Scotch-Lok", Ideal "Wingnut", Thomas and Betts Type "PT", or Buchanan "B Cap". Other hard insulated wire connectors which have bakelite or ceramic insulation are prohibited. (Non-metallic thread connectors shall not be used.)

2.12 Splices No. 8 AWG and larger shall be made using the following:

A. Approved crimp type connectors with special crimping tool: T&B, Burndy, Buchanan or approved equal. Joints and free ends shall be covered with tape or approved moistureproof insulating kits. Applied insulation shall exceed 150 percent of conductor insulation voltage rating.

B. For two or more taps use Power Distribution Blocks by Square D, Gould, Taylor, Ilsco or Connectron.

2.13 Wiring in vertical raceways shall be supported with strain relief devices; Kellem's grips or approved equal.

2.14 Connections to equipment shall be made with pressure type terminals. On stranded wire, use spade type terminals or terminals approved for use with stranded wire. Connections shall contain only single conductors unless approved for multiples.

A. For conductors No. 10 AWG and smaller, applied crimp type terminals shall be T&B "Sta Kon" or approved equal.
B. For No. 8 AWG and larger conductors, applied crimp type terminals shall be Burndy, T&B or approved equal.

2.15 Direct buried underground cable, where shown on drawings, shall be direct buried type rated 75 degrees C. Cable shall be multi-conductor, copper with a separate ground conductor sized per N.E.C. 250 122. Install in a PVC sleeve under all walkways and drives.

2.16 Where tape is applied over wires and connectors on 600 volt or lower voltage applications, it shall consist of a minimum of two (2) half lapped layers of Scotch "88" or Plymouth No. 4240 for both indoor and outdoor applications, except Scotch 33 Plus or Plymouth No. 4453 is acceptable for use indoors.

2.17 Where fireproofing of cables is noted on the drawings or required by Code, each cable shall be arc and fireproofed with one (1) half lapped layer of Scotch Brand 77 Electric Arc and Fireproofing Tape. Tape shall be secured with a 2 layer band of Scotch Brand 69 Glass Electrical Tape over the last wrap. Installation shall comply with manufacturer's recommendation.

2.18 Where installed underground, splices and terminations shall be listed and approved for waterproof application. Utilize kits approved for the application.

PART 3 - EXECUTION

3.1 Branch circuit conductor identification means shall be permanently posted at each panelboard and switchboard. This identification shall be installed on the inside of the door and shall identify conductor colors for each voltage system in the building. Provide identification at all new panelboards and existing panelboards utilized within this project.

3.2 Conduit systems shall be clear and clean before pulling wire. Branch circuit conductors shall be pulled without resorting to levers or heavy pulling devices.

3.3 Cable pulling tensions shall not exceed recommended values.

3.4 Group ungrounded and grounded circuit conductors for each multiwire branch circuit by cable ties in panelboards and tap boxes.

3.5 Each branch circuit or multiwire branch circuit shall have its own dedicated neutral. Group neutral conductors with phase conductors by wire ties in each enclosure where multiple neutrals provided.

3.6 Shielded VFD cables shall be provided for VFD to motor conductors length longer than 25 feet. VFD motor feed cables shall be terminated per VFD manufacturer's direction.

3.7 Control conductors shall not be run in same raceway with branch circuit or motor circuit conductors.

3.8 Unless noted otherwise on the drawings, a maximum of 8 conductors shall be installed in a branch circuit conduit. This maximum is a count of all phase and neutral conductors only, ground conductors are not counted when determining maximum fill for this purpose.

3.9 Wire tags shall be provided on all main and feeder conductors in all pull boxes, wireways and panelboard and switchboard wiring gutters. Tags shall identify wire or cable number and/or equipment served. Tags shall be of flame resisting adhesive material, T&B Type WSL or approved equal.

3.10 Perform meggar tests on all feeders and motor branch circuit conductors prior to energization of circuits. Provide documentation in standard NETA format to the Engineer for review. Do not run meggar check on solid state equipment.
PART 1 - GENERAL

1.1 This section covers copper multi-conductor metal clad cable, Type MC. Metal clad cable constructions shall conform to UL #1569, UL 83 and N.E.C. Article 330.

PART 2 - PRODUCTS

2.1 Multi-Conductor Metal Clad Cable, Type MC, with copper conductors in sizes #12 thru #6 for continuous operation at a maximum conductor temperature of 90 degrees C dry. Cables shall have Underwriters' Laboratories labels for Metal Clad Cable and are suitable for use as branch circuits in both exposed or concealed work in accordance with the applicable sections of the National Electrical Code, Article 330.

2.2 Multi-conductor, Super Neutral, Metal Clad Cable, Type MC, with copper conductors in sizes #12 through #1/O AWG for continuous operation at a maximum conductor temperature of 90 degrees C dry. Super Neutral Cable, Type MC Cables are comprised of four or more conductors with one neutral per phase for three phase, a ground for four-wire power supply systems to receptacle circuits. Cables shall have Underwriters' Laboratories labels for Metal Clad Cable and are suitable for use in both exposed or concealed work or in accordance with the applicable sections of the National Electrical Code, Article 330. Receptacle circuits requiring separate neutrals, the neutrals shall be considered a current carrying conductor and derated per NEC 310.15.

2.3 Multi-Conductor Metal Clad Cable Conductors shall be copper type THHN with a full sized copper ground conductor and mylar assembly tape. MC cable type utilizing an integrated aluminum grounding/bonding conductor system as the equipment grounding conductor is not acceptable.

PART 3 - EXECUTION

3.1 Multi-Conductor Metal Clad Cable shall be supported and installed per NEC. Article 330. Except not permitted to be run exposed in finished spaces and the use of non-metallic ties for support is prohibited.

3.2 Plastic anti-short bushing (red head) shall be inserted into the armor cover at terminations.

3.3 Branch circuits from panelboards shall be run in conduit to a central junction box in spaces or group of spaces containing terminal blocks and ground bar where all incoming conductors and outgoing MC cable conductors are terminated. At these terminal blocks the transition is made to type MC cable with all terminal points identified along with the circuit numbers. The Multi-Conductor Metal Clad Cable runouts continue to lighting fixtures, receptacles, etc.

3.4 MC cable shall not be run horizontally in walls between device boxes. Box-to-box wiring must go up the wall, over to the stud cavity for the next box and down the wall.

3.5 Conductors in central junction boxes shall be labeled indicating panel and branch circuit, refer to Electrical Identification; Section 26 05 53.

END OF SECTION
26 05 26  GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 Work includes grounding and bonding of system neutral, equipment and conduit systems to conform to requirements of NEC and as detailed on the plans and in the specifications.

PART 2 - PRODUCTS

2.1 Grounding rods shall be copper clad, molten-welded copper to steel; unless otherwise designated, 0.625 inch diameter x 10 ft. long.

2.2 Clamps and continuity devices shall be non-ferrous material, UL approved. Connections to ground rods and all underground connections shall be “Thermoweld” or “Cadweld”.

2.3 Ground conductors shall be insulated, identified by green insulation or by painting or taping green at all accessible locations and shall be connected with approved connectors and terminators to boxes, devices, equipment, etc. and to ground bars in panels.

PART 3 - EXECUTION

3.1 Provide a listed intersystem bonding termination system with capacity for a minimum of 5 - #4 - 4awg and 1 - #6 – 2 awg bonding conductor terminations. Locate external to the service entrance equipment and connect to the grounding electrode system.

3.2 Wiring devices shall be connected with grounding jumper from ground pole on device to grounding screw in the outlet box. Branch circuit to be connected to grounding screw in the outlet box.

3.3 The complete metal conduit system shall be used for the equipment grounding system. Conduit systems and associated fittings and terminations shall be made mechanically tight to provide a continuous electrical path to ground and shall be safely grounded at all equipment by bonding all metallic conduit to the equipment enclosures with locknuts cutting thru paint or enclosures. Bond all conduits entering wireway and panelboards with a ground wire connecting the grounding type bushings to the equipment ground bar. Conductors shall be sized per NEC Tables 250.66, 250.102 and 250.122. Bond all communications conduit systems to ground.

3.4 In addition to using the conduit system for grounding, a complete auxiliary green wire equipment grounding system shall be installed, continuous from main ground, thru distribution and branch circuit panelboards and paralleling all feeders and branch circuit wiring. Grounding conductor sizes shall comply with NEC Table 250.122, minimum size shall be #12 copper except #14 on control circuits. This shall apply to all circuits rated 100 volts or more above ground potential.

A. Connect ground terminal on wiring devices to auxiliary green wire equipment grounding system.

3.5 Motor frames shall be bonded to the equipment grounding system by an independent green insulated copper wire, sized to match equipment grounding conductor. Motors with VFD shall be bonded with flat braided tinned copper straps in lieu of wire.

3.6 Cord connected appliance frames shall be grounded to the equipment grounding system thru a green wire in the cord.

3.7 Equipment mounted on vibration isolation hanger and supports shall be bonded so bond does not transmit vibration. Size bond to match equipment ground conductor.

3.8 A green grounding conductor shall be installed in each non-metallic conduit and all flexible conduits, including exterior underground conduits.
3.9 System neutral connections shall be insulated from metal enclosures except at the neutral of the service entrance equipment and on the neutral of a separately derived system. Connections to the panelboard enclosure shall be by means of bonding jumpers.

3.10 The building neutral shall be identified throughout with white conductors. Where there are neutral conductors from a separately derived system (such as 120/208 volt, 3 phase, 4 wire where the main building service is 277/480 volt, 3 phase, 4 wire) the neutrals of the two systems shall be separately identifiable per NEC Article 200.

3.11 Where metal covers on pull boxes and junction boxes are used, they shall comply with the grounding and bonding requirements of NEC Article 250.

END OF SECTION
26 05 33 RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 This specification section covers common conduit systems, boxes, firestopping and sleeves. Where other methods are specified under separate sections for specific applications, the specific application requirements shall govern.

1.2 Refer to Section 26 05 05 Firestopping for firestopping requirements.

1.3 Refer to Section “Communication System Pathways and Support Equipment” for future communication system.

PART 2 - PRODUCTS

2.1 Conduit Type - Application (Use only conduit types listed)

A. Conduit - Rigid or Intermediate Grade Galvanized Threaded. Application - restrictions - (Not to be used in):
   1. Direct buried in corrosive soils.
   2. Corrosive atmospheres.

B. Conduit - Rigid Aluminum threaded. Application - restrictions - (Not to be used in):
   1. Underground.
   2. Corrosive atmospheres.
   3. In concrete.

C. Conduit - Thinwall EMT. Application - restrictions - (Not to be used in):
   1. Poured concrete.
   2. Exposed to weather.
   4. Exposed in mechanical equipment or other equipment/process rooms below 48 inches.
   5. Hazardous or corrosive atmospheres.
   6. Not to be used for medium voltage (2001 volts or higher) cable.
   7. Not to be used in utility tunnels.

D. Conduit - PVC Type 40 (Schedule 40) rigid, conforming to ANSI, NEMA specifications and each length UL labeled. Application - use limited to:
   1. In or under concrete slabs on grade where permitted by electric legend on the drawings.
   2. Exterior use when encased in 3 inch concrete.
   3. Direct buried, underground when indicated on drawings.

E. Conduit - PVC, NEMA Type TC 6, rigid, conforming to ANSI, NEMA specifications and each length UL labeled. Application - use limited to:
   1. Exterior use when encased in 3 inch concrete, for duct bank use only.

F. Conduit - Flexible Metal (Greenfield type), galvanized steel or aluminum. Application - use limited to:
1. Connection to lighting fixtures; not over 6 ft. in length. Note: Metal-Clad Cable: Type MC may be used for fixture whips only; must contain green insulated ground conductor, be limited to 6 ft. in length and must use UL approved connectors.
2. Narrow movable partitions where other raceways are not practicable, when approved by the Architect or Engineer.
3. Connections to transformers, dynamic equipment and for motors only when in air streams or plenums.
4. In existing walls for remodel projects, vertical drops to outlets and switches; no more than 3 ft. out the top of the wall.

G. Conduit - Liquidtight Flexible Metal.
Application - use and limitations:
1. Connections to all motors, except in air stream or plenum.
2. Connections to controls on dynamic equipment, transformers, etc., outdoors and indoors in wet locations.
3. Use not permitted underground or where subject to physical damage.

H. Plastic jacketed rigid steel conduit shall be ETL performance verified. Application – use in corrosive atmospheres including swimming pool areas, pool equipment rooms, chlorine storage areas, etc. and other areas as noted on the drawings.

I. Conduit Reinforced Thermosetting Resin RTRC shall meet UL 1684 for extinguishing flame and shall not contain any compounds that release halogens.
Application use limited to:
1. In or under concrete slabs on grade where permitted by electric legend on drawings.
2. Exterior uses when encased in 3” concrete.
3. Direct buried, underground when indicated on drawings.
4. Exposed corrosive atmospheres including pool equipment rooms, chlorine storage areas, etc. and other areas as noted on drawings.
5. Where subject to physical damage shall be identified for use i.e., types RTRC-X W.

2.2 Conduit sizes

J. Conduits shall be 0.75 inch minimum size except 0.50 inch size may be used for switch legs and flexible connections to lighting fixtures.

2.3 Conduit Fittings

A. Fittings and workmanship shall ensure electrical continuity. All conduit systems in poured concrete shall be concrete tight.

B. Application of bushings, locknuts and insulated fittings shall comply with NEC requirements.

C. Use conduit fittings as manufactured by Efcor, Steel City, Raco, Midwest, Appleton, ETP / O-Z / Gedney, American Fitting Corporation or T&B, equal to the following catalog numbers:

1. Rigid and intermediate conduit
   • all fittings, couplings and connectors shall be threaded type.
   • grounding bushings, malleable iron; insulated; Steel City BG-801; Midwest Series GLL.
2. EMT
   • fittings shall be all steel, set screw or compression type, concrete tight.
   • set-screw type couplings; Midwest Series 460; Steel City TK 121; Appleton TW 50S.
• compression type couplings; Midwest series 660S; Steel City TK111; Appleton TWC50CS.
• set-screw type connectors; Midwest Series 450; Steel City TC 121; Appleton TWC 50S.
• compression type connectors; Midwest Series 650; Steel City TC111; Appleton TW110.

3. Flexible metal conduit
• malleable iron, "squeeze" type, non-insulated; Midwest series 1708; Steel City XC 901; Appleton 7481V. (For lighting fixture whips only - all steel or die cast screw in connector; Midwest 771; Steel City XC 241; Appleton SGC 50DC).

4. Liquid tight conduit
• steel or malleable iron; Midwest Series LT; Steel City LT 100; Appleton ST.

5. PVC Type 40 and Type TC-6
• couplings and fittings socket type solvent weld, coupling and solvent by same manufacturer as conduit.

6. RTRC
• Coupling and fittings socket type adhesive jointing. Coupling and adhesive by same manufacturer as conduit. Gasketed jointing system may be used underground where encased in conduit.

2.4 Boxes

A. Junction boxes and pull boxes shall be code gauge galvanized steel with multiple screw fasteners and galvanized steel covers.

B. Outlet boxes all steel construction with galvanized or plated finish or otherwise all metal, by Steel City, Appleton, Crouse Hinds, R&S or Raco.

1. Lighting fixture outlet boxes 4 inches square or octagonal, 2.125 inches deep, with 0.375 inch fixture studs. Equal to Steel City Series 54171; Series 52171 with FE 421 stud. Fixtures weighing more than 50 lbs. shall be supported independently of the outlet box.

2. Flush mounted device outlet boxes shall be minimum 4 inches square. Provide extension rings as required. Use Erico Caddy No. H2-3 mounting support plate where metal studs are used.

3. Device rings in finished masonry or tile walls shall be square corner masonry type with no extended ears, to allow flush mounting of plates.

4. Surface mounted device boxes shall be cast "FS" type or special surface mounted boxes for use with surface raceway systems.

C. Floor boxes shall be UL listed for its application as manufactured by Hubbell, Steel City, Walker, Raco or Wiremold. Drawings identify material type.

D. Provide water tight boxes, slip expansions and bonding jumpers where dictated by construction conditions.

E. Terminations at boxes shall be secured by locknuts or approved bushings.

2.5 Surface Metal Raceways

A. Snap on cover types by Mono-Systems, Panduit or Wiremold / Walkermold with prime gray finish (enamel finish coat to match room finishes in remodel areas). Application - permitted only when specifically shown on the drawings.

1. Fittings, boxes and extension rings: Furnish manufacturer's standard accessories; match finish of raceway.
2.6 Sleeves and Openings

A. Sleeves and formed openings shall be placed in walls, partitions, floor slabs and poured concrete roof decks for the passage of conduit, cable, wireway, cable tray and bus duct. Sleeves and formed openings are not required:

1. In floor slabs on grade.
2. Where conduit is installed before the wall, partition or slab is constructed.
3. Openings are cut for conduit passage and patched with equal or comparable material to close the space around the conduit.
4. In stud and gypsum board or plaster walls and partitions which are not fire rated.
5. For conduit passing thru masonry walls and partitions and stud and gypsum board or plaster walls and partitions. Sleeves are required however, for which expansion, contraction and other movement can be expected.
6. In core drilled openings in solid concrete not requiring water protection. Sleeves are required, however, at core drilling thru hollow pre-cast slabs and concrete block walls, to facilitate containment of required firestopping material.
7. In large floor openings for multiple pipe and duct risers which are within a fire rated shaft, unless the opening is to be closed off with concrete or other material after conduits are set.
8. Sleeves for passage of conduit and cables shall be schedule 40 black steel pipe or galvanized rigid conduit. Rectangular sleeves for cables, wireway, cable tray and bus duct shall be 18 gauge galvanized steel in poured concrete floors, walls and roof decks; 26 gauge galvanized sheet steel in other than poured concrete.
9. Sleeves shall be sized to afford 0.25 inch to 0.75 inch clearance space.

2.7 In areas having special membrane waterproofing in or on the floor slab, a Josam 26420, or equal approved by the Architect, riser sleeve with clamping ring and auxiliary conduit sleeve extending 4 inches above finished floor or 8 inches above finished roof shall be used. Waterproofing membrane for roof and floor construction shall be secured by the clamping ring. These are to be used in areas having special membrane water-proofing in or on the floor slab and at roof decks.

2.8 Multiple conduits extending through the roof may be fitted with a manufactured pipe curb weatherproofing assembly equal to Pate # pca, lpca and mpca as an alternative to that specified in paragraph 2.7 above.

2.9 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 conduits penetrate walls, floors, ceilings or overhead structure.

2.10 Anchors and Fasteners

A. Anchors and fasteners shall be of a type designed and intended for use in the base material to which the material support is to be attached and shall be capable of supporting the intended load and withstanding any associated stresses and vibrations.

B. In general, screws shall be used in wood, masonry anchors on concrete or brick, toggle bolts in hollow walls, and machine screws, bolts or welded studs on steel.

C. Nails shall not be used except for temporary support or for light loads in wood frame construction.

D. In outdoor locations or other corrosive atmospheres, the anchors and fasteners shall be non-corrosive or have suitable corrosion resisting coatings.
PART 3 - EXECUTION

3.1 Conduit shall be run concealed in all finished areas of new construction and elsewhere unless specifically indicated or upon specific permission by the Architect. All conduit shall parallel building lines.

3.2 Conduit shall be run overhead and shall not be run in or below concrete slabs unless specifically indicated on the drawings and in the legend on the drawings.

3.3 Where feeders are permitted to be run below floor slab on grade, they shall be installed in non-metallic conduit encased in 3 inch concrete using galvanized rigid steel or RTRC (equal to Champion Fiberglass) elbows with all necessary fittings and couplers. (NOTE: Where not required to be run overhead, branch circuits may be installed in 1 inch or smaller Schedule 40 PVC conduit below the vapor barrier, shall have a minimum of 6-inch fill over the conduit below the vapor barrier without concrete encasing the PVC. The 90 degree elbow and stub up shall be galvanized rigid steel).

3.4 All conduits installed below concrete slab on grade shall have a minimum of 6-inches fill over the conduits in order to prevent accidental damage to conduits should the floor be saw-cut in the future.

3.5 Conduits shall not be installed above the vapor barrier in concrete floors poured on grade.

3.6 Conduit crossing building expansion joints shall have expansion provisions with grounding continuity; use special expansion fittings or other NEC approved method. Refer to the Architectural and Structural floor plans and details for locations of expansion joints.

3.7 Do not install wall-mounted boxes back-to-back in opposite sides of wall; in stud walls, boxes shall be on opposite side of studs. In acoustic rated and fire rated walls boxes shall be separated a minimum of 24 inches.

3.8 Boxes not otherwise accessible in ceilings and walls shall be made accessible by installation of hinged door access panels. Refer to Section 26 05 04 - Basic Electrical Materials and Methods.

3.9 Use cast floor boxes for installation in slab on grade; formed steel boxes are acceptable for other installations.

3.10 Work shall be so planned as to:

A. Minimize the number of offsets and junction boxes. For feeder conduits, use all long radius conduit bends or accessibly located large junction boxes with screw covers.

B. Generally run conduit and conductors as high as practicable against underside of floor slab in concrete construction or immediately below the top chord of bar joist construction unless otherwise shown. This high level zone shall be used for running electrical raceways. Running conduits promiscuously at various levels and directions will not be acceptable. Runs at bottom chord level or ceiling grid level will not be acceptable.

C. Where spray on fireproofing is used, coordinate with the General Contractor about installing supports, panel feeders and larger conduits before fireproofing is applied. Branch circuit conduits and smaller size conduits may be run as high as possible on stud walls that go all the way up to the structure; this will minimize damage to spray on fireproofing. Patch and repair damaged spray on fireproofing caused by electrical installation; conduits shall not be fully covered with fireproofing.

D. Coordinate activity in advance to avoid interference with other trades.
E. Provide access to all junction and pull boxes.

F. Maintain 6 inches from conduit to paralleled hot water piping and 4 inches from cross piping and 12 inches from generator exhaust piping.

3.11 Secure feeder conduit to basic structural elements with galvanized strap hangers and clamps; use of trapeze type hangers is encouraged for multiple conduits where space will permit. Galvanized metal clamps and screws may be used for attaching and supporting branch circuit conduit. Non-metallic fasteners shall not be used except plastic inserts may be used in concrete for small conduits. Vertical conduits shall be supported at each floor by clamps.

3.12 Surface mounted horizontal and vertical conduit supports on walls up to a height of 7 feet-0 inches above the floor shall be one or two hole sheet metal pipe straps. Pinch type hangers similar to Minerallac type may only be used at heights greater than 8 feet-0 inches. The use of pinch type hangers similar to Minerallac type are expressly prohibited on ductwork, air handling units and other mechanical equipment below 8 feet-0 inches.

3.13 During construction temporarily cap open ends of conduit. Caution trades to take special care of runs in concrete slabs during pouring.

3.14 Empty conduit installed for communications use or for future systems shall have an insulated pull wire or heavy nylon cord inserted for use in pulling wires.

3.15 Pull mandrel or large swab thru conduit to ensure freedom from debris before pulling wires. Use pulling lubricants sparingly.

3.16 Sleeves for passage of conduit, cables, wireway, cable tray and bus duct shall be placed 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 Architect.

3.17 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. Refer to the following paragraph for qualifications and exceptions relating to firestopping.

3.18 Refer to 26 05 05 Firestopping. 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.

3.19 Where firestopping is not required, the annular space between the sleeve, core drilling or opening and the conduit, cable, cable tray, bus duct and raceway shall be closed with caulking to retard the passage of smoke.

3.20 Where permitted by OBC Section 712 Penetrations, metallic conduits requiring no pipe sleeves in passing thru concrete floors or concrete or masonry walls and partitions, the annular space shall be closed full depth of the penetration with materials and methods compatible with the floor, wall or partition material (concrete, grout or mortar).

3.21 Openings for multiple conduits extending through floors where water protection is required (mechanical rooms, kitchens, other potentially wet areas) may be protected with a 4 inch high by 4 inch wide concrete curb with chamfered corners in lieu of individual sleeves. These concrete curbs may be used in lieu of the Josam 26420 riser sleeve and clamping ring provided the floor membrane and curbing are arranged to maintain the integrity of the membrane.
3.22 Conduits, wire and cables entering from outside the building shall be sealed water and moisture tight. Seal between conduit and sleeves, conduits and core drilled holes and around conductors inside conduits. Provide cast iron pipe or schedule 40 galvanized steel conduit sleeves in exterior walls below grade, with intermediate wall stop and anchor collar set in place before concrete pouring. Sleeve shall be a part of the sealing assembly. When the wall opening is core drilled the wall sleeve may be omitted. A mechanically compressed rubber sealing assembly equal to Thunderline Corp. "Link-Seal" shall be placed in the annular space between conduit and sleeve or core drilling.

3.23 Conduits extending through the roof shall be made watertight by means compatible with the roofing system and as directed by the Roofing Contractor (the company who presently holds the warranty on the roof) and approved by the Architect.

3.24 Power actuated fasteners of any type are prohibited in occupied buildings. This includes anchors which are driven into place by any device which produces an impact force by use of a powder charge, compressed air, gas or any other propellant.

3.25 Provide four (4) 1 inch diameter spare conduits for each flush mounted branch circuit panelboard; extend from top of panelboard to above an accessible ceiling for future use.

3.26 All conduit terminations to be equipped with locknuts and bushings. Conduits 1-1/2 inches and larger shall have insulating bushings, grounding lug and shall have locknuts inside and outside the enclosure.

3.27 Outlet Box Installation

A. Set box square and true with finished building surfaces and trim.

B. Secure boxes firmly to building structure.

C. Verify location of outlets and switches in finished rooms with Architectural Drawings of interior details and finish. In centering outlets and locating boxes, allow for overhead pipes, ducts and mechanical equipment, variations in fireproofing and plastering, window and like, and correct any inaccuracy from failure to do so without expense to the Owner.

D. Maintain symmetry of all outlets as closely as possible contained within Architectural Elevation. For example, the Contractor shall center light fixture over doorway or receptacle in section of masonry wall, if shown in that approximate position. If receptacle is shown in same location as counter or bench, determine countertop height and set receptacle to clear top and trim of counter and render outlet easily accessible.

E. In the event of conflict between locations of electrical outlets as shown on the Electrical Drawings and on the Architectural Drawings, outlets shall be installed in accordance with the latter.

F. Locate light switches on latch side of door and verify door hinge location in field prior to switch outlet installation.

G. The Owner reserves the right to relocate any device as much as 10 feet-0 inches (measured horizontally) from its indicated location at no additional cost, provided the contractor is notified prior to roughing that device in.

3.28 Contractor shall record carefully on a set of "as built" prints the exact location of all feeder conduits.
3.29  Unless noted otherwise on the drawings, a maximum of 8 conductors shall be installed in a branch circuit conduit. This maximum is a count of all phase and neutral conductors only - ground conductors are not counted when determining maximum fill for this purpose.

END OF SECTION
26 05 53  IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 Equipment Identification

A. Identify all the following items with laminated plates:
   1. Every motor, lighting and equipment controller and disconnect switch.
   2. Panelboards.

B. Nameplate on motor controllers, disconnect switches, automatic transfer switches, switchgear, switchboards, panelboards and transformers shall indicate source, voltage, disconnect location, and load served.

C. Branch circuit panelboards:
   1. Identify panel designation on directory card within the panel.
   2. Fill out branch circuit directory indicating circuit number and area served, rooms, group of rooms, lighting, convenience outlets, motors, etc. Card index shall be neatly typed. Provide electronic file for card using Excel.
   3. Update or replace branch circuit directory in existing panelboards in areas of alteration.
   4. Branch circuit phase conductor color format shall be permanently identified inside each panelboard.

D. Conduit and junction boxes:
   1. Color code or label all junction boxes and exposed conduit at 10 ft. intervals. Coding shall be painted or labels of the pre manufactured type permanently mounted with metal or plastic band.
   2. Provide a color identification scheme under heavy plastic cover hanging in the electrical rooms; identification shall be:
      a. Emergency - Orange
      b. Normal - Black
      c. Fire Alarm - Red
      d. Nurses Call - Blue
      e. Life Safety - Purple
      f. Telephone – Paging and Intercom- Yellow

E. Wire identification:
   1. Identify communications and signaling system wiring and branch circuit wiring by circuit number in panels and motor control center wiring gutters by means of permanent durable wire markers wrapped around or fastened to conductors. This shall be done concurrently with pulling of conductors.
   2. Wiring or fiber cabling installed by Contractor for termination by Owner’s vendor such as for telephone or data systems shall be identified at both ends utilizing the alpha/numerical identification schedule established by the system vendor.

F. For disconnecting means where power can be backfed (like tie breaker) provide permanent sign at disconnecting means saying: ‘DANGER – CONTACTS ON EITHER SIDE OF THIS DEVICE MAY BE ENERGIZED BY BACKFEED.’ Also, provide a single-line showing local switching arrangement on permanent sign.
PART 2 - PRODUCTS

2.1 Nameplates

A. Nameplates shall be laminated phenolic with black surface (red surface for emergency) and white core. Use 0.0625 inch thick material for plates up to 2 inches x 4 inches and 0.125 inch thick for larger sizes. The lettering shall be Condensed Gothic with space between the lines equal to the width of the letters. Use 0.25 inch minimum height letters on the small plates increasing the size proportionately to plate size.

B. The lettering on the plate shall indicate the name of equipment, the specific unit number, voltage, phases, which panel, switchboard or motor control center the equipment is served from, and any other reference data pertinent to the operation. Names and numbers shall coincide with those listed on the drawings. Sample: Panel 3A; 277/480 V, 3 phase, 4 wire, served from unit substation USI.

PART 3 - EXECUTION

3.1 Nameplates shall be secured with screws, one on each end.

END OF SECTION
26 05 65  SPECIFIC WIRING APPLICATIONS

PART 1 - GENERAL

1.1 Specific wiring applications are identified. Refer to applicable sections of the specifications.

PART 2 - PRODUCTS

2.1 Materials and equipment shall be as indicated on the drawings and in the specifications.

PART 3 - EXECUTION

3.1 Final connections to fixture pigtails shall be made with approved pressure connectors such as 3M “Scotchlok”.

3.2 Miscellaneous Equipment Connections

A. Various items of equipment such as kitchen, laboratory, laundry, etc. will be furnished and set in place by other trades. This equipment, unless otherwise shown on the drawings, will be furnished with necessary electrical outlets, operating and control switches, terminating in an electrical outlet box, or equivalent electrical connector located on the equipment. This Contractor shall furnish power wiring to these various items of equipment and connect them up complete and ready for operation.

B. Where disconnect switches are indicated or where otherwise required, these shall be mounted in an accessible location; but in the case of laboratories, kitchens and finished areas, in an inconspicuous a place as possible. Under counter installation of disconnect switches is preferred to locations above the counter, however, care shall be taken that such switches will be accessible and do not interfere with installation of the equipment.

C. Roughing in drawings for equipment shall be obtained from the Architect as the time approaches when such equipment is required. (Allow a reasonable period from the time of notice to secure this information.)

D. Where necessary to expose conduit in kitchens and laboratories, rigid aluminum conduit and LB fittings shall be used.

3.3 Miscellaneous Wiring and Interlocks

A. Various items of work in connection with interlocking motor and starter operations and providing wiring to serve equipment which is furnished by other trades.

B. Interlocks between motor controllers for purposes of accomplishing sequence control or simultaneous operation of motors are all to be included by the Contractor. Requirements for a simple simultaneous motor operation interlock are indicated by a schedule on the drawings. These interlocks consist of auxiliary contacts on the starter of the lead motor wired in, according to standard diagrams of the motor starter manufacturer to energize the holding coil of the starter for the motor. These interlocks shall be thru the “automatic” position only of the starter where HOA switches are supplied. Where interlocks, other than the simple sequence above are required, these shall be as described hereinafter. This Contractor shall inquire of the Engineer during bidding, or at the earliest practical date, regarding any questions which may arise regarding the intention and scope of this work. This Contractor shall furnish extra contacts for his starters where required, in lieu of which he may furnish externally mounted relays to accomplish the specified function.

C. Air handling unit motors shall lead and exhaust fans and moving media air filters follow. Chiller pumps shall lead, followed by chiller, condenser pump and cooling tower, in that order.
Condenser pumps shall lead and chemical feeder shall follow. Hot water pumps shall lead and boilers follow.

D. The following is a list of equipment and systems requiring wiring. Note that these are in addition to standard interlocks which are scheduled on the drawings.

1. Refer to the Fire Alarm Specification 28 31 00 for Smoke Damper Operation Requirements.
2. Motorized Doors - Door controls, including relays, operating switches, limit switches and wiring diagrams, will be furnished by the door equipment supplier. These shall be received by the Contractor and installed complete and ready for use, in accordance with approved wiring diagrams. Where motorized doors are located in fire walls and smoke partitions, provide a signal from the fire alarm system to disable the door controls and allow it to be manually operable while maintaining its latching feature.
3. Motorized backdraft dampers on exhaust fans and power roof ventilators shall be connected up to their respective associated motor leads to energize the backdraft damper motor and open the damper when the fan operates. Dampers, operator and transformer if required, will be furnished by the fan supplier. Where the motors are fed from a variable frequency drive controller (VFD) provide a separate branch circuit to serve the dampers from the nearest panelboard (normal or emergency use same type of source as the associated fan motor) with control through the VFD damper control output relay. Coordinate requirements with the VFD Supplier.
4. Power supply for heat tapes shall be provided as indicated on the drawings. Heat tapes are furnished under Division 23. Coordinate with Division 23 for detailed location and method of connection; provide ground fault protection of equipment per NEC Article 427.
5. Independently mounted controllers, furnished by others: where starters are furnished by other trades, and are required to be mounted remote from the motor, this Contractor shall accept and mount them and perform all power and control wiring between controls and motors as indicated. Motor controllers equipped with automatic alternators shall have two independent circuits and control sources to preclude loss of operation when one circuit fails.

3.4 Wiring in Hazardous Locations

A. The areas indicated on the drawings and where required by Code are to be considered hazardous locations.

B. All switches, outlet devices, fixtures and wiring to be installed in these areas shall comply with special requirements of the National Electric Code Article 500, Class I, Division 1. Explosion proof devices shall be used throughout.

C. To avoid expense and to minimize the hazards, electrical work shall be so laid out and installed as to require only a minimum of wiring and outlets.

END OF SECTION
PART 1 - GENERAL

1.1 Scope

A. Provide a protective device coordination study for the new electrical distribution system provided by this project and those portions of the existing electrical power distribution system affected by this project. It is not intended that the entire existing building be included in the study.

B. The study shall include a short-circuit study and equipment-interrupting or withstand evaluation on all portions of the electrical distribution system from the normal and emergency sources of power through the low-voltage distribution systems to the branch circuit panelboard level. All modes of operation shall be thoroughly covered in the study.

C. The study shall include an arc flash analysis study per NFPA 70E including labeling of equipment. Coordinate with the owner for design of the labels provided where existing part of system is labeled.

1.2 References

A. Institute of Electrical and Electronics Engineers,

2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
3. IEEE 399 – Recommended Practice for Power Systems Analysis
4. IEEE 551 – Calculating Short Circuit Currents in Industrial and Commercial Power Systems
5. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations

B. National Fire Protection Association,

1. NFPA 70 – National Electrical Code
2. NFPA 70E – Standard for Electrical Safety in the Workplace

1.3 Qualifications

A. The short-circuit, protective device coordination and arc flash analysis studies shall be conducted under the supervision and approval of a Registered Electrical Engineer skilled in performing and interpreting the power system studies. The Registered Professional Electrical engineer shall be a full-time employee of the Engineering Services Company.

B. Submit qualifications and background of firm. Submit qualifications of Professional Engineer performing the study.

1.4 Submittals

A. The short circuit and protection device coordination studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings. If formal completion of the studies may cause delay in equipment manufacturing, approval from the engineer may be obtained for preliminary submittal of sufficient data to ensure that the selection of device and characteristics will be satisfactory.
B. The results of the short-circuit, protection device and arc flash hazard analysis studies shall be summarized in a final report. Three (3) bound copies of the complete report shall be submitted for owner reference. A disc copy of final analysis shall also be provided.

PART 2 - PRODUCTS

2.1 Studies

A. The Contractor is to furnish short-circuit and protective device coordination studies as prepared by the equipment manufacturer(s) or Engineering Services Company.

B. The coordination study shall be from the facility distribution board protective device and include all of the electrical protection devices down to and include the largest feeder breaker and motor starter in the 480 volt motor control center, equipment control panels and power distribution panels, the stepdown transformer and branch panelboards.

2.2 Data Collection

A. The Contractor shall furnish all data as required for the power system studies. The Engineer performing the short-circuit and coordination studies and flash analysis shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to ensure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Source combination may include present and future motors and generators.

C. Load data utilized shall include existing and proposed loads obtained from Contract Documents provided by Owner, or Contractor.

D. Include fault contribution of existing motors in the study, with motors <50 hp grouped together. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

2.3 Short-Circuit And Protective Device Evaluation Study


B. Transformer design impedances and standard X/R ratios shall be used when test impedances are not available.

C. Provide the following:

1. Calculation methods and assumptions
2. Selected base per unit quantities
3. One-line diagram of the system being evaluated
4. Source impedance data, including electric utility system, generation system and motor fault contribution characteristics
5. Typical calculations
   a. Fault Impedance
   b. X to R ratios
   c. Asymmetry factors
   d. Motor fault contributors
   e. Short circuit kVA
   f. Symmetrical and Asymmetrical phase-to-phase and phase-to-ground fault currents
   g. Tabulation of calculated quantities and results
6. Tabulations of calculated quantities
7. Results, conclusions, and recommendations.

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:

1. Electric utility’s supply point
2. Incoming switchgear
3. Unit substation primary and secondary terminals
4. Low voltage switchgear
5. Motor control centers
6. Standby generators and automatic and manual transfer switches
7. UPS primary and secondary terminals and by-pass secondary terminals
8. Branch circuit panelboards
9. Busway
10. Equipment control panels
11. Other significant locations throughout the system

E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.

F. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short circuit ratings
2. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses
3. Adequacy of transformer windings to withstand short-circuit stresses
4. Cable and busway sizes for ability to withstand short-circuit heating
5. Notify Owner in writing, of existing, circuit protective devices improperly rated for the calculated available fault current

2.4 Protective Device Coordination Study

A. Proposed protective device coordination time-current curves shall be graphically displayed on log-log scale paper.

B. Include on each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.

D. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot the following characteristics on the curve sheets, where applicable:

1. Electric utility’s protective device
2. Medium voltage equipment relays
3. Medium and low voltage fuses including manufacturer’s minimum melt, total clearing, tolerance, and damage bands
4. Low voltage equipment circuit breaker trip devices, including manufacturer’s tolerance bands
5. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters
6. Conductor damage curves
7. Ground fault protective devices, as applicable
8. Pertinent motor starting characteristics and motor damage points
9. Pertinent generator short-circuit decrement curve and generator damage point
10. Equipment control panels.
11. Other system load protective devices for the largest branch circuit and the largest feeder circuit breaker in each motor control center

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

2.5 Arc Flash Hazard Analysis

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2015, Annex D.

B. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model.

C. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and equipment control panels) where work could be performed on energized parts.

D. The Arc-Flash Hazard Analysis shall include all MV, 480V locations and significant locations in 240V and 208V systems fed from transformers equal to or greater than 45 kVA.

E. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm^2.

F. The Arc Flash Hazard analysis shall include calculations for maximum and minimum contributions of fault current magnitude. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume a minimum motor load. Conversely, the maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

G. Arc flash computation shall include both line and load side of main breaker calculations, where necessary.

H. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2.

2.6 Report Sections

A. Input Data:
   1. Short-circuit reactance of rotating machines with associated X/R ratios
   2. Conductor type, construction, size, # per phase, length, impedance and conduit type
   3. Bus duct type, size, length and impedance
   4. Transformers
   5. Reactor impedance and continuous ampere rating
   6. Aerial line type, construction, conductor spacing, size, # per phase and length
   7. Circuit resistance and reactive values

B. Short-Circuit Data:
   1. Utility three-phase and line-to-ground available contributor with associated x/R ratios
   2. Source fault impedance and generator contributions
   3. X to R ratios
   4. Asymmetry factors
5. Motor contributions
6. Short circuit kVA
7. Symmetrical and asymmetrical fault currents

C. Recommended Protective Device Settings

1. Phase and Ground Relays:
   a. Current transformer ratio
   b. Current setting
   c. Time setting
   d. Instantaneous setting
   e. Specialty non-overcurrent device settings
   f. Recommendations on improved relaying systems, if applicable
2. Circuit Breakers:
   a. Adjustable pickups and time delays (long time, short time, ground)
   b. Adjustable time-current characteristic
   c. Adjustable instantaneous pickup
   d. Recommendations on improved trip systems, if applicable

D. Incident Energy and Flash Protection Boundary Calculations

1. Arcing fault magnitude
2. Device clearing time
3. Duration of arc
4. Arc flash boundary
5. Working distance
6. Incident energy
7. Hazard risk category
8. Recommendation for arc flash energy reduction

PART 3 - EXECUTION

3.1 Field Adjustment

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the engineering service division of the equipment manufacturer under the startup and acceptance testing contract portion.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify owner in writing of any required major equipment modifications.

D. Following completion of all studies, acceptance testing and startup by the field engineering service division of the equipment manufacturer, a 2-year warranty shall be provided on all components manufactured by the engineering service parent manufacturing company.

3.2 Arc Flash Warning Labels

A. The vendor shall provide a 3.5 in. X 5 in. Thermal transfer type label of high adhesion polyester for each work location analyzed.

B. The label shall have a header with the wording, orange header - "Warning, Arc Flash Hazard" or red header - "Danger Arc Flash Hazard", and shall include the following information:
   1. Location designation
2. Nominal voltage  
3. Flash protection boundary  
4. Hazard risk category  
5. Incident energy  
6. Working distance  
7. Engineering report number, revision number and issue date  

C. Labels shall be machine printed, with no field markings.  

D. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.  

1. For each 480 and applicable 208 volt panelboards and disconnects and equipment control panel, one arc flash label shall be provided.  
2. For each motor control center, one arc flash label shall be provided on each side in door/panel.  
3. For each low voltage switchboard, one arc flash label shall be provided on each front and rear door.  
4. For each switchgear, one arc flash label shall be provided on each front and rear panel.  
5. For medium voltage switches one arc flash label on each front and rear door shall be provided.  

E. Labels shall be field installed by the Engineering Service Division of the equipment manufacturer or the Engineering Service company.  

END OF SECTION
26 09 23  LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 Lighting control devices are identified on the drawings per legend symbols or as specifically noted. Catalog numbers from acceptable manufacturers for the common wiring devices shall be as listed herein. Catalog numbers are not listed for all devices. Other devices, such as key switches, clock hanger outlets, etc. shall be furnished by one of the manufacturers listed and shall be equal in quality to the device series listed.

1.2 When shop drawings are required for wiring devices the submittal shall be comprehensive for all wiring device configurations listed in the legend and for devices specifically noted on the drawings, including wall box dimmers, occupancy sensors and load control relays.

PART 2 - PRODUCTS

2.1 Toggle type AC switches shall be listed by Underwriters Laboratories, Inc. Switches shall be 20 ampere, 120/277 volt AC and ivory (select color) in color unless noted otherwise.

<table>
<thead>
<tr>
<th>Acceptable Manufacturer</th>
<th>General Purpose</th>
<th>Red Pilot</th>
<th>Illuminated Handle</th>
<th>Momentary</th>
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<td>PS20AC2 RPL series</td>
<td>20AC1 SL series</td>
<td>1251 series</td>
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2.2 Ceiling/Wall Mount Occupancy Sensor

A. Sensor shall be dual technology to detect human presence in controlled area by ultrasound and passive infrared. Dual sensing with both technologies must occur to activate lighting system. Sensor to be fully adaptive with self-adjusting and self-calibration.

B. Sensor shall have signal processing to respond to only those signals caused by human motion. Sensor to operate instantly for room motion and time off delay adjustable for 5 – 30 minutes. Sensor to be equipped with a walk-thru mode.

C. Sensor area coverage to be minimum of 1000 SF for one sensor. Provide multiple sensors where needed for space coverage.

D. Sensor shall have provisions for manual-off function for lighting circuit from remote momentary switch (reset when not occupied) or maintained (off override).

E. Provide an additional single-pole, double throw isolated contact with each power pack for remote interface.

F. Provide in ceiling mounted sensor where noted on drawings.

G. Power pack for remote mounting to match occupancy sensor.

H. Verify color with Architect.

I. All components to have 5-year warranty.

J. Manufactured by Watt-Stopper, Greengate (Cooper Controls), Hubbell Control Solutions, Leviton, Sensor Switch or Lutron.
2.3 Wall Switch Occupancy Sensor (Small Offices and similar room w/single entry door)

A. Switching w/manual and automatic control. Sensor shall use PIR sensing and shall have photocell/daylight override, vandal resistant lens. Sensor to be fully adaptive with self-adjusting and self-calibration.

B. Switches to provide two level and incorporate two dedicated relays in addition to the manual switches.

C. Verify color with Architect.

D. All components to have 5-year warranty.

E. Manufactured by Watt Stopper, Greengate (Cooper Controls), Hubbell Control Solutions, Leviton, Sensor Switch or Lutron.

2.4 Electronic Low Voltage (0 – 10V) Dimmer

A. General Requirements

1. Utilize air gap off, activated when user selects "off" to disconnect the load from line supply.
2. Operates at the rated capacity across the full ambient temperature range including modified capacities for ganged configurations which require removal of fins.
3. Provide radio frequency interference suppression.
4. Surge Tolerance: Designed and tested to withstand surges of 6,000 V, 200 amps according to IEEE C62.41.2 without impairment to performance.
5. Dimmers: Provide full range, continuously variable control of light intensity.
6. Dimmers for Electronic Low Voltage (ELV) Transformers:
   a. Provide circuitry designed to control the input of electronic (solid-state) low voltage (ELV) transformers. Do not use dimmers that utilize standard phase control.
   b. Provide resettable overload protection that provides automatic shut-off when dimmer capacity is exceeded. Do not use protection methods that are non-resettable or require device to be removed from outlet box.
   c. Designed to withstand a short, per UL 1472, between load hot and either neutral or ground without damage to dimmer.
7. Fluorescent Dimmers:
   a. Provides direct control of fluorescent dimming ballasts up to the ballast manufacturer's specified rating.

B. Preset Smart Wall Dimmers and Switches:

1. Dimmer Control: Multi-function tap switch with raised rocker for dimmer adjustment.
   a. Rocker raises/lowers light level, with new level becoming the current preset level.
   b. Switch single tap raises lights to preset level or fades lights to off.
   c. Switch double tap raises light to full on level.
   d. Switch tap and hold slowly fades lights to off over an extended period.
   e. LEDs adjacent to tap switch indicate light level when dimmer is on, and function as locator light when dimmer is off.
   f. Preset Smart Dimmer: 3-wire fluorescent ballast/LED driver (6 A, 120 V); multi-location capability using companion dimmers (up to nine companion dimmers may be connected); minimum load requirement.
   g. Companion Dimmer: Provides multi-location capability for compatible dimmers.

C. Preset Smart Wall Dimmers and Switches with Wireless Communication Inputs:
1. Communicates via radio frequency with up to nine compatible occupancy/vacancy sensors and/or wireless control stations, and one daylight sensor.

2. Dimmer Control: Multi-function tap switch with small, raised rocker for dimmer adjustment.
   a. Rocker raises/lowers light level, with new level becoming the current preset level.
   b. Switch single tap raises lights to preset level or fades lights to off.
   c. Switch double tap raises light to full on level.
   d. Switch tap and hold slowly fades lights to off over period of 10 seconds.
   e. LEDs adjacent to tap switch indicate light level when dimmer is on, and function as locator light when dimmer is off.

D. Dimmer shall be rated for the wattage it is supplying. Contractor shall coordinate lighting load on each respective dimmer and provide properly rated dimmer accordingly (600w to 1000w).

E. Contractor is responsible to coordinate the dimmer with each lighting manufacturer and verify that dimmer is compatible and capable of controlling lighting loads/fixtures from fixture manufacturer being supplied on the job.

F. Verify color of dimmer with architect prior to ordering.

G. Dimmer shall control loads down to 1%.

H. 0-10V electronic digital dimmer shall be Lutron Skylark Contour, Leviton IllumaTech, Hunt Simplicity, Cooper Slide, Watt Stopper Architectural or approved equal.

2.5 Provide a device plate to suit each particular application. Cover all empty outlet boxes with a blank plate. Coverplates shall be manufactured by Pass and Seymour, Hubbell, Cooper, Bryant, Leviton or Mulberry; Taymac is an acceptable manufacturer for weatherproof non-metallic coverplates Multi-Mac Series, “While-In-Use” type, 3.5 inches depth, opaque grey, locking tab marked “EXTRA Duty.”

2.6 In finished spaces, wall plates shall be nominal .032 inch thick, made of 302 high nickel stainless steel with brushed satin finish and beveled edges. Screws shall be metal with countersunk heads and finished to match plates. Sectional plates will not be permitted.

2.7 Installations consisting of three or more wall switches or wall box dimmers mounted together with either separate coverplates or a common coverplate shall have each coverplate engraved so as to identify the circuits or fixtures being controlled by each switch or dimmer. Refer to the drawings for special instructions.

PART 3 - EXECUTION

3.1 Locate devices as shown on the drawings, coordinate exact location with other trades, to avoid interference. Check for potential interference from door swings, cabinets, HVAC equipment and other wall mounted devices.

3.2 Clean debris from device boxes prior to installation of devices. Adjust devices and coverplates to be flush and level.

3.3 Wiring Installation

A. Lighting control low voltage wiring shall be furnished and installed in accordance with manufacturer’s recommendations in compliance with all Local, State and National codes. This Contractor shall be responsible for furnishing and installing all required cabling between components to form a complete and operational system meeting all the requirements of this specifications.
B. Provide firestop material and seal all cable penetrations as required.

C. All wiring shall be organized and run parallel or perpendicular to building lines above ceilings. Provide all required cable management systems such as J-hooks to support wiring to meet building codes and manufacturer’s recommendations.

D. Cables shall not be laid upon ceilings, structure or equipment or supported in a manner that would violate any codes or standards.

E. All cabling installed in accessible ceiling spaces shall be UL plenum rated.

F. All control and signal cable shall be installed continuous and without splices. Provide appropriate connectors or pre-manufactured cables for each application.

3.4 Identification/Labeling

A. Contractor shall identify all major items of equipment and tag all cables with permanent type markers to denote equipment served. Cables shall be tagged at both ends and at each point where the cable is administered.

3.5 Occupancy Sensor Installation

A. Verify location of occupancy sensor(s) with selected manufacturer prior to rough-in to minimize false activation of the device. Locate sensor and adjust activation field to avoid nuisance activation by movement outside of the controlled space. Sensors shall sense any human motion in the space and allow turn on with entrance into the space.

B. Provide all material and labor for a complete and operational system including power and slave packs, auxiliary relay modules and backboxes. Verify application voltage rating and provide proper rated devices.

C. Low voltage wiring can be open wired above accessible ceilings, utilize plenum rated cabling. Installation in exposed or inaccessible locations shall be installed in conduit.

D. Coordinate time delay off setting of each occupancy sensor with the Owner. Maximum time delay off shall be 30 minutes. Minimum off delay is 10 minutes for intermittent use spaces.

E. Maintain 6 feet (minimum) to 8 ft. distance from an HVAC air outlet.

3.6 Daylight Harvesting Installation and Commissioning

A. Prior to installation, during installation and after installation manufacturer shall coordinate proper mounting locations, aiming, set up, calibration, etc. of every device. At completion of project, manufacturer shall submit proof every device is calibrated and commissioned and in good working order.

B. Minimum of 2 hours of Owner training shall be provided by manufacturer’s representative on use of remote controls, low voltage wall switch, system components (accessible and concealed), maintenance and how to maximize energy savings. Submit outline and Owner signature sheet that this has been completed at completion of project.

C. Provide 2 spare photo sensors of each type used on project, 2 spare remotes and 2 spare multi-channel dimming controllers/power packs used on the project. Submit proof of spares turnover to Owner with O&M Manuals.

3.7 Emergency Lighting Control Relay Installation
A. Install per manufacturer’s instructions. System operation to be connected to be operable at all times.

B. Provide all material and labor for a complete and operational system including verify voltage rating and provide properly rated devices.

C. Emergency and normal circuits are to be identified on relay or box cover.

D. Verify operation for each operating condition.

3.8 Functional Testing – Lighting control devices and control systems shall be tested to ensure that control hardware and software are calibrated, adjusted, programmed, and in proper working condition in accordance with the construction documents and manufacturer’s installation instructions. When occupant sensors, time switches, programmable schedule controls, or photosensors are installed, at a minimum, the following procedures shall be performed:

A. Occupant Sensors

1. Certify that the sensor has been located and aimed in accordance with manufacturer recommendations.
2. For projects with up to seven (7) occupancy sensors, all occupancy sensors shall be tested.
3. For projects with more than seven (7) occupancy sensors, testing shall be done for each unique combination of sensor type and space geometry.
   a. For each sensor to be tested, verify the following:
      1) Status indicator (as applicable) operates correctly
      2) Controlled lights turn off or down to the permitted level within the required time
      3) For auto-on occupant sensors, the lights turn on to the permitted level when someone enters the space
      4) For manual-on sensors, the lights turn on only when manually activated
      5) The lights are not incorrectly turned on by movement in nearby areas or by HVAC operation

B. Automatic Time Switches

1. Confirm that the automatic time-switch control is programmed with appropriate weekday, weekend, and holiday (as applicable) schedules.
2. Document for the owner automatic time-switch programming, including weekday, weekend, and holiday schedules, as well as all setup and preference program settings.
3. Verify that correct time and date are properly set in the time switch.
4. Verify that any battery backup (as applicable) is installed and energized.
5. Verify that the override time limit is set to no more than two (2) hours.
6. Simulate occupied condition. Verify and document the following:
   a. All lights can be turned on and off by their respective area control switch.
   b. The switch only operates lighting in the enclosed space in which the switch is located.
7. Simulate unoccupied condition. Verify and document the following:
   a. All nonexempt lighting turns off
   b. Manual override switch allows only the lights in the enclosed space where the override switch is located to turn on or remain on until the next scheduled shut off occurs

C. Daylight Controls

1. All control devices (photocontrols) have been properly located, field-calibrated, and set for appropriate setpoints and threshold light levels.
2. Daylight controlled lighting loads adjust to appropriate light levels in response to available daylight.
3. The location where calibration adjustments are made is readily accessible only to authorized personnel.

D. Testing shall be performed by equipment supplier. Provide report certifying operation and performance level to Engineer.

3.9 Training Requirements

A. Provide all training and utilize specified manuals and record documentation. Training shall be provided to all Owner designated staff at the project site.

B. Demonstrate adjustment, operation and maintenance of the system including each component and control.

END OF SECTION
26 09 29  LOW VOLTAGE SWITCHING

PART 1 - GENERAL

1.1 Work includes a complete system of relays, devices and wiring to accomplish switching of lights and devices by means of low voltage wiring in lieu of line voltage switching.

PART 2 - PRODUCTS

2.1 System shall be manufactured by General Electric, Pass & Seymour or Touchplate.

2.2 Transformers shall be energy limiting type approved for Class II systems, rated 120/230 volt as required. G.E. catalog number RT1 or approved equal.

2.3 Relays: Remote control relays shall have load contacts rated 1.50 HP, 250 volt AC; 20 amps, 120 volt AC. Relays shall be burnout proof, three wire, 24 volt split coil design. Relays shall be available with integral pilot light switches where specified. Relays shall be for mounting in 0.50 inch knockouts. G.E. catalog number RR 7, standard type or G.E. catalog number RR 8 pilot light relay or approved equal. Provide one spare relay in each relay cabinet.

2.4 Remote control switches shall be of the normally open, single pole, double throw type with center "off" position. Switches shall be momentary contact, having duty toggle type rated 3 amps, 24 volt AC/DC with color as indicated, flush mounted complete with matching coverplate.

2.5 Master selector switches shall have eight (8) individual on/off switches and directory. Incorporate master locking switch that can be used to lock out the control of any number of individual switches on master selector unit. These switches shall be mounted in a recessed cabinet.

2.6 Relays shall be mounted in flush steel cabinet equipped with suitable terminal strips as required for the connection of low and high voltage leads. In addition to relays required for installation, provide space for 25 percent additional relays for future use.

2.7 Low voltage wiring shall be multiconductor cable, minimum 20 gauge, 30 volt, teflon insulated type approved for use in air plenums; run cables above ceilings or in concealed conduit; support cables from structure do not lay on ceilings. Complete wiring systems shall be color coded and conductors shall be tagged or identified at terminals.

PART 3 - EXECUTION

3.1 Installation and wiring shall be in strict accordance with factory recommendations.

3.2 Functional Testing – Lighting control devices and control system shall be tested to ensure the control hardware is adjusted and in proper working condition. Testing shall be performed by the equipment supplier. Provide report to Engineer.

END OF SECTION
26 24 16  PANELBOARDS

PART 1 - GENERAL

1.1 Each panelboard shall comply with all applicable codes, recommended practices and standards of IEEE, NEMA and UL. Panelboard shall be UL labeled.

1.2 The panelboard manufacturer shall supply equipment which is rated, listed, and labeled for the available short circuit current and the fuse/circuit breaker combinations indicated in the fault current analysis.

PART 2 - PRODUCTS

2.1 Panelboard Types

A. 240 Volt (Maximum) AC Panelboards
   1. Breakers shall be “bolt-on” type and in sizes thru 100 amp shall be minimum 10,000 amp, I.C. rated with adequate rating to interrupt the available fault current, for a fully rated system.
   2. GFCI breaker – UL Class A (5 milliampere sensitivity, combination type). Ground fault circuit protection shall be an integral part of the branch circuit breaker which also provides overload and short circuit protection. Space required in panelboard shall be same as standard single pole circuit breaker.
   3. Panelboard by Square D Type “NQ”.

B. 277/480 Volt AC Panelboards
   1. Breakers shall be “bolt-on” type and in sizes thru 100 amps shall be minimum 14,000 amp I.C. rated with adequate rating to interrupt the available fault current; for a fully rated system.
   2. Panelboards by Square D type "NF”.

C. Circuit Breaker Distribution Panelboard
   1. Removable front with hinged door. Bussing braced for the available fault current; 1200 amp bussing and less.
   2. Main and branch breakers shall be solid state trip molded case type with long time, short time, instantaneous trip and Breakers shall be molded case type, thermal-magnetic protection, 80 percent rated.
   3. Power and distribution panelboards by Square D "I-Line”.

2.2 Refer to “Identification for Electrical System” Section 26 05 53, for nameplate requirements.

2.3 General Construction

A. Code gauge, galvanized steel tubs with minimum 4 inches clear gutters all sides. Minimum tub width 20 inches, depth 5 inches.

B. Locking type reinforced doors with concealed hinges; equipped with directory card holder on inside of door; enameled finish. Doors over 48 inches high shall have 3 point latch and vault locks. All locks shall be master keyed cylinder, keyed alike.

C. Provide door-in-door construction. Outer door to be mounted with piano hinge and include lock.
D. For service entrance panelboards, provide a barrier so no service terminals or bus bar is exposed when servicing load terminal.

E. Permanent individual breaker pole numbers affixed adjacent to each breaker in a uniform position consisting of a stamped metallic or painted numeral.

F. Bussing shall be copper.

G. Branch circuit panelboard tubs and fronts shall be sized to have 225 amp bussing and accommodate 42 poles unless indicated otherwise on the drawings. Furnish number of breakers shown.

H. A neutral bar assembly (when required) and separate ground bar assembly shall be provided. Each assembly shall be copper and have the adequate number of terminals, of sufficient size and type of anti-turn solderless lugs. Each assembly shall have conductor terminal screwdriver slots facing the front of the panel. Bond ground bar assembly to panel cabinet.

I. Terminals for feeder conductors to the panelboard mains, neutral, ground and branch circuit breaker wiring shall be suitable for the type of conductor specified.

J. Main or sub-feed breakers shall be provided where indicated. Shunt trip breakers where specified, shall have 120 volt coil and coil clearing contacts.

K. Circuit breakers shall be bolted on type and where more than one pole is used, they shall employ a common trip.

L. Breakers in panelboards used for switching of 120 and 277V. fluorescent lighting circuits shall be rated for switching duty UL "SWD" or "HID" type; for switching high-intensity discharge lighting shall be "HID" type.

M. Breakers used for protection of heating, air conditioning and refrigeration equipment shall be UL "HACR" type.

2.4 All panelboards serving life safety loads are to have a SPD connected to each panel. Provide branch circuit breaker and SPD refer to specification section 26 43 13 Surge Protective Devices.

2.5 The panelboards and breakers shall be adequately rated for the available fault current as indicated on the drawings and in the specifications. The total breaker and fuse short circuit and overcurrent protective system shall be U.L. Fully Rated System.

PART 3 - EXECUTION

3.1 Mount top of wall mounted cabinets 6 feet 0 inches above floor. Coordinate location of recessed panels so they are accessible and to avoid interference with other equipment and trades. Mount and anchor floor set panelboards on a 4 inch high concrete pad furnished by this Contractor.

3.2 The position of breakers in each panel shall be arranged in the field for sequence phasing by this Contractor to best suit wiring conditions and balancing of phases. Fill in, typewritten, the directory of each branch circuit panelboard.

3.3 For multi-wire branch circuit group circuit breaker together and provide breaker handle tie. Group conductors together with tie-wrap.

3.4 Adjust circuit breaker trip and time delay settings to values as indicated in the coordination study.

END OF SECTION
## PART 1 - GENERAL

1.1 Wiring devices are identified on the drawings per legend symbols or as specifically noted. Receptacles are identified in the legend by NEMA configuration numbers only. Catalog numbers from acceptable manufacturers for the common wiring devices shall be as listed herein. Catalog numbers are not listed for all devices. Other devices, such as clock hanger outlets, etc. shall be furnished by one of the manufacturers listed and shall be equal in quality to the device series listed.

1.2 When shop drawings are required for wiring devices and coverplates, the submittal shall be comprehensive for all wiring device configurations listed in the legend and for devices specifically noted on the drawings.

## PART 2 - PRODUCTS

2.1 Hospital extra hard use specification grade receptacles shall be so constructed as to meet or exceed hospital grade requirements of Underwriters Laboratories, Inc. Receptacles shall be minimum 20 ampere, 125 volt, NEMA configuration 5 20R and ivory in color unless noted otherwise. Each hospital grade receptacle must have an identifying green dot. Where identified on drawing that receptacle is controlled a device of same design to be furnished but with controlled symbol marking.

<table>
<thead>
<tr>
<th>Acceptable Manufacturer</th>
<th>Single</th>
<th>Duplex</th>
<th>Ground Fault</th>
<th>Isolated Ground</th>
<th>Tamper Resistant</th>
<th>TR Hosp. GFI</th>
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2.2 Receptacles installed in a damp or wet location shall be a listed weather-resistant (WR) type.

A. Receptacle shall be installed in a listed weatherproof enclosure, whether or not the attachable plug cap is inserted.

2.3 Provide GFCI devices as shown on drawings and in compliance with NEC 210.8 for type and location. Where GFCI receptacle devices not available at rating required a GFCI protection device to be provided. Bender Lifeguard series.

2.4 Tamper-Resistant Receptacles. All 15- and 20-ampere, 125- and 250-volt nonlocking-type receptacles in the following areas shall be listed tamper-resistant receptacles.

A. Dwelling units

B. Guest rooms and guest suites of hotels and motels

C. Child care facilities

D. Preschools and elementary education facilities

E. Business offices, corridors, waiting rooms and the like in clinics, medical and dental offices and outpatient facilities

F. Gymnasiums, skating rinks, auditoriums and airport waiting areas

G. Dormitories
2.5 Transient voltage surge suppressors (SPD-ANSI/IEEE Category A and B), UL 1449 suppression (clamping) rating of 400 V, 3 mode protection (LN/LG/NG) for 120 V branch circuits:

A. Duplex receptacles, 120 V, 20 A shall be LeGrand 5362-ISP, Hubbell HBL5362ISA, Leviton 5380-I, Bryant SP53-TIGIA or Eaton 5350S. Receptacle to be listed UL 1449 Type 3.

B. Suppression strip with a heavy duty 6 ft. 14-2 AWG power cord, 6 electrical NEMA 5-15R 120V, 15 A outlets, computer grade on/off 20 A switch, resettable circuit breakers, internal thermal fusing, hybrid suppression circuit and comprehensive diagnostics. Strip to be listed UL 1449 Type 3.

EFI Electronics Corp. - Model 453 (15 A Overload Protection)
Wiremold Sentrex "High Performance" - Model M6S (10 A Overload Protection)
Joslyn Electronic Systems - Model 1203-03 (15 A Overload Protection)
Pass and Seymour - Model PS7 (15 A Overload Protection)
Hubbell Model HBL6PS350A (15A Overload Protection)
Leviton Model 5300

2.6 Provide a device plate to suit each particular application. Cover all empty outlet boxes with a blank plate. Coverplates shall be manufactured by Pass and Seymour, Hubbell, Cooper, Bryant, Leviton or Mulberry; Taymac is an acceptable manufacturer for weatherproof non-metallic coverplates Multi-Mac Series, “While-In-Use” type, 3.5 inches depth, ‘Extra Duty’, opaque grey, locking tab. Provide jumbo size plates for outlets installed in masonry walls.

2.7 In finished spaces, wall plates shall be nominal .032 inch thick, made of 302 high nickel stainless steel with brushed satin finish and beveled edges. Screws shall be metal with countersunk heads and finished to match plates. Sectional plates will not be permitted.

2.8 Coverplates for telephone and other communication system outlets shall be a blank coverplate or shall have a 0.625 inch diameter grommeted opening unless indicated otherwise on the drawings or in the respective communication system specifications. Color and material of plates shall match plates provided for other wiring devices (for 302 stainless steel, 0.625 inch I.D. grommet in 0.875 inch hole, strap mounted; two gang equal to P & S Sierra #S 788N).

PART 3 - EXECUTION

3.1 Locate devices as shown on the drawings, coordinate exact location with other trades, to avoid interference. Check for potential interference from door swings, cabinets, heating equipment and other wall mounted devices.

3.2 Clean debris from outlet boxes.

3.3 Install receptacles with grounding pole on top.

3.4 Verify each receptacle device is energized and test each device for proper polarity.

3.5 Adjust devices and wall plates to be flush and level.

END OF SECTION
26 28 16 DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 Provide disconnect switches, fused and non-fused, where indicated on the drawings and in the specifications, and where required by the NEC.

PART 2 - PRODUCTS

2.1 Disconnect switches shall be listed by Underwriter's Laboratories and shall be manufactured by Square D, Siemens, G.E. or Eaton. All starters and disconnect switches shall be of the same manufacturer unless otherwise approved.

2.2 Switches shall be Heavy-Duty Type, NEMA 1 enclosures, non-fused except where fuses are specified or required to protect wiring from overload; provide raintight NEMA 3R type enclosures for outdoor applications unless otherwise noted.

2.3 Disconnect switches shall be quick-make, quick-break, externally operated with door interlocked with operating handle. Provide solid neutral and ground bars where indicated or where required by the application.

2.4 Disconnect switches shall have multiple padlock provisions in the off position.

2.5 The fuse holders shall be designed for Class "R" rejection type fuses.

2.6 Refer to "Identification for Electrical Systems" Section for nameplate requirements.

PART 3 - EXECUTION

3.1 Mount top of wall mounted disconnect switch 6 ft.-0 inches above floor where space permits.

3.2 Coordinate location of disconnect switches to avoid interference with other equipment and trades and allow access for safe operation.

END OF SECTION
26 51 13  INTERIOR LUMINAIRES, LAMPS AND BALLASTS

PART 1 - GENERAL

1.1 Refer to schedule on the drawings for information on luminaires, lamps and manufacturers. Luminaires of manufacturers other than those listed, if offered, shall be on a substitute basis and so listed as a substitute with the bid. (Refer to Section 26 05 01, para. 2.4 B.)

1.2 The catalog numbers listed on the schedule do not necessarily have complete prefix and suffix designations for placing the luminaire order. The Contractor shall verify these numbers and include in his bid the necessary plaster frames, accessories, trim, mounting hardware, etc. to achieve a coordinated installation with ceiling types indicated on the architectural drawings and in specifications. The Contractor shall provide any hardware indicated by notes on the fixture schedule.

1.3 Luminaires, ballasts and individual components shall bear UL label. All ballasts including compact fluorescents shall be high efficiency and high-power factor (HPF).

1.4 Where luminaires are installed in fire rated ceilings the following methods may be utilized: fire rated light covers, fire boxes or custom-built boxes. Detail of method shall be submitted.

1.5 Submittals

A. Detailed cut sheets for all LED luminaire complete assembly shall be submitted for approval with shop drawings. Identifying pertinent information such as the manufacturer, frequency operation, THD, crest and ballast factor, reset thermal protection, etc. Also, submit emergency battery ballast cut sheets for review. Shop drawings will be rejected if required information is not submitted.

B. Submittals shall include dimensions, ratings, performance data and components of each luminaire. Where indicated on schedule, submit two (2) color chips illustrating luminaire finish color.

PART 2 - PRODUCTS

2.1 LED Luminaires Components

A. LED Luminaires

1. LED luminaire shall be rated for an installation/ambient temperature from -40 degrees C to +40 degrees C.
2. LED luminaire shall be modular in design (when applicable per the basis of design) with the ability to replace drivers, light engines, arrays, optics, reflectors, etc., without having to replace the entire luminaire.
3. The heat sink shall be easily accessible for maintenance or cleaning to maintain the overall thermal performance of the luminaire within specifications. The light engine and driver shall be easily accessible for maintenance.
4. LED luminaire (type V distribution) shall have an even distribution of luminous intensity within the 0 degree to 90 degree zone. Luminous intensity at any angle within this zone shall not differ from the mean luminous intensity for the entire 0 degree to 90 degree by more than 10 percent.
5. Exterior LED luminaire shall be full cutoff or fully shielded as defined by IESNA-RP-8.
6. LED luminaire shall come standard with the ability for full dimming. When luminaire is to be powered by generator for emergency operation the luminaire is to be UL 924 listed.
7. LED Luminaire shall have a minimum of 5 year warranty.
B. LED/LED Module

1. LED/LED Module(s) shall be manufactured by:
   a. Nichia
   b. Cree
   c. Achriche
   d. Phillips
   e. Osram/Sylvania
   f. Approved Equal (By Engineers approval)
2. LEDs shall be of the highest production quality.
3. LED/LED Module shall be rated for 50,000 hours of life at 70 percent output (L70) and shall have been tested in accordance with IESNA LM-79, LM-80, and TM-21.
4. LED/LED Module manufacturers shall adhere to LED package manufacturer guidelines, certification programs, and test procedures for thermal management.
5. LED/LED Module(s) shall be rated for a minimum luminous efficacy of 80 Lumens per Watt (lm/W).
7. LED/LED module shall have a minimum CRI of 70. High CRI where noted shall be minimum 85 (sample R1 – R8) with sample R9 minimum 80.
8. LED/LED Module(s) shall have one of the following designated CCTs (Correlated Color Temperature) per ANSI C78.377-2008 and all within the 7-step chromaticity quadrangles as defined below:
   a. 2700 K
   b. 3000 K
   c. 3500 K
   d. 4100 K
   e. 5000 K
9. LED/LED Modules shall originate from a common manufactured batch source.
10. Contractor shall provide 5 percent of each module specified as spare in original sealed packaging and transport to the Building (and put in storage) as directed by the Owner.

C. LED Driver

1. The driver shall have 50,000 hrs. of anticipated/rated life. Minimum efficiency of 85 percent at full load conditions.
2. UL 8750 approved.
3. Driver shall meet UL Class 2 for use in dry or damp location.
5. Driver shall have inherent short-circuit protection, self-limited, overload protected. (UL 1449)
6. Driver shall have a Class A sound rating.
7. Driver rated for 100 to 277 volt input. Power factor .90 or higher.
8. All drivers shall provide full LED dimming range. The drivers in every LED fixture shall have the capability to be dimmable, whether indicated to be dimmed or not on the drawings. When luminaire is to be powered by generator for emergency operation the driver is to be UL 924 listed.
9. Driver shall have a minimum of 5 year warranty.
10. Contractor shall provide 5 percent of each driver specified as spare in original sealed packaging and transport to the building (and put in storage) as directed by the Owner.

D. The complete LED luminaire assembly shall be of the latest and highest efficacy design available.

E. The LED luminaire assembly shall be Design Lights Consortium (DLC) approved.

2.2 Battery Powered Exit and Emergency Lighting Luminaires
A. Each unit shall consist of a battery, lights, lamps, automatic controls and connection to the lighting circuit ahead of all switches. Operation shall be such that the battery is maintained constantly charged under normal conditions; upon a loss of normal power, the light shall be switched on and the operating current obtained from the battery.

B. Units shall be UL labeled. Refer to drawings for mounting, capacity and manufacturer.

C. Fasten battery operated exit and emergency lighting units to wall or ceiling using factory-furnished bracket and make rear concealed electrical connection.

D. Electric source shall be from unswitched active lighting circuits only, to ensure that battery will be charged from an active circuit.

2.3 LED AC/Emergency Driver Units – Battery Type

A. Emergency lighting shall be UL listed and labeled and shall be provided by using standard LED luminaires equipped with a self-contained mounted battery-inverter power pack. Furnish and install with each designated luminaire a power pack unit to operate one lamp assembly upon loss of normal power. Initial output rating shall be minimum 3.1 watt. Warranty shall be 5 years from date of acceptance.

B. Emergency operation shall be fully automatic with the power pack unit capable of driving the selected lamp at rated output for a minimum of 90 minutes with a lumen depreciation no greater than 35 percent.

C. Power pack units shall include a sealed maintenance-free nickel cadmium battery, a Solid-state charger, an automatic transfer circuit, a low voltage battery disconnected circuit and a high frequency inverter. An accessible test switch and AC “on” pilot light shall be installed in the fixture and require no field wiring.

D. The power pack’s inverter electronics and battery driver shall, without requiring modification, be compatible with standard driver and lamp assembly supplied and shall not affect normal luminaire operation and shall be used with either a switched or unswitched luminaire. Connect to an unswitched hot leg for either base for charging/loss of power.

E. Provide remote test switch for installation where indicated on plan or where routine testing would be difficult due to luminaire location or accessibility. This option shall consist of a pushbutton test switch and AC “on” pilot light mounted on a white nylon single gang switch plate.

F. LED type inverter units shall be Dual Lite or equal by Chloride, Siltron, Power Sentry, Bodine, Side Lite or IOTA Engineering Company.

PART 3 - EXECUTION

3.1 Luminaire Hanging and Supporting

A. Support each surface mounted or suspended luminaire in a minimum of two locations. In addition, where luminaires are in a continuous row, they shall be fastened together on each end in two places. For suspended luminaires provide pendant length required to suspend luminaire at indicated height.

B. Recessed luminaires shall be supported at all four corners. Additionally, securely fasten each luminaire to the ceiling framing member by mechanical means such as bolts, screws, rivets or approved clips; install a minimum of one on each of the four sides of luminaire. This Contractor shall coordinate luminaire locations and luminaire weight with the trade installing
the ceiling system to ensure adequate hangers are installed to support the weight of the ceiling plus twice the weight of each luminaire.

C. Surface or flush luminaires in ceilings of the suspended lay in type shall be installed so that the long dimension of the luminaire is supported on the main support members of the ceiling system.

D. In addition, all recessed LED luminaires for lay in ceilings shall be equipped with at least two galvanized steel safety support wires, or chains, attached from the luminaire housing to the structure independent of the ceiling system; hangers supporting ceiling system shall not be used.

E. Do not support light fixtures directly from light weight roof decks. Provide supplemental angle iron support as required. Do not connect to bottom cord of roof joist without supplemental angle iron ties to the upper cord of joist.

F. For wall mounted exterior luminaires include gasketed cast junction box.

G. Wire battery powered emergency fixtures to circuit which is constantly on. For lamps in fixtures which are switched the charging / sensing circuit shall be extended from ahead of room switch.

3.2 Alignment and Cleaning

A. Luminaires shall be mounted straight, level and true to the building lines. Warped or damaged luminaires shall be replaced or repaired to the satisfaction of the Architect and Owner.

B. Immediately preceding the final inspection, this Contractor shall thoroughly clean all luminaires of dust, dirt, grease, fingermarks, etc. All lamps shall be operating at the time of Owner's acceptance.

C. Coordinate location of luminaires carefully with the Architectural reflected ceiling plan. Verify that no surface mounted luminaire interferes with door swings.

1. Coordinate locations of luminaires with mechanical ducts, sprinkler pipes/heads, smoke alarms and fire alarm devices prior to rough-in to prevent conflicts.

2. Where reflected ceiling plans indicate a larger quantity of luminaires than that shown on the electrical drawings for a particular space, the reflected ceiling plan shall be followed for that space.

D. Adjust all adjustable fixtures to the satisfaction of the Engineer and the Owner.

3.3 Turn over spare LED components to Owner.

END OF SECTION
26 52 00  EXIT AND EMERGENCY LIGHTING

PART 1 - GENERAL

1.1 Exit lighting and emergency lighting system wiring shall be run in conduit system which is completely independent of normal wiring systems.

1.2 Equipment to transfer power from a normal source to an emergency source are to be listed and labeled for load transfer.

PART 2 - PRODUCTS

2.1 Exit lights with battery to have sealed, maintenance free nickel-cadmium battery which delivers 90 minutes capacity to emergency lamps. Test switch provides manual activation of 30-second diagnostic testing for visual inspection. Where noted for self-diagnostic testing fixture to operate 30 seconds every 30 days and 90 minutes annually. Performing diagnostic of LED light source, AC to DC transfer, charging and battery condition.

2.2 Battery powered emergency light. Unit to include test switch, status indicator, and rechargeable battery. Maintenance-free nickel cadmium to provide 90 minutes of emergency power. Charger to have two charge rates and automatically recharges after battery discharge. A low voltage disconnect to prevent battery damage from deep discharge. (Self-diagnostics testing, where noted, operates 30 seconds every 30 days and 90 minutes once annually. Lights to indicate diagnostic evaluation of LED light source, AC to DC transfers, charging and battery condition.)

PART 3 - EXECUTION

3.1 All circuits shall have dedicated neutral conductor.

3.2 Adjust coverage of occupancy sensors and dimming control.

3.3 Test system operation for full 90 minutes witnessed by the AHJ. Provide report of required corrections, of any.

3.4 Batteries shall carry a five year warranty.

END OF SECTION