MECHANICAL INDEX

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SECTION 200100 - GENERAL PROVISIONS - MECHANICAL

1. GENERAL

A. The Advertisement for Bids, Instructions to Bidders, Bidding Requirements, General, Special and Supplementary Conditions, and all other contract documents shall apply to the Contractor's work as well as to each of his Sub-Contractor's work. All manufacturers, suppliers, fabricators, contractors, etc. submitting proposals to any part if for work, services, materials or equipment to be used on or applied to this project are hereby directed to familiarize themselves with all documents pertinent to this Contract. In case of conflict between these General Provisions and the General and/or Special Conditions, the affected Contractor shall contact the Engineer for clarification and final determination.

B. The work included in this division consists of the furnishing of equipment, material, appurtenances and services necessary for the satisfactory installation of the complete and operating Mechanical System(s) indicated or specified in the Contract Documents.

C. Any materials, labor, equipment or services not mentioned specifically herein which may be necessary to complete or perfect any part of the Mechanical Systems in a substantial manner, in compliance with the requirements stated, implied or intended in the drawings and/or specifications, shall be included as part of this Contract.

D. It is the intent of this Contract to deliver to the Owners a "like new" project once work is complete. Although plans and specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing or new systems which interfere with new equipment or materials required for the complete installation without additional cost to the Owner.

E. Definitions and Abbreviations

(1) Contractor - Any Contractor whether proposing or working independently or under the supervision of a General Contractor and/or Construction Manager and who installs any type of mechanical work (Controls, Plumbing, HVAC, Sprinkler, Gas Systems, etc.) or, the General Contractor.

(2) Engineer - The Consulting Mechanical-Electrical Engineers either consulting to the Owners, Architect, other Engineers, etc. In this case: CMTA, Inc., Consulting Engineers.

(3) Architect - The Architect of Record for the project.

(4) Furnish - Deliver to the site in good condition and turn over to the Contractor who is to install.

(5) Provide - Furnish and install complete, tested and ready for operation.

(6) Install - Receive and place in satisfactory operation.

(7) Indicated - Listed in the Specifications, shown on the Drawings or Addenda thereto.
(8) Typical - Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.

(9) Contract Documents - All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, Instructions to Bidders, General and Special Conditions, Addenda, Alternates, Lists of Materials, Lists of Sub-Contractors, Unit Prices, Shop Drawings, Field Orders, Change Orders, Cost Breakdowns, Schedules of Value, Periodical Payment Requests, Construction Contract with Owners, etc.

(10) Proposer - Any person, agency or entity submitting a proposal to any person, agency or entity for any part of the work required under this contract.

(11) OSHA - Office of Safety and Health Administration.

(12) KBC - Kentucky Building Code.

(13) The Project - All of the work required under this Contract.

(14) NEC - National Electrical Code.


(16) ASME - American Society of Mechanical Engineers.

(17) AGA - American Gas Association.

(18) SMACNA - Sheet Metal and Air Conditioning Contractors National Association.


(20) ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers.

(21) NEMA - National Electrical Manufacturers Association.

(22) UL - Underwriters Laboratories.

(23) ADA - Americans with Disabilities Act.

(24) IMC - International Mechanical Code.


(26) IFGC - International Fuel Gas Code.

F. Required Notices:

(1) Ten days prior to the submission of a proposal, each proposer shall give written notice to the Engineer of any materials or apparatus believed inadequate or unsuitable; in violation of laws,
ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted. In the absence of such written notice, Proposers signify that they have included the cost of all required items in the proposal and that the Proposer will be responsible for the safe and satisfactory operation of the entire system.

2. INTENT

A. It is the intention of the Contract Documents to call for finished work, tested and ready for operation.

B. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

C. This project is a phased construction in an occupied building. The Construction Documents include Phasing Plans which roughly lay out the sequence of the work. The Contractor may suggest alternate schedules that improve the overall phasing and decrease the duration or limit outages. The Owner and Engineer will review any proposed schedule and determine if it is acceptable.

3. DRAWINGS AND SPECIFICATIONS

A. The drawings are diagrammatic only and indicate the general arrangement of the systems and are to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with the work. The drawings are not intended to show every item which may be necessary to complete the systems. All proposers shall anticipate that additional items may be required and submit their bid accordingly.

B. The drawings and specifications are intended to supplement each other. No Proposer shall take advantage of conflict between them, or between parts of either. Should this condition exist, the Proposer shall request a clarification not less than twelve days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.

C. The drawings and specifications shall be considered to be cooperative and anything appearing in the specifications which may not be indicated on the drawings or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.

D. Contractor shall make all his own measurements in the field and shall be responsible for correct fitting. He shall coordinate this work with all other branches of work in such a manner as to cause a minimum of conflict or delay.

E. The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.

F. Should conflict or overlap (duplication) of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume that he is to be relieved of the work which is specified under his branch until instructions in writing are received from the Engineer.
G. Unless dimensioned, the mechanical drawings only indicate approximate locations of equipment, piping, ductwork, etc. Dimensions given in figures on the drawings shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to ensure no conflict with other work.

H. Each Proposer shall review all drawings to ensure that the work he intends to provide does not encroach a conflict with or affect the work of others in any way. Where such effect does occur, it shall be the Proposer's responsibility to satisfactorily eliminate any such encroachment conflict or effect prior to the submission of his proposal. Each Proposer shall in particular ensure that there is adequate space to install his equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded the proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to ensure adequate spaces.

I. Where on the drawings a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.

J. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

K. Where on the Drawings or Addenda the word typical is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.

L. Special Note: Always check ceiling heights indicated on Architectural Drawings and Schedules and ensure that they may be maintained after all mechanical and electrical equipment is installed. Do not install equipment in the affected area until the conflict is resolved.

4. EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS

A. When any Contractor requests approval of materials and/or equipment of different physical size, capacity, function, color, access, it shall be understood that such substitution, if approved, will be made without additional cost to anyone other than the Contractor requesting the change regardless of changes in connections, space requirements, electrical characteristics, electrical services, etc., from that indicated. In all cases where substitutions affect other trades, the Contractor requesting such substitutions shall advise all such Contractors of the change and shall remunerate them for all necessary changes in their work. Any drawings, Specifications, Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense. Review of Shop Drawings by the Engineers does not in any way absolve the Contractor of this responsibility.

B. Notwithstanding any reference in the specifications to any article, device, product, material, fixture, form, or type of construction by name, make or catalog number, such reference shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition; any devices,
products, materials, fixtures, forms, or types of construction which, in the judgment of the Engineer, are equivalent to those specified are acceptable, provided the provisions of Paragraph (A) immediately preceding are met. Requested substitutions shall be submitted to the Engineer a minimum of twelve days prior to bids.

C. Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the Engineers.

D. Each Proposer shall furnish along with his proposal a list of specified equipment and materials which he is to provide. Where several makes are mentioned in the specifications and the Contractor fails to state which he proposes to furnish, the Engineer shall choose any of the makes mentioned without change in price. Inclusion in this list shall not ensure that the Engineers will approve shop drawings unless the equipment, materials, etc., submitted in shop drawings is satisfactorily comparable to the items specified and/or indicated.

5. CORRECTION PERIOD

A. All equipment, apparatus, materials, and workmanship shall be the best of its respective kind. The Contractor shall replace all parts at his own expense, which are proven defective as described in the General Conditions. The effective date of completion of the work shall be the date of the Engineer's Statement of Substantial Completion. Items of equipment which have longer guarantees, as called for in these specifications, shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall not invalidate the guarantee except that the Owner shall be liable for any damage to equipment during this period, due to negligence of his operator or other employees. Refer to other sections for any special or extra warranty requirements.

B. It is further clarified that all required and specified warranties shall begin on the date of Substantial Completion, not at the time of equipment start-up.

6. CHANGES IN MECHANICAL WORK

REFER TO GENERAL AND SPECIAL CONDITIONS.

7. CLAIMS FOR EXTRA COST

REFER TO GENERAL AND SPECIAL CONDITIONS.

8. MATERIALS AND WORKMANSHIP

A. All equipment, materials and articles incorporated in the work shall be new and of comparable quality to that specified. Each Proposer shall determine that the materials and/or equipment he proposes to furnish can be brought into the building(s) and installed within the space available. In certain cases, it may be necessary to remove and replace walls, floors and/or ceilings and this work shall be the responsibility of the Contractor. All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement of filters, etc. Extra compensation will not be allowed for
relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s). Ensure, through coordination, that no other Contractor seals off access to space required for equipment, materials, etc.

B. Materials and equipment, where applicable, shall bear Underwriters' Laboratories label where such a standard has been established.

C. All equipment shall bear the manufacturer's name and address. All electrically operated equipment shall bear a data plate indicating required horsepower, voltage, phase and ampacity.

9. MOTORS

A. Motors shall be built in accordance with the latest standards of NEMA and as specified. Motors shall be tested in accordance with standards of A.S.A. C50, conforming to this and all applicable standards for insulation resistance and dielectric strength.

B. Each motor shall be provided by the equipment supplier, installer or manufacturer with conduit terminal box, and N.E.C. required disconnecting means as specified or required. Three-phase motors shall be provided with external thermal overload protection in their starter units. Single-phase motors shall be provided with thermal overload protection, integral to their windings or external, in control unit. All motors shall be installed with NEMA-rated starters as specified and shall be connected per the National Electrical Code.

C. The capacity of each motor shall be sufficient to operate associated driven devices under all conditions of operation and load and without overload, and at least of the horsepower indicated or specified. Each motor shall be selected for quiet operation, maximum efficiency and lowest starting KVA per horsepower. Motors producing excessive noise or vibration shall be replaced by the responsible contractor. See Division 26 of Specifications for further requirements related to installation of motors.

10. OPERATING INSTRUCTIONS, MAINTENANCE MANUALS AND PARTS LISTS

A. Upon completion of all work tests, the Manufacturer shall instruct the Owner or his representative(s) fully in the operations, adjustment and maintenance of all equipment furnished. The time and a list of representatives required to be present will be as directed by the Engineer. Turn over all special wrenches, keys, etc., to the owner at this time.

B. The Manufacturer shall furnish three (3) complete bound sets for delivery to the Engineer of typewritten and/or blueprinted instructions for operating and maintaining all systems and equipment included in this contract prior to substantial completion. All instructions shall be submitted in draft, for approval, prior to final issue. Manufacturer's advertising literature or catalogs alone will not be acceptable for operating and maintenance instructions.

C. The Contractor, in the instructions, shall include a preventive maintenance schedule for the principal items of equipment furnished under this contract and a detailed, parts list and the name and address of the nearest source of supply.

11. INDEMNIFICATION
A. The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons, (including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

END OF SECTION 200100
SECTION 200200- SCOPE OF THE MECHANICAL WORK

1. GENERAL

A. The Mechanical work for this Contract shall include air handling units and exhaust fans. This work shall primarily include, but is not necessarily limited to the following:

   (1) All mechanical exhaust fans.

   (2) All air handling units.

   (3) One air handling unit shall be bid as an Alternate.

   (4) Pricing for the air handling units and exhaust fan shall be submitted separately.

   (5) The equipment pricing shall be part of the RFP process. The University and Engineer shall review each proposal, request clarifications and then request a best and final submittal.

   (6) All applicable services and work specified in Section 200100; General Provisions - Mechanical.

   (7) Provide all required motor starters, etc. not provided under the electrical sections.

   (8) One year guarantee of all mechanical equipment, materials and workmanship.

   (9) Thorough instruction of the owner’s maintenance personnel in the operation and maintenance of all mechanical equipment.

   (10) Thorough coordination of the installation of all piping, equipment and any other material with other trades to ensure that no conflict in installation.

   (11) Factory start-up of all major equipment (including terminal HVAC equipment) and submission of associated factory start-up reports to the Engineer.

END OF SECTION 200200
1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified herein.

B. Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer’s Checklist.

C. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists. This shall include air handling units, boilers, chillers, cooling towers, VFDs, etc.

D. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90 and/or International Energy Conservation Code 2012, whichever is more stringent.

E. Installation of all heating, ventilating and air conditioning systems shall be performed by a master HVAC contractor licensed in the state the work will be performed.

F. Note to Suppliers and Manufacturers Representative furnishing proposals for equipment for the project:

1) Review the section of these specifications entitle: SHOP DRAWINGS, DESCRIPTIVE LITERATURE, MAINTENANCE MANUALS, PARTS LISTS, SPECIAL KEYS, TOOLS, ETC., and provide all documents called for therein.

2) Ensure that the equipment which you propose to furnish may be installed, connected, placed in operation and easily maintained at the location and in the space allocated for it.

3) Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.

4) Where manufacturers’ temperature controls are specified, they shall be in full compliance with International Mechanical Code Section 606 including automatic smoke shut down provisions.

5) Provide factory start-up on site by a factory representative (not a third-party contractor) for all HVAC equipment, including VFDS, air handling units, exhaust fans, etc. Submit factory start-up reports to the Engineer.

6) Provide training to the Owner by a factory representative for each type of equipment. Training shall be a minimum of eight (8) hours on site and the Engineer shall be notified one (1) week in advance of the training. Training shall only occur when the systems are complete and 100% functional. All training shall be video taped.
7) Review the Section on Motor Starters and Electrical Requirements for Mechanical Equipment.

8) Requirements for motors controlled by variable frequency drives:
   a. All motors shall be inverter duty rated.
   b. Motors less than 100 HP in size shall be furnished with shaft grounding kit, Aegis SGR Bearing Protection Ring or equal. One shaft grounding ring and related hardware shall be provided on drive end or non-drive end of motor per manufacturer’s instructions. These shall be factory mounted and installed on the exterior of the motor to allow for visual inspection. Ground motor frame per manufacturer’s instructions. Install kit in strict accordance with manufacturer’s instructions.

9) All condensate producing equipment shall be provided with a condensate trap as recommended by the equipment manufacturer and a condensate overflow switch.

10) Provide a complete air tight enclosure with opening door that seals air tight for all filters on air moving equipment.

11) All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.

2. EQUIPMENT

1. FACTORY AND SITE BUILT CUSTOM AIR HANDLING UNITS

A. GENERAL
   1) AHU-1, AHU-2, AHU-3 and AHU-4 shall be sectional/modular units and all sections and components shall be made such that they can fit and be taken through a 13’W x 9’ T louvered opening to the penthouse. All components shall be protected during shipment.

   2) AHU 5 and AHU 6 shall be a knockdown/site built units and all components shall be made such that it can fit and be hoisted through a 60”W x 84”T doorway in existing mechanical rooms. All components shall be protected during shipment.

   3) AHU-6 shall be considered a bid alternate. Bidder shall guarantee the bid price for 60 days from contract award.

   4) The owner shall withhold 5% of the total equipment cost at time of purchase until the construction project has reached substantial completion.

   5) Manufacturer shall be a company specializing in the design and manufacture of commercial/industrial custom HVAC equipment. Manufacturer shall have been in production of custom HVAC equipment for a minimum of 15 years.

   6) Each unit shall bear an ETL or UL label under UL Standard 1995 indicating the complete unit is listed as an assembly. ETL or UL listing of individual components, or control panels only, is not acceptable.
7) Manufacturer shall have at least 10 unique installations of fan array (minimum 4 fans in fan array) air handling units.

8) Furnish and install custom air handling units construction features as specified below. The units shall be furnished in strict accordance with the specifications. All units shall be complete with all components and accessories as specified. Any exceptions must be clearly defined.

9) The unit shall be tested by a certified testing agency on site after completion by the contractor. All testing shall be the responsibility of the mechanical contractor. Provide all testing equipment and instrumentation needed for the testing.

10) The manufacturer shall provide a full time on site construction supervisor during the installation of AHU-5 and AHU-6. The supervisor shall manage the unit assembly and provide a lead contact for project meetings, owner/engineer/mechanical contractor relations and answer questions from associated trades.

11) Units shall be completely factory assembled and tested with the exception of unit splits as required for shipping or installation requirements as indicated on the schedule and drawings. The equipment's cooling, heating, ventilating, exhausting capacity and performance shall meet or exceed that shown on the schedule. Tags and decals to aid in service or to indicate caution areas shall be provided. Electrical wiring diagrams shall be attached to the control panel access doors. Operation and Maintenance manuals shall be furnished with each unit.

B. WARRANTY

1) The complete unit shall be covered by a parts warranty issued by the manufacturer covering the first year of operation. This warranty period for all air handlers shall start upon the projects construction substantial completion.

2) The installing contractor shall provide labor warranty during the unit’s first year of operation.

3) 

C. ACCEPTABLE MANUFACTURERS

1) Basis of design is ClimateCraft and ClimateCraft ACCESS. To be approved, manufacturers shall meet or exceed performance and construction aspects as described and detailed herein. Requests for prior approval must be submitted 10 days prior to bid date. Submittal is to be in sufficient detail to determine equivalency. Substitution requests must originate from a bidder which is an equipment vendor.

2) Provide custom air handling units as manufactured by:

   a. ClimateCraft
b. Nortek Air Group (Governair)

c. York Custom

D. ON SITE/FACTORY TESTING AND QUALITY CONTROL

1) Factory Tests: The fans shall be factory run tested to ensure structural integrity and proper RPM. All electrical circuits shall be tested to ensure correct operation before shipment of unit. Units shall pass quality control and be thoroughly cleaned prior to shipment.

2) On Site Leak Testing: The unit manufacturer shall provide an on site leak test after the unit has been constructed. This shall be performed by a certified company in accordance with AMCA Standard 210. The cabinet shall be tested at 1.5 times the static pressure of differential static pressure across the cabinet exterior walls for both the high and low pressure sides. Cabinet leakage shall not exceed 0.5% of design airflow. All supply and return air openings shall be sealed. The air shall then be pumped into the unit until the appropriate operating pressures are achieved. Air flow measurements shall be performed in compliance with AMCA Standard 210. The unit shall also be tested to show that the specified airflow is produced at the specified static pressure for both supply and return fans.

3) Acoustic Requirements: The equipment manufacturer shall furnish calculations showing the estimated sound power levels at the supply and return connections, as well as unit casing radiation for each air handling unit. Calculations shall be based on fan sound power levels which were determined in accordance with AMCA Standard 300 and 301. These shall meet or exceed the sound power levels indicated on the drawings. Sound data from a single fan or group of fans shall not be acceptable. Sound calculation shall calculate resultant sound valves entering or leaving the unit.

E. REFERENCES

1) AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings
2) AMCA Publication 99 – Standards Handbook
3) AMCA Standard 203 – Field Performance Measurement of Fan Systems
4) AMCA Standard 210 – Laboratory Methods of Testing Fans for Performance Rating
5) AMCA Standard 300 – Reverberant Room Method for Sound Testing of Fans
6) AMCA Standard 500 – Laboratory Methods for Testing of Dampers and Louvers
7) ARI Standard 410 – Forced Circulation Air-Cooling and Air-Heating Coils
9) ASHRAE Standard 52.1 – Dust-Spot Procedures for Testing Air-Cleaning Devices
10) ANSI/ASHRAE Standard 52.2 – Method of Testing Air-Cleaning Devices for Removal Efficiency by Particle Size
12) ANSI/ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality
13) ANSI/ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential
F. SUBMITTALS
   1) Submit shop drawings and product data in accordance with Division 1
   2) Submittals shall include the following:
      a. Dimensioned plan and elevation view drawings, including motor starter and control cabinets, required clearances, and location of all field connections.
      b. Cabinet material, metal thickness, finishes, insulation and accessories.
      c. Ladder-type schematic drawing of the power and auxiliary utility field hookup requirements, indicating all items that are furnished by the manufacturer.
      d. Manufacturer’s performance of each unit. Selection shall indicate, as a minimum, the following:
         i. Fan curves with system operating conditions indicated.
         ii. Certified coil performance ratings with system operating conditions.
         iii. Calculations required for base rail heights to satisfy condensate trapping requirements of cooling coil.
         iv. Filters with performance characteristics.
         v. Rated load amp draw.
         vi. Approximate unit shipping weight.

G. OPERATION AND MAINTENANCE DATA
   1) Include data on design, inspection and procedures related to preventative maintenance. Operation and maintenance manuals shall be submitted at the time of unit shipment.

H. QUALIFICATIONS
   1) Manufacturer shall be a company specializing in the design and manufacture of custom air handling equipment and in business for no less than 15 years.
   2) Each unit shall bear an ETL label, conforming to UL Standard 1995.
   3) Units shall comply with the requirements of UL 1995 and NFPA 90.
   4) Each unit shall have a prominently displayed IBC Seismic Compliance Label issued by an independent third-party approval agency which is specific for the size of the component and tested acceleration levels.

I. DELIVERY, STORAGE, AND HANDLING

HVAC EQUIPMENT
1) The mechanical contractor shall take receipt of the owner furnished equipment and store (if required) until such time the equipment is ready to be installed.

2) Deliver, store, protect and handle products to site under the supervision of the owner in accordance with the manufacturers Operation and Maintenance Instructions.

J. SEQUENCING AND SCHEDULING

1) Coordinate work performed under this section with work performed under the separate installation contract.

PRODUCTS

K. CABINET CONSTRUCTION

1) Sectional Units: Cabinets shall be constructed in a watertight and airtight manner. The manufacturer's standard cabinet construction shall result in an ASHRAE/ANSI Standard 111 Leakage Class 5 rating, or better, as measured in accordance with AMCA Standard 210. A leakage rate as a percent of airflow shall only be submitted following calculation at specific project conditions. Maximum casing leakage (cfm/100 ft² of casing surface area) = CL x P^0.65. Published leakage rates at generic conditions shall not be submitted.

2) Site Assembled units: Units shall be provided by a manufacturer in the business of producing factory and site assembled custom air handling equipment and shall be specifically engineered for final assembly at the jobsite. Site assembly shall be accomplished using the same procedures and techniques as would be used by the manufacturer in the factory and shall yield the same performance characteristics. Site assembly techniques that negate thermal break or other performance characteristics shall not be accepted.

a. The installing contractor shall provide technicians for training at the AHU manufacturer’s facility prior to site assembly or offer written documentation of AHU manufacturer’s training within the last 24 months. AHU-5 and AHU-6 assembly shall be supervised by a direct employee of the AHU manufacturer or by a manufacturer certified technician. All unit warranty coverage shall be the same as for a factory assembled unit.

b. Complete units shall be shipped, broken down into individual panel and component form and all pieces shall be engineered for site assembly with no disassembly required. Dimensions and weights of critical sized components shall be provided at time of submittal review by the engineer.

c. All AHU components, assembly instructions, gasket and assembly hardware shall be provided by the AHU manufacturer. Assembly instructions shall include easy-to-follow photo details. These details shall include:

i. Detailed unit specific assembly instructions with typical photos of assembly for both unit and component installation

ii. List of tools required for field installation

D. Panel gasket supplied with the unit shall be a high-quality weather resistant closed-cell EPDM sponge rubber. Units relying on field applied caulk for sealing are not acceptable. Units shall be securely assembled using machine bolts. Units relying on sheet metal binding screws for field assembly are not acceptable.

e. Units shall be accompanied by detailed bills of material for each pallet and crate, pallet check lists, panel maps, parts, construction information and document check lists. All major components shall be identified to match the bills of material and packing lists.
3) All units: Casing deflection shall not exceed L/200 at +10.0 w. g. in all positive pressure sections and -10.0 w. g. in all negative pressure sections where L is defined as the panel span. Panels shall be designed to deflect no more than 1/200 (.0005” per inch) of span under operating design conditions when measured at the panel span. Casing shall be rated for 1% leakage at 1.5 times the operating pressure with a maximum overall pressure of 10” w. g.

4) All units: The unit shall be constructed on an 8” welded structural tubular steel base. Base tubing shall be cold-formed carbon steel, electric resistance welded. Equipment using a die-formed sheet metal base is not acceptable. Formed intermediate cross members shall be constructed of hot rolled 12-gauge galvanized steel. After fabrication, the base frame shall be thoroughly cleaned and coated with high solids, polyamide epoxy paint system for superior corrosion resistance.

5) All Units: Units shipped in multiple sections shall be engineered for ease of field assembly. Gasket supplied with the unit shall be a high-quality weather resistant closed-cell EPDM sponge rubber. Each section shall include a permanent label to aid in proper field assembly. All gasket and necessary assembly hardware shall ship loose with unit. Floors shall be designed to deflect no more than 1/200 of span under operating conditions.

6) All Units: Floors
   a. Shall be fabricated of 3/16” aluminum tread plate. All floor sheets seams shall be continuously welded and welded to the unit base structure with a 2” turned up lip at the perimeter.
   b. Floor seams at shipping splits shall be welded in the field by the installing contractor. The manufacture shall provide 3/16” aluminum tread plate strips to cover the floor seams. The strip shall be continuously welded on both sides.
   c. All accessible sections without a drain pan shall have a 1.25” diameter floor drain piped through the unit base for drainage.
   d. Floors shall be insulated with a two-part polyurethane water impervious foam insulation. A 20-gauge G90 galvanized steel under liner shall be provided.

7) All Units: Wall and Roof panels
   a. Panels shall be 3” thick double wall construction. Panel joints shall be sealed with an industrial EPDM gasket to form a water and airtight seal. Air handling manufacturers using caulk to seal panels must include an owner witnessed field leakage test. The test shall require the unit to be field design air flow tested and cabinet leak tested for 1% at 1.5 times the operating pressure.
   b. Panels shall be individually removable for service without removing the roof or compromising the integrity of the cabinet wall. Panels shall be joined with 5/16” bolts that can be removed and refastened. Panel attachment with screws is not acceptable. All panels shall utilize thermal break construction between the exterior panel and the interior liner and between the panels and the base and roof frames.
   c. AHU-3 sections/modules shall be constructed in a manner where each section is capable of being assembled and securely fastened together without requiring exterior fasteners across the top of each section. The combined AHU, curb and housekeeping pad height will not offer sufficient clearance between the AHU and penthouse roof structure to install exterior fasteners. The fastening technique will not in any way result in additional air leakage or cause the AHU to fail air leakage tests defined herein.
   d. For long term durability, exterior panels shall be a minimum 16-gauge G60 galvanized steel.
e. Interior liners shall be a minimum 20-gauge 304 stainless steel. Panel liners shall be of a single piece construction and attached to the exterior panels with a full thermal break. To allow for cleaning, no fasteners shall be used on the exposed liner surface. Single wall units are not acceptable.

8) All Units: Insulation
   a. All wall and roof panels shall be insulated with an injected foam insulation with an R value of 6.6/inch. Panels shall be designed to deflect no more than 1/200 of span under operating design conditions when measured at the panel seam. Insulation shall fill the panel without voids. Panels shall have a minimum 20-gauge 304 stainless steel solid interior liner. The composite R-value of the 3” unit casing shall be no less than R-19.8.

9) All Units: Access doors shall be provided into all sections of the air-handling unit as indicated in the plan documents. Doors shall be sized as shown on plan drawings, shall be a minimum 3” thick with R19.8 polyurethane foam insulation and shall be double wall construction using the same material type as the corresponding section. Doors shall comply with the requirements of UL 1995 and NFPA 90. The door frame shall be 0.125” extruded 6063-T5 aluminum. Each door shall be mounted with adjustable die cast aluminum hinges. All doors and mounting frames shall incorporate a thermal break design and the doors shall seal to a replaceable extruded EPDM sponge rubber gasket. Doors shall open against static pressure or shall include a pressure relief feature on the door latch.
   a. The door latch assembly shall consist of a roller cam compression arm with a chrome plated steel inner handle and glass fiber/nylon composite outer handle. One tool operated lock shall be provided on each fan section access door. All doors shall have a minimum of two latches.
   b. A 10” x 12” thermal pane viewing window with one wire mesh safety glass pane and one clear pane shall be provided. The frame shall have a no-through-metal thermal break design. Viewing windows shall be on all doors serving a lighted section.

10) All Units: The entire unit, including walls, roof, doors, joints, and seams shall include thermal break construction. This construction shall be supported by tested performance producing no condensation on the exterior surface when the air tunnel temperature is 50°F DB under the following exterior conditions:
   a. \( \frac{(Th - 50)}{(Th - Tdp)} < 3.4 \)
   b. Th = Ambient dry bulb temperature (°F) external to housing
   c. Tdp = Ambient dew point temperature (°F) external to housing

11) Curb – AHU-3 shall be provided with a curb measuring 16” tall and a width and length to match the AHU dimensions. It shall contain partitions to form a return air plenum with partitions positioned to encapsulate both the existing floor opening as well as new return air duct connections. The combined height of the curb and AHU shall not exceed 9’-7”. The curb shall be capable of being furnished in sections that can fit and be taken through a 13’W x 9’ T louvered opening to the penthouse.

M. FAN ASSEMBLIES – GENERAL

1) The fan shall be of the size and type specified in the unit schedule. To assure maximum performance, fans shall be supplied by a manufacturer specializing in fan design and production. All fan assemblies shall be designed for heavy-duty industrial applications. Fan framing assemblies shall be fabricated from structural steel electrically welded to form a rigid, integral base. Individual fan assemblies shall be independently isolated.
2) All motors shall be NEMA design B with Class F insulation. Electrical characteristics and horsepower shall be as specified on the project schedule. All motors shall have a minimum service factor of 1.15. Motors shall have ball bearings. Motors shall be premium efficiency ODP type and shall be factory wired to a fan array motor overload panel. The motor shall be located within the unit and mounted on an adjustable heavy steel base. The motor base shall be fastened securely to the structural steel framing of the fan assembly.

3) All fans shall meet the minimum efficiency and maximum brake horsepower values as scheduled. All fans shall be selected to operate at a point no higher than 90% of the peak static pressure rating as defined by the fan performance curve at the selected operating speed. Manufacturer must ensure maximum fan RPM is below the first critical speed.

4) Each fan shall be provided with a factory installed airflow measuring device. Airflow device to be mounted out of the direct air stream so as not to affect system static pressure or sound performance. Sensor accuracy shall be +/- 3%. Factory installed assembly shall include flow sensors for field connection to a transducer provided by others.

N. FAN ASSEMBLIES – DIRECT DRIVE FAN ARRAY

1) Approved manufacturers: ClimateCraft, Greenheck, HuntAir, and Twin City Fan & Blower

2) Fan Arrays shall be direct-drive, non-overloading SWSI plenum fans designed for industrial duty and suitable for continuous operation.

   a. Fans shall be arranged in an array using one or more welded structural steel assemblies and shall be of the size and quantity specified in the unit schedule. Screwed or riveted frames are unacceptable. Fan assemblies shall be attached directly to base structural members.

   b. Fan wheels shall have a minimum of 12 airfoil blades for superior sound characteristics and shall be constructed of aluminum to reduce rotational weight and vibration. Fan blades shall be extruded aluminum for uniformity and improved vibration characteristics.

   c. Each fan and motor assembly shall be independently isolated within the structural assembly using 1-inch deflection spring isolators. Isolators shall be mounted in a three-point arrangement that provides both vertical and horizontal (thrust) isolation and shall not require field adjustment. If hard mounted or rubber in shear is used in place of internal spring isolations, external isolation of the entire air handling unit is required, no exceptions. Isolation system shall be seismic rated to withstand seismic forces in excess of 4G horizontally and vertically to satisfy specified IBC seismic requirements.

   d. A fan inertia base shall be provided or the fan structure shall exceed an equivalence of 2x mass of the total rotating parts of the fan array. Fan and motor assemblies shall be designed such that no natural frequencies exist within the operating RPM range of the fan, eliminating the need for “lockout” frequency settings in the variable speed drive. The purchasing contractor will be responsible for all costs associated with externally isolating any unit that does not include individual fan isolation.

   e. All fan arrays shall meet the minimum motor efficiency, maximum brake horsepower and total motor horsepower values scheduled. All fans shall be selected to operate at a point no higher than 90% of the peak static pressure rating as defined by the fan performance curve at the selected operating speed. Manufacturer must ensure maximum fan RPM is below the first critical speed. Fans shall be Class 2 construction.

   f. All fan and motor assemblies shall be dynamically balanced by the manufacturer to a maximum allowable vibration of 0.040 inches per second at design RPM and a maximum 0.080 inches per second overall vibration limit to bring the fan balance in conformance to a
BV-5 Grade G1 per ANSI/AMCA 204. In addition, the manufacturer shall insure that no critical frequencies exist in the fan operating range by varying motor speed in 1Hz increments from design RPM to 50% of design RPM.

3) Unloading
   a. Supply and return fans (AHU-3) shall be provided with unloading capability to allow fan modulation without surge from 100% to 30% with a duct static pressure control set point of 1.25” w. g. There shall be no static pressure or intake plenum losses or any horsepower penalty associated with the system.
   b. The system shall provide either a manual or automatic positive shutoff for each fan in case of a fan failure.

4) Motors
   a. Electrical characteristics and horsepower shall be as specified on the project schedule.
   b. Motors shall be Premium Efficiency per NEMA MG1 Table 12-12 type, shall have NEMA Class F insulation, shall meet NEMA Standard MD-1 Inverter Duty rating and shall be designed to withstand 1600V peak voltage spikes and rise times ≥0.1 microseconds.
   c. Motors shall have grease lubricated ball bearings designed to deliver a minimum L10 life of 250,000 hours at full load and the maximum operating RPM of the associated fan. Grease zerks and spring-loaded grease relief valves shall be provided in each motor to allow easy bearing lubrication without damaging the seals due to over lubrication. Permanently lubricated bearings are allowed if a spare motor per fan array is provided.
   d. For efficient operation in a direct drive application, motors shall be capable of operating greater than 60HZ to at least the design operating speed of the fan.
   e. Motors shall be factory wired to a motor control center for connection to a VFD. The motor control center shall include for each motor circuit a control device providing overload protection, short circuit protection and a manual disconnect means, and all circuits shall be wired to a common main panel terminal block. Each control device shall include an auxiliary output capable of providing remote notification of a motor failure. All motors shall operate at all times and be controlled in unison, maintaining a consistent and uniform airflow pattern over coils, filters and other devices.
   f. Each motor shall be provided with a shaft grounding device to harmlessly bleed potential induced shaft voltages to ground.

5) Warranty
   a. All rotating parts shall be warranted by the unit manufacturer for a full five (5) years from date of unit start-up. Parts warranties provided by third parties are not acceptable.

6) Options
   a. In the fan section, provide an overhead motor removal system to facilitate motor replacement.

   (1) The assembly shall include a manually operated winch, capable of being easily moved to any motor location and a structural steel I beam for mounting a trolley to assist in fan motor removal. The beam system shall be mounted overhead of the fan and motor. The beam system shall be supported and mounted to the unit’s base support system. The motor removal system shall be capable of removing the motor out of the air handling unit so it can be safely lowered to the mechanical room floor.
   b. Outlet safety screens shall be provided for all fans to prevent injury from rotating equipment.

7) Fan Array Controls
a. AHU-1 and AHU-4: Fan arrays shall be controlled using a common control signal, such as the duct static control signal, to modulate the fan speed.

b. AHU-2, AHU-3, AHU-5 and AHU-6: Fan arrays shall run at constant speed. Variable frequency drives shall be installed for future fan speed modulation.

c. Each fan array in the air handling unit shall be provided with a factory installed airflow measuring instrument. Every fan in the array will have an airflow measuring device that is guaranteed by the unit manufacturer to have no impact on the fan airflow performance and will not increase the fan sound power. The output of the airflow measurement device on each fan shall be wired by the unit manufacturer back to a central processor mounted on the cabinet exterior that will add the flow from each fan to provide a total airflow for the fan array. Using one air flow measuring device and multiplying by the number of fans provided is not acceptable due to lack of accuracy.

The central processor shall be able to detect and report a fan failure. Auxiliary contacts on the motor starters are not acceptable as fans can fail without tripping overloads. Current sensors wired into the central processors can be utilized. Acceptable manufacturers are: AccAMP series ACSX, CR Magnetics model CR439, Greenheck FMS, NK Technologies series AS1.

Piezometric volume taps with pressure transducers are acceptable. Transducer accuracy shall be 1% of pressure reading from full scale down to 30% of full scale reading to improve accuracy to less than 0.5% of calculated flow from 100%-30% of flow. The square root linearization and conversion of the pressure signal to flow shall be done at the central processor. Acceptable pressure transducers are: MatrixMonitor™ Fan Sensor, Omega PX656, Greenheck FMS, Setra Model 239.

d. Measure the airflow back flowing through all failed fans in the array. The backflow shall be subtracted from the sum of the operating fans to provide an accurate delivered airflow for the entire fan array. The system measurement accuracy shall be ±5% of measurement throughout the entire operating range of the fan array down to 15% of design flow. Systems with accuracy rated as a percentage of full scale are not acceptable. The system shall adjust for changes in barometric pressure and temperature to maintain accuracy in changing atmospheric conditions and at any altitude. The system shall be able to measure airflow and report it in units of ACFM or SCFM as selected by the user.

The system shall have the capability to communicate to the BMS with discretely wired analog signals or through an RS485 two wire multi drop network using the BACnet protocols. At a minimum, there shall be two locally scalable 0 to 10 VDC signals to report airflow and array pressure rise to the BMS. In addition, there shall be three SPDT relay outputs to report on the condition of the fan array. One relay will switch when the control is energized, one will switch in the event of fan failure detection and one will switch if fan surge is detected.

O. FAN SPEED CONTROL

1) Each AHU fan array shall be controlled by a field installed variable frequency drive furnished by others. Each fan array shall have one (1) VFD to control all fans.

P. UNIT SOUND POWER

1) Fan sound power levels (dB) for the unit shall not exceed values as specified on the equipment schedule.

2) Unit manufacturer shall provide certified inlet, supply and casing radiated, sound power levels based on the final unit configuration.
Q. COILS

1) Provide complete coil section(s) with service access door(s) as shown on the plan drawings. Coil connections shall extend through the section casing for ease of installation. Coil connections must be sealed from both the inside and exterior surfaces of the panel with the sleeve of the inner seal covering the pipe within the depth of the panel, all to minimize leakage and condensation. An integral double wall stainless steel air seal which completely seals around the cooling coil casing and extends to the unit pressure bearing surface shall be provided. Air seals/safing materials that are mechanically fastened to the inner liner of the cabinet only shall be constructed of 16 gauge materials to match the material type in the appropriate section and shall be gasketed and have fasteners every 3 inches.

2) Multiple, “stacked” coil arrangements must be constructed so as to allow independent removal of any coil without the removal of another within the coil bank.

3) All coils shall meet or exceed the capacities specified on the mechanical schedule and all water coil performances shall be certified in accordance with the AHRI Forced Circulation Air Heating and Air Cooling Coil certification program which is based on AHRI Standard 410. Face velocities shall not exceed those specified on the mechanical schedule.

4) All blow-through cooling coils shall have removable stainless-steel mist eliminators as manufactured by Mistop regardless of coil face velocity.

5) All cooling coil and energy recovery coil sections shall include a double sloped drain pan constructed from 304L stainless steel. All corners shall be welded watertight. Coils shall rest on stainless steel supports. The pan shall have a minimum pitch of 2” from high point to the bottom of the drain outlet connection, providing at least a 1/8” per foot slope. The drain pan shall be insulated with a 2-part sprayed on polyurethane, water impervious foam. Insulation shall be applied to the entire under side of the drain pan and coil section base assembly. If multiple stacked coils are used, intermediate drain pans are required. Intermediate pans shall be insulated and drained with 3/4” copper down-comers to the main pan.

6) Water and glycol solution coils shall be of a staggered tube design with high efficiency die formed corrugated plate-type fins for maximum performance. All coils shall be tested with 400 psig compressed air under clear water. Coils shall be designed to operate at 300 psig internal pressure and up to 250°F. Tubes shall be 5/8” diameter, seamless 0.035” wall copper, mechanically expanded into full drawn fin collars for a continuous compression bond over the full finned length for high efficiency performance. Cooling coil casings shall be a minimum 16-gauge stainless steel. Heating coil casings shall be a minimum 16-gauge galvanized steel. Coil casing reinforcements shall be required for fin lengths over 42”. Coil fins shall be 0.0095” thick aluminum. Coils shall be serviceable using 0.25” M.P.T. drain and vent taps on the supply and return headers. Threaded seamless red brass coil connections shall be brazed to copper supply and return headers.

7) Integral face and bypass coils with multiple alternating heating and bypass sections shall be provided where scheduled. Dampers shall be a wrap design that fully encases the coil elements when shut. Actuators shall be provided and mounted by the unit manufacturer. Coils shall be steam with capacities as listed in the mechanical schedule. Coils shall be suitable for continuous operation at 200 psig and 400°F. Coils shall utilize .035” copper tubes with mechanically bonded 0.0095” thick aluminum fins. Coils shall be ARI 410 Certified for performance.

R. FILTERS

1) Provide complete filter section(s) with filter racks and service access door(s) as shown on the plan drawings. Holding frames provided for medium efficiency applications will be accessible. Holding frames provided for high efficiency applications will be upstream accessible. Holding
frames shall be constructed from heavy gauge galvanized steel and shall be equipped with polyurethane foam gaskets. Frames shall be installed with vertical stiffeners and appropriate frame-to-frame sealant to provide a rigid leak tight assembly. An integral air seal which completely seals around the filter frame assembly and extends to the unit pressure bearing surface shall be provided. Air seals/safing materials that are mechanically fastened to the inner liner of the cabinet only shall be constructed of 16 gauge materials to match the material type in the appropriate section and shall be gasketed and have fasteners every 3 inches.

Filter fasteners shall be capable of being installed without the requirement of tools, nuts or bolts. The holding frame shall be designed to accommodate standard size filters with the application of the appropriate type fastener. The filter rack shall be designed to use standard 24”x24” and 12”x24” filters only. Odd sized filters are not allowed. Holding frame assemblies shall be sized to meet or exceed the face area specified by the mechanical schedule.

2) Gauges
   a. A Magnehelic differential pressure gauge shall be provided factory installed for measuring the pressure drop across each filter type. The gauge shall be a diaphragm-actuated dial type, 4¾" O.D., with white dial, black figures and graduations and pointer zero adjustment.

3) Medium efficiency pleated filters shall be 2” thick MERV 8 as rated by ASHRAE Standard 52.1 test methods. Filter media shall be of the non-woven cotton fabric type. Filters shall be UL900 Class 2 listed. 100% outside air units shall have 4” thick MERV 8 filters.

S. DAMPERS

1) Mixing box and economizer outdoor air, return air, and exhaust air openings shall be airfoil low-leak dampers. Damper shall be opposed (exhaust air) and parallel (outdoor air and return air) blade type. The frame shall be fabricated from 16-gauge galvanized steel. Damper shall meet the leakage requirements of ASHRAE Std. 90.1 and of the International Energy Conservation Code by leaking less than 3 CFM/sq. ft. at 1” of static pressure and shall be AMCA licensed as a Class 1A damper.

2) The dampers shall be equal to Ruskin CD60.

T. ELECTRICAL POWER AND CONTROLS

1) Unit operating voltage shall be 208V, 3-phase, 60Hz. All wiring and electrical equipment supplied by the manufacturer shall conform to and be installed in accordance with the requirements of UL1995.

   Provide copper wires, bus bars, and fittings throughout, except internal wire of the control transformer may be aluminum if copper termination is provided. Identify power supply terminals with permanent markers. The maximum temperature of terminals shall not exceed 167°F (75°C) when the equipment is tested in accordance with its rating. Wiring shall be run in plated EMT and Liquid Tight conduit.

   Mount a permanent nameplate on the unit to display the manufacturer, serial number and model number, date of manufacture, horsepower, current rating and voltage.

2) Each section provided with a service access door, or as indicated on the plan drawings, shall be equipped with a vapor proof LED service light. All lights shall be completely installed and wired to a single 60-minute timer switch. All switch boxes shall include a GFCI convenience receptacle. Lights and GFCI outlets shall be wired to a separate 115VAC power connection.
PART 3 - EXECUTION

A. INSTALLATION
   1) Install in strict accordance with manufacturer’s requirements, shop drawings, and Contract Documents.
   2) Equipment rigging and assembly to be supervised by the manufacturer’s representative. Provide for as long a period of time as is necessary to ensure proper assembly or onsite training but no less than 2 full days.
   3) Adjust in alignment on concrete foundations, sole plates or other supporting structure. Level, grout, and bolt in place.
   4) Coordinate electrical installation with electrical contractor.
   5) Coordinate controls with control contractor.
   6) Provide all appurtenances required ensuring a fully operational and functional system.

B. START-UP
   1) Equipment start-up is to be supervised by the unit manufacturer’s representative service organization. Physical connections and start-up are provided by the installing contractor. The start-up engineer shall conduct such operating tests as required to ensure that the unit is operating in accordance with design. Complete testing of all safety and emergency control devices shall be made. The start-up engineer shall submit a written report to the owner and manufacturer containing all test data recorded as required above and a letter certifying that the unit is operating properly.
   2) Provide complete Operation & Maintenance Manuals with descriptive literature, model, and serial number of all equipment, performance data, manufacturer’s instructions for operating and maintenance, lubrication recommendation and schedule, and winter shutdown procedure.

II. LAB EXHAUST FANS

A. GENERAL
   1) A mixed flow induced lab hood exhaust fan system comprised of 3 equally sized fans, where any 2 fans normally operate and the third is a backup. An energy recovery system, housed in a plenum with one or more energy recovery coils, a filter bank and all required dilution and isolation dampers, access panels and related equipment for proper performance.
   2) The complete assembly shall be factory produced with a single location final assembly point where it shall be tested.
   3) The owner shall withhold 10% of the total equipment cost at time of purchase until the construction project has reached substantial completion.

B. WARRANTY
   1) Fan manufacturer shall provide a 7 year parts warranty from time of purchase to include fan, motor and drive mechanisms including pillow blocks, sheaves, shafts, couplings and belts. This warranty shall be held solely by the fan manufacturer. It is unacceptable to extend the warranty of a provided component supplier (i.e. motors, dampers, actuators). All warranty claims shall be the sole responsibility of the fan manufacturer.
2) The installing contractor shall provide labor warranty during the unit’s first year of operation. The warranty shall begin upon substantial completion.

C. ACCEPTABLE MANUFACTURERS

1) The plans and specifications for the laboratory fume hood exhaust system are based on systems and equipment manufactured by Strobic Air Corporation.

2) In strict accordance with this specification, alternative laboratory exhaust systems and equipment shall only be considered for approval provided that the equipment be equal in every respect to energy consumption, sound levels, vibration levels, footprint, maintenance requirements, operational characteristics, capacities, and intent specified herein. Approval to bid does not relieve the alternate exhaust system supplier from complying with the minimum requirements or intent of this specification.

3) The engineer and owner shall be the sole judges of quality and equivalence of equipment, materials, methods, and life cycle cost.

4) Provide Lab Hood Exhaust Fan system as manufactured by:
   a. Strobic Air Corporation
   b. Twin City Blower
   c. Greenheck

D. FACTORY TESTING AND QUALITY CONTROL

1) The fans shall be factory run tested to ensure structural integrity and proper RPM. All electrical circuits shall be tested to ensure correct operation before shipment of unit. Units shall pass quality control and be thoroughly cleaned prior to shipment.

E. REFERENCES

1) Fans must be tested in accordance with AMCA 210 and 300 in an AMCA accredited laboratory and certified for air and sound performance.
2) Fans shall be UL and CUL listed per UL 705 safety standard.
3) Fans shall meet the criteria of NFPA-45.
4) Classification for Spark Resistant Construction shall conform to AMCA 99.

F. SUBMITTALS

1) Submit shop drawings and product data sheets including performance data, fan performance curves, coil performance, vibration levels, access door locations, coil connection locations, structural framing, external support requirements (guy wire connections, etc..) maintenance requirements and sound power levels.
2) Fan manufacturer shall furnish a certificate of guarantee stating that the fan, mixing plenum, outlet nozzle, acoustical silencer nozzle, stack extension if any, and all related accessories specified herein have been pre-tested at the factory and that the fan curves have been de-rated for any and all system effects created by the accessories.

PRODUCTS

G. MIXED FLOW INDUCED DILUTION FAN

1) Impellers shall be mounted directly to the motor shaft to provide Arrangement 4 Direct Drive. Motors shall be isolated from the primary exhaust air stream. Motor maintenance shall be limited to greasing and accessible from the fan exterior. Models that are not Arrangement #4 will be rejected.

2) Mixed flow impellers shall consist of combination axial/backward curved blades and shall be of welded steel construction unless scheduled AMCA B. The impellers shall have non-stall and non-overloading performance characteristics with aerodynamically stable operation at any point on the fan curves.

3) Fan Performance shall be as stated on the schedule. The Static Pressure stated on the schedule shall be at the inlet to the “Fan System” and does not include any losses of equipment provided by the fan manufacturer (ie: HRU, Filters, Silencers, etc…). All losses for the equipment provided by the fan manufacturer shall be detailed in the fan manufacturers technical proposal and or submittal.

4) Fan and all drive components shall have a combined bearing life of a minimum of $L_{10} = 150,000$ hours.

5) Maintenance shall only be required on a minimum of 18-month intervals. This maintenance shall be limited to re-greasing of the motor bearings.

6) Stationary discharge guide vane sections shall be provided to increase fan efficiencies.

7) Fan dynamic balance shall not exceed 0.5 mil, peak-to-peak for nominal 900RPM, 1200RPM, and 1800RPM fans, or 0.055 in/sec -peak for 1800 RPM, 0.035 in/sec — peak for 1200 RPM, and 0.030 in/sec-peak for 900 RPM fans measured at the blade pass area when operating at fan frequency. Vibration isolation shall be limited to rubber-in-shear pad type isolators unless otherwise specified.

8) Factory test reports detailing vibration levels at the blade pass area shall be provided. Vibration levels shall be reported in both the axial and radial direction. If fan vibration is greater than 0.5 mils peak-to-peak at the blade pass area, fan manufacturer shall be responsible for providing vibration isolators on each fan and flexible connection at each duct inlet. Manufacturer shall add 0.5" additional static pressure to the fan system to compensate for losses through the flexible connection. Vibration isolators, 2” deflection seismic rated spring, must be installed on each individual fan with a minimum of four per fan. In addition, fan manufacturer shall be responsible for providing a method to repair or replace flexible connection or vibration isolators without shut down of the fan system. This includes any engineering, additional ductwork, and isolation dampers required to perform repairs while the
HVAC EQUIPMENT

9) If a belt drive fan is supplied the fan manufacturer shall include a seven (7) year service contract for maintaining the belts, sheaves and drive mechanism. This is to include monthly inspections as noted in the ANSI Z9.5, 4.14.7.2 and any tensioning, and belt replacement during the seven (7) year period. This contract shall be detailed in the proposal and included in its total value.

10) Standard fan assemblies (4 feet or lesser above standard height) shall be designed for mounting on conventional roof curb without the need for guy wire supports.

11) Discharges shall include twin FRP nozzles with passive third central stacks that are capable of generating aspiration. The FRP shall be chemically and UV resistant.

12) Entrainment windbands shall provide secondary induction of outside air. Induction shall take place downstream of the fan impeller and shall not influence BHP or static pressure requirements. Windbands shall discharge up to 270% of the design flow rates. The manufacturer shall publish discharge volumes for all fans at specified primary exhaust flow.

13) Fan shall be constructed to AMCA “C” standards per AMCA 99 with a non-ferrous inlet bell provided in order to reduce sparking in the event of a motor bearing failure.

14) Fans shall be modular construction and capable of being assembled on the roof.

15) Chemical resistant gaskets shall be provided at all companion flanged joints.

16) Fasteners shall be 316 stainless steel.

17) A bolted access door shall be provided for impeller inspection on each fan.

18) Fans and accessories shall have internal drain systems to prevent rain water from entering building duct system.

19) Electric motors shall be TEFC Mill & Chemical duty with a 1.15 service factor and an L10 bearing life of 150,000 hours. Premium Efficient motors shall have regreasable bearings with grease relief fittings in every NEMA frame. Fan motors shall be C-Face and foot mounted.

20) Extended motor lube lines of Teflon tubing covered with braided stainless steel shall be provided. Extended lube lines shall be mounted to a bracket located on the fan housing with grease relief fittings on each line.

21) A NEMA 3R non-fused disconnect switch shall be provided, mounted and wired to the motor.

22) All steel and aluminum surfaces components within the airstream that are not stainless steel or fiberglass must be surface prepped by abrasive blast clean to SSPC-SP10. Chemically cleaning of these components as a form of surface preparation is not acceptable. These components must be coated with a high solids epoxy with low VOC chemical resistant barrier coating epoxy. The coating system, a total thickness of up to 12 mils, is not affected by the UV component of sunlight (does not chalk), and has superior corrosion resistance to acid, alkali, and solvents. Coating system shall exceed 7000 hour ASTM B117 Salt Spray.
Resistance. Standard finish color to be gray. All coatings that include a zinc-rich epoxy primer are strictly prohibited. Zinc coatings react with alkalis and acids, thus causing premature failure of the coating system and should never be used for laboratory applications.

23) The fan supplied must meet the system exhaust CFM and the motor HP shall not be larger than that shown on the fan schedule. Any variation in HP shall require prior written approval from the engineer.

24) Fan and Mixing Box systems supplied by the manufacturer must have a footprint as shown on the drawings/schedule. Any variations from these sizes shall be highlighted in the equipment submittal.

25) The static pressure shown on the schedule is based on the static pressure requirements at the inlet to the mixing box. Any system deviating from the basis of design shall include and detail in their proposal additional losses for flexible connectors, fan losses, elbows, mixing box, etc. that are not included in their fan curves. In addition any deviation from the basis of design shall be subject to requirements stated in sections 1.3.2, 2.1.8 and 2.1.23.

H. ACCESSORIES

1) Inlet mixing plenums shall be provided by the fan manufacturer. Each plenum shall be sized to support the weight and performance requirement of the number of fans listed on the schedule. Multiple-fan plenums shall be insulated double wall construction with structural stiffeners. Double-wall plenums, except for fans over 3hp, shall have an overall minimum wall thickness of 1.5”, and the insulation shall have a minimum R value of 4.34. Outer skin of double wall plenums shall be coated 12Ga galvanized steel. Inner skin shall be uncoated 18Ga 304 stainless steel. Multiple-fan plenums shall be able to withstand a minimum of 12 in. w.g. of negative pressure. Single-fan plenums shall be of continuously welded, heavy gauge steel construction. For single-thickness plenums, coatings shall be the same as specified for the fans. All plenums shall be capable of supporting the fan(s) without guy wires or supports. The plenums shall include hinged access doors. The primary air inlets shall be located on the bottom or side as noted on construction drawings. Unless otherwise specified, plenums shall be suitable for mounting on roof curbs. Safety screens shall be supplied over inlet of fan.

2) Bypass dampers shall be provided with all mixing plenums for outside air with primary exhaust. Bypass damper(s) shall be sized to bypass the airflow capacity of one fan at the required static pressure of the system. Dampers will be opposed blade low leakage air foil control dampers with extended shaft for connection to an operator. The dampers shall be all aluminum construction unless otherwise specified. Rain hoods shall be provided with each damper. The dampers shall be controlled by 24v electric proportional control damper actuators (or hand quadrant where specified), which require no crank arm nor linkage. Bypass damper actuators shall be warrantied under the original part manufacturer’s warranty term.

3) An acoustic louver shall be provided at the inlet to the bypass dampers on systems requiring sound attenuation.
4) Low leakage isolation dampers shall be constructed of aluminum air foil extrusions and epoxy coated. Operators shall be 2 position, spring return and shall have On-off spring return damper actuators that are direct coupled type which require no crank arm and linkage and be capable of direct mounting to a jack shaft. Isolation damper actuators shall be warranted under the original part manufacturer’s warranty term.

5) Vortex breakers shall be provided on all side inlet and multiple fan plenums.

6) A galvanized steel roof curb shall be provided to support the fans/plenums. The curb shall be minimum 14 gauge and canted for rigidity in wind loads. The curb shall include a rigid fiberglass liner and a wood nailer.

7) Acoustical Silencer Nozzle shall be designed as an integral component of the exhaust fan discharge nozzle and shall not increase the height of the overall assembly. Integral Acoustical Silencer Nozzle with a minimum of 12dBA insertion loss. Lining the interior of the wind band is not an acceptable method of attenuation due to line of sight sound in the free area between the nozzle and wind band.

8) The Acoustical Silencer Nozzle shall provide the attenuation values as specified in the following schedule. The published insertion loss values shall be obtained from an AMCA 300 test with the silencer installed on the fan specified. Ratings based on separate silencer and fan testing is not acceptable.

<table>
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<th>OCTAVE BAND CENTER FREQUENCY (Hz)</th>
<th>FAN SIZE</th>
<th>SILENCER LENGTH</th>
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<th>125</th>
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<td>1000</td>
<td>2000</td>
<td>4000</td>
<td>8000</td>
<td></td>
</tr>
<tr>
<td>TS-2</td>
<td>64&quot;</td>
<td>0</td>
<td>4</td>
<td>9</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>9</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>TS-3</td>
<td>88&quot;</td>
<td>0</td>
<td>6</td>
<td>7</td>
<td>10</td>
<td>11</td>
<td>7</td>
<td>11</td>
<td>2</td>
<td></td>
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<tr>
<td>TS-4</td>
<td>89&quot;</td>
<td>5</td>
<td>8</td>
<td>9</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>10</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>TS-5</td>
<td>93&quot;</td>
<td>3</td>
<td>14</td>
<td>15</td>
<td>17</td>
<td>18</td>
<td>13</td>
<td>8</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

9) The silencer shall be constructed with an outer shell of fiber-reinforced plastic. The inner liner shall be perforated corrosion-resistant steel. The silencer shall match the color of the fans. Acoustic media shall be isolated from the air stream by a non-fibrous acoustical media.

I. HEAT RECOVERY UNIT

1) Strobic Air, Model Heat Recovery Plenum is the basis of design and specification for this project. Others will be considered as an alternate equipment manufacturer for review by the engineer with regard to approval or disapproval. The naming of such alternate equipment does not imply that they are approved. Such manufacturers are required to meet all details of this specification without exception. Manufacturers other than those named will not be considered and are not acceptable.

2) Side and Roof Panel Construction:
   a. Outdoor/weatherproof construction: All side panels shall provide a smooth, architecturally pleasing exterior surface with no exposed bolts or screws. Roof panels shall utilize welded seam construction. Shipping splits shall have mated roof seams with sealed cap strips over mating joints. Roof shall have a sloped roof with a minimum of 1/4
in/ft (20mm/meter) slope to ensure rain and snow runoff. Roof system shall be designed for 30 pounds/ft² snow load. Side and roof panels shall utilize overlapping seam construction on interior and are to be assembled with bolts such that each panel is individually removable. Bolted and removable panels are required for service access. Casing shall be of not less than 16 gauge galvanized steel. All pressure bearing side and roof panels shall be mechanically fastened construction for leak-free integrity and removability of panels.

b. All exterior walls shall be constructed of minimum 2” (50mm) thick acoustical/thermal panels. Maximum allowable deflection of any panel shall not exceed 1/200th of any span in any direction at unit design CFM. Casing shall be built to exceed AMCA Class “C” plenum requirements as outlined in AMCA 99 - Standards Handbook.

c. All panels shall be assembled with minimum of 1/4” Tek, 316SS on maximum 12” centers. After completion of the unit casing and after all panel bolts have been secured, each panel seam is sealed for air and water tightness with a continuous bead of high performance polyurethane sealant which meets ASTM C-920, Type S, Grade NS, Class 25 and is USDA-approved, paintable and EPA-approved for potable water contact.

d. Provide a unit housing with a minimum STC (Sound Transmission Class)(per ASTM E 90 and E413) as shown in the following tables:

<table>
<thead>
<tr>
<th>Octave bands</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1K</th>
<th>2K</th>
<th>4K</th>
<th>STC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2” wall, No Liner</td>
<td>23</td>
<td>27</td>
<td>35</td>
<td>44</td>
<td>50</td>
<td>49</td>
<td>39</td>
</tr>
<tr>
<td>2” wall, Solid Liner</td>
<td>21</td>
<td>38</td>
<td>44</td>
<td>52</td>
<td>51</td>
<td>53</td>
<td>45</td>
</tr>
<tr>
<td>4” wall, No Liner</td>
<td>24</td>
<td>29</td>
<td>41</td>
<td>50</td>
<td>57</td>
<td>62</td>
<td>42</td>
</tr>
<tr>
<td>4” wall, Solid Liner</td>
<td>28</td>
<td>39</td>
<td>48</td>
<td>55</td>
<td>55</td>
<td>60</td>
<td>50</td>
</tr>
</tbody>
</table>

e. 5. Interior liner shall be fabricated from minimum of 20 gauge 304 S.S..

J. UNIT BASE FLOOR

1) Unit base shall be constructed of welded structural steel around the perimeter of unit, with intermediate channel and angle iron supports. Bolted or formed C channel bases are not acceptable.

<table>
<thead>
<tr>
<th>A.H. UNIT/LENGTH</th>
<th>MINIMUM / CHANNEL SIZE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>UP TO 10’</td>
<td>4” X 1-5/8”</td>
<td>(5.4lbs/Lin.Ft.)</td>
</tr>
<tr>
<td>11’ TO 20’</td>
<td>6” X 2”</td>
<td>(8.2lbs/Lin.Ft.)</td>
</tr>
<tr>
<td>21’ TO 30’</td>
<td>8” X 2-1/2”</td>
<td>(11.5lbs/Lin.Ft.)</td>
</tr>
<tr>
<td>31’ TO 50’</td>
<td>12” X 3”</td>
<td>(20.7lbs/Lin.Ft.)</td>
</tr>
</tbody>
</table>

2) The unit floor is to be covered with 16 Ga 304 stainless steel, welded to base channel (no drive screws acceptable). All floor seams shall be supported underneath by intermediate channel and welded to supports. All seams shall be further sealed with a continuous bead of high performance polyurethane sealant which meets ASTM C-920, Type S, Grade NS, Class 25 and is USDA-approved, paintable and EPA-approved for potable water contact.
3) Removable type lifting lug assembly shall be welded to structural steel base. Provide a minimum of 4 lugs per section to ensure proper rigging. Rigging and lifting safety instructions shall be attached to unit.

4) All duct connections or control dampers in the floor of the unit shall be covered with heavy gauge steel “walk-on” safety bar grating bolted in place, to prevent people and large objects from passing through the unit floor into the ductwork. Bar grating shall be designed for a maximum deflection of 1/4” under a concentrated load(C) of 300# at mid span.

5) Curb mounted units shall come complete with roof curb support angle welded on interior side of welded base assembly. Curb support shall be concealed on interior of base to help prevent possibility of roof leakage. Units which perimeter base rests on roof curb is not permitted.

6) Roof curbs assembly shall be manufactured with 12 gauge galvanized steel designed to insure that each unit is level, compensating for roof pitch. Each air handling unit shall be supported by a single common roof curb designed to accommodate the entire assembly. Roof curbs shall have a 2” x 4” nailer strip along the outside edge of the entire perimeter to allow the contractor to attach the roofing material to the curb, therefore ensuring a weatherproof seal between the curb and the roof. The curbs shall be provided with a self-adhesive gasketing material (to be installed by the contractor) to provide the seal between the air handling unit assembly and the roof curb.

K. ACCESS DOORS

1) Provide full height (thru 7’7”) tall doors, 2” thick, double wall, insulated access doors where specified on unit drawings. Exterior and interior door skin shall be constructed from minimum of 16 gauge galvanized and painted steel (interior door skin will be unpainted 304 S.S. in all sections that have S.S. interior liners). Door insulation shall be 2” 3.0 lb/cu ft density.

2) Hinged, double wall, insulated, man size access doors shall be provided in all sections requiring access for maintenance or service. Access doors shall be fully gasketed with a closed cell, replaceable neoprene gasket. The gasketing material shall be installed to allow for easy removal and replacement. Access door must not leak more than 25 CFM @ 6” static pressure.

Door hinges and latches shall be easily adjustable, without the use of shims or special tools, to allow for a tight seal between the door and the doorframe as the gasketing material compresses over time. The door hinge design shall allow for field modification of door swing and doors shall be easily removable. Provide door detail drawing with submittal package.

Latches shall utilize knurled knobs. The latch assembly shall incorporate a built-in safety catch to release cabinet operating pressure prior to opening the door.

Doors entering into any section of the air handler that contains rotating fans shall be provided with zinc-plated nuts in lieu of knurled knobs. The nuts shall limit access to personnel with proper tools.

J. INSULATION:

1) The wall and ceiling panels shall be insulated with 2” – 1 1/2# duct board insulation secured in place with insulation retainers and Grip-Nail fasteners welded in place when necessary.
Insulation shall be NFPA-90a rated. Insulation shall have thermal conductivity K factor of .24 (Btu in./hr. sq ft oF) (@75oF mean) (R value = 7.8).

K. PAINTING:

1) All panels (wall and ceiling) shall be coated with Polyurethane primer and automotive grade polyurethane semi-gloss top coat. Paint color shall be Gray. Industrial grade primer shall be applied by air brush to 2 mils thickness and polyurethane top coat shall be applied by air brush to 6 mils thickness, for a total dry thickness of 8 mils. Paint system shall offer excellent color retention, low fade characteristics, excellent UV resistance, very good resistance to solvents, chemical fumes, acids and alkalis, and very good abrasion resistance. Paint system shall pass a minimum of 1000 hr. salt spray test per ASTM B-117. Test documentation shall be available upon request. Unit panels manufactured with Stainless Steel will not be painted.

2) Structural steel base and unit floor shall be coated with Polyurethane primer and automotive grade polyurethane semi-gloss top coat. Paint color shall be Gray. Industrial grade primer shall be applied by air brush to 2 mils thickness and polyurethane top coat shall be applied by air brush to 6 mils thickness, for a total dry thickness of 8 mils. Unit floors manufactured with Stainless Steel will not be painted.

L. COILS:

1) Heat recovery coils shall be of the plate fin extended surface type and ARI 410 certified. The primary surface shall be a minimum of 5/8” outside diameter seamless copper [0.020"] minimum wall thickness, and shall be expanded into the fin collars to provide a permanent mechanical bond: no metallic or thermal bonded materials shall be used. The secondary surface shall be flat or formed of 0.006” aluminum fins and shall be spaced not closer than 12 fins per inch with integral spacing collars that cover the tube surface. All coils shall be constructed with .025” thick brazed replaceable return bends. Same end connections are required. [Headers shall be non-ferrous seamless copper (cast iron headers are not acceptable), and provided with bronze brazed [steel] male pipe connections and separate 3/8” diameter pipe vent and drain connections extended through unit casing. All coils shall be fully drainable with no trapped tubes by design]. All coils shall be counterflow construction, with connections left or right hand as specified on the drawings.

2) Coil casings shall be minimum 16 gauge Stainless steel with double formed 1 1/4” flange on all sides of coil with tube sheets having extruded tube holes. Coil casing reinforcements shall be furnished so that the unsupported casing length is not over 60”. Reinforcements shall be made of same material as coil casing.

3) All tubes shall be tested at a minimum of 1500 PSIG and all assemblies tested under water at 350 psig and rated for 180 psig working pressure.

4) The coils shall be arranged for easy removal and coils shall be supported by 12 gauge stainless steel support channels. Coils shall be carefully blanked off with 16 gauge 304 stainless steel to insure no air bypasses the coil. The coil headers shall be located inside the cabinet casing with only the male pipe connections extending through the cabinet and cabinet penetration sealed air tight.

M. HI-EFFICIENCY FILTER SECTION:
1) Filter section shall be factory fabricated as part of air handling unit. Filters shall be arranged for upstream loading into positive sealing stainless steel filter frames. Frames shall be welded together, structural supports welded to frames and then the filter rack assembly mounted in air handler. Filter rack shall be thoroughly caulked and sealed to minimize filter bypass.

2) Provide with positive sealing stainless steel filter frames compatible with the filters.

3) Air handling unit manufacturer shall provide and flush mount (for each filter section), a Dwyer 3000 (or approved equal) Magnehelic air filter gage with weatherproof housing.

N. HI-EFFICIENCY SIDE ACCESS FILTER SECTION:

1) Filter section shall be factory fabricated as part of air handling unit. The side access filter rack shall accept 2” medium efficient pre-filters. Filter rack shall be thoroughly caulked and sealed to minimize filter bypass.

2) Air handling unit manufacturer shall provide and flush mount (for each filter section), a Dwyer 3000 (or approved equal) Magnehelic air filter gage with weatherproof housing.

3) Provide access door on side of unit per drawings.

O. MIXING BOX SECTION:

1) Mixing box section shall be complete with opposed blade type dampers and linkage. Inlet sizes shown are minimum allowable, in order to keep damper pressure drop and noise to a minimum. Opposed blade low leakage air foil control dampers with extended shaft for connection to an operator. The dampers shall be all aluminum construction. Rain hoods shall be provided with each damper. The dampers shall be controlled by a 24V electric operators

2) Low leakage isolation dampers shall be constructed of aluminum air foil extrusions and epoxy coated 10 mils DFT. Operators shall be 2 position, spring return and shall be 24V or 110V electric. Electric operators shall be factory wired, unless variable frequency drives are specified, (via a transformer when required) to the fan disconnect switch to open when the fan is energized and close via a spring return when de-energized. When the fan ships separate from the plenum, all wiring and conduit shall be factory supplied for easy connection in the field.

3) Provide weather hoods where shown on drawings. All weather hoods shall be fabricated with 10 gauge Aluminum or equivalent fiberglass. Weather hood shall have 1/2” (13mm) mesh, 19 gauge galvanized bird screen. Weather hood shall be 60 deg design and sized at a maximum of 600 fpm. Weather hoods will not extend beyond the horizontal envelope of unit dimensions by more than 40” and requires a minimum of 3’ clearance for proper performance.

P. ELECTRICAL

1) The motor horsepower, voltage and phase shall be as scheduled.

2) Each motor shall have an independent electrical connection.

3) Each fan shall be controlled by a variable frequency drive mounted in a NEMA 3S enclosure and mounted in the fan assembly.
Q. MOTOR CONTROLS

1) The motor RPM will be controlled and modulated by a static pressure sensor located in the exhaust duct.

2) Motor switching for fan failure or exercising rotation shall be accomplished by the controls contractor.

III. COMBINATION VARIABLE FREQUENCY DRIVE / DISCONNECT (VFD) FOR MOTORS 50 HP AND LESS

1) Manufacturers


2) General

   a. Furnish complete variable frequency VFDs with bypasses as specified herein for the fans and pumps designated on the drawing schedules to be variable speed. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. VFD shall be housed in a metal NEMA 12 and NEMA 3S enclosure of type according to the installation and operating conditions at the job site. The VFD’s UL listing shall allow mounting in plenum or other air handling compartments. If a NEMA 12 enclosure is required for the plenum rating, the manufacturer must supply a NEMA 12 rated VFD.

   b. The VFD shall have integral disconnecting means to disconnect power to device in accordance with NEC. The VFD shall include a manual bypass in case of a drive failure.

   c. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control and to eliminate the need for motor derating.

   d. With the motor’s rated voltage applied to the VFD input, the VFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor’s service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

   e. The VFD shall include an input full-wave bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.

   f. The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be assembled by the manufacturer, which shall be UL-508 certified for the building and assembly of option panels. Assembly of the option panels by a third-party panel shop is not acceptable. The appropriate UL stickers shall be applied to
both the VFD and option panel, in the case where these are not contained in one panel. When these VFDs are to be located in Canada, CSA or C-UL certifications shall apply. Both VFD and option panel shall be manufactured in ISO 9001 certified facilities.

g. The VFD shall have a dual 5% DC link reactor on the positive and negative rails of the DC bus to minimize power line harmonics and protect the drive from power line transients. The reactor shall be non-saturating (linear) to provide full harmonic filtering throughout the entire load range. VFDs with saturating (non-linear) DC link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load, where harmonic performance is most critical.

h. The VFD’s full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% of rated current for up to 0.5 second while starting.

i. The VFD shall be able to provide full torque at any selected frequency from 29 Hz to base speed to allow driving direct drive fans without derating.

j. An automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continually monitor the motor’s speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.

k. Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.

l. An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.

m. Galvanic and/or optical isolation shall be provided between the VFD’s power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete I/O shall include additional isolation modules.

n. VFD shall minimize the audible motor noise through the used of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.

o. VFD supplier shall coordinate with motor supplier to ensure that all motors 20 horsepower and greater are provided with grounding bushings.

3) Protective Features

a. A minimum of Class 20 $I^2t$ electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications shall be provided.
b. Protection against input transients, loss of AC line phase, output short circuit, output ground fault, overvoltage, undervoltage, VFD overtemperature and motor overtemperature. The VFD shall display all faults in plain English. Codes are not acceptable.

c. Protect VFD from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output with an input voltage as low as 164 V AC for 208/230-volt units, 313 V AC for 460-volt units, and 394 volts for 600 volts units.

d. The VFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.

e. VFD package shall include semi-conductor rated input fuses to protect power components.

f. To prevent breakdown of the motor winding insulation, the VFD shall be designed to comply with IEC Part 34-17. Otherwise the VFD manufacturer must ensure that inverter rated motors are supplied.

g. VFD shall include a “signal loss detection” circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10 V DC, and shall be programmable to react as desired in such an instance.

h. VFD shall function normally when the keypad is removed while the VFD is running and continue to follow remote commands. No warnings or alarms shall be issued as a result of removing the keypad.

i. VFD shall catch a rotating motor operating forward or reverse up to full speed.

j. VFD shall be rated for 100,000 amp interrupting capacity (AIC).

k. VFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.

l. VFD shall continue to operate without faulting until input voltage reaches 300 V AC on 208/230-volt units, 539 V AC on 460-volt units, and 690 volts on 600-volt units.

4) Interface Features

a. Hand/Start, Off/Stop and Auto/Start selector switches shall be provided to start and stop the VFD and determine the speed reference.

b. The VFD shall be able to be programmed to provide a 24 V DC output signal to indicate that the VFD is in Auto/Remote mode.

c. The VFD shall provide digital manual speed control. Potentiometers are not acceptable.

d. Lockable, alphanumeric backlit display keypad can be remotely mounted up to 10 feet away using standard 9-pin cable.
e. The keypads for all sizes of VFDs shall be identical and interchangeable.

f. To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD’s keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters.

g. Display shall be programmable to display in 9 languages including English, Spanish and French.

h. The display shall have four lines, with a minimum of 20 characters on three lines and a minimum of eight large characters on one line.

i. A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.

j. A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD eliminating the need for macros.

k. As a minimum, the following points shall be controlled and/or accessible:

1) VFD Start/Stop
2) Speed reference
3) Fault diagnostics
4) Meter points
   (a) Motor power in HP
   (b) Motor power in kW
   (c) Motor kW-hr
   (d) Motor current
   (e) Motor voltage
   (f) Hours run
   (g) Feedback signal #1
   (h) Feedback signal #2
   (i) DC link voltage
   (j) Thermal load on motor
   (k) Thermal load on VFD
   (l) Heatsink temperature

l. Four additional Form C 230-volt programmable relays shall be available for factory or field installation within the VFD.

m. Two set-point control interface (PID control) shall be standard in the unit. VFD shall be able to look at two feedback signals, compare with two set-points and make various process control decisions.

n. Floating point control interface shall be provided to increase/decrease speed in response to contact closures.
o. Four simultaneous displays shall be available. They shall include frequency or speed, run time, output amps and output power. VFDs unable to show these four displays simultaneously shall provide panel meters.

p. Sleep mode shall be provided to automatically stop the VFD when its speed drops below set “sleep” level for a specified time. The VFD shall automatically restart when the speed command exceeds the set “wake” level.

q. The sleep mode shall be functional in both follower mode and PID mode.

r. Run permissive circuit shall be provided to accept a “system ready” signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the VFD to start.

s. The following displays shall be accessible from the control panel in actual units: Reference Signal Value in actual units, Output Frequency in Hz or percent, Output Amps, Motor HP, Motor kW, kWh, Output Voltage, DC Bus Voltage, VFD Temperature in degrees, and Motor Speed in engineering units per application (in GPM, CFM, etc.). VFD will read out the selected engineering unit either in a linear, square or cubed relationship to output frequency as appropriate to the unit chosen.

t. The display shall be programmed to read in inches of water column (in-wg) for an air handler application, pressure per square inch (psi) for a pump application, and temperature (°F) for a cooling tower application.

u. VFD shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.

v. If the temperature of the VFD’s heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the VFD shall automatically reduce its output frequency to the motor. As the VFD’s heat sink temperature returns to normal, the VFD shall automatically increase the output frequency to the motor and return the carrier frequency to its normal switching speed.

w. The VFD shall have temperature controlled cooling fans for quiet operation and minimized losses.

x. The VFD shall store in memory the last 10 faults and related operational data.

y. Eight programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.

z. Two programmable relay outputs, one Form C 240 V AC, one Form A 30 V AC, shall be provided for remote indication of VFD status.

aa. Three programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two voltages (0 to 10 V DC, 2 to 10 V DC) and one current (0 to 20 mA, 4 to 20 mA) input.
bb. Two programmable 0 to 20 mA analog outputs shall be provided for indication of VFD status. These outputs shall be programmable for output speed, frequency, current and power. They shall also be programmable to provide a selected 24 V DC status indication.

c. Under fire mode conditions, the VFD shall be able to be programmed to automatically default to a preset speed.

d. On motors connected to variable frequency drives, 20hp or greater in size. Provide grounding bushings to prevent arcing.

5) Interface with Building Automation System/Direct Digital Control System

a. VFD manufacturer shall provide an interface to the BAS/DDC system. Manufacturer shall coordinate as required with the Controls Contractor. Provide Bacnet, Lonworks, FLN, Modbus, or any other interface required for a complete and operational system.

b. Provide mode of operation to BAS/DDC system (hand, off, auto, etc.). BAS/DDC graphic shall highlight or produce pop-up graphic when VFD is in hand or off. Also, provide all points to BAS/DDC identified in section (4).K of this Specification.

6) Adjustments

a. VFD shall have an adjustable carrier frequency in steps of not less than 0.1 kHz to allow tuning the VFD to the motor.

b. Sixteen preset speeds shall be provided.

c. Four acceleration and four deceleration ramps shall be provided. Accel and decel time shall be adjustable over the range from 0 to 3,600 seconds to base speed. The shape of these curves shall be automatically contoured to ensure no-trip acceleration and deceleration.

d. Four current limit settings shall be provided.

e. If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: under voltage, overvoltage, current limit and inverter overload.

f. The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.

g. An automatic “on delay” may be selected from 0 to 120 seconds.

7) Service Conditions

a. Ambient temperature, -10 to 40°C (14 to 104°F), without derating.

b. 0 to 95% relative humidity, non-condensing.

c. Elevation to 3,300 feet without derating.

d. AC line voltage variation, -10 to +10% of nominal with full output.
e. No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.

8) Quality Assurance

a. To ensure quality and minimize infantile failures at the jobsite, the complete VFD shall be tested by the manufacturer. The VFD shall operate a dynamometer at full load and speed and shall be cycled during the test.

b. All optional features shall be functionally tested at the factory for proper operation.

9) Submittals

a. Submit manufacturer’s performance data including dimensional drawings, power circuit diagrams, installation and maintenance manuals, warranty description, VFD’s FLA rating, certification agency file numbers and catalog information.

The specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from the specification are identified, the supplier shall be bound by the specification.

a. Harmonic filtering. The seller shall, with the aid of the buyer’s electrical power single line diagram, providing the data required by IEEE-519, perform an analysis to initially demonstrate the supplied equipment will met the IEEE standards after installation. If, as a result of the analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then the cost of such equipment shall be included in the bid. A harmonic analysis shall be submitted with the approval drawings to verify compliance with the latest version of IEEE-519 voltage and current distortion limits as shown in table 10.2 and 10.3 at the point of common coupling (PCC). The PCC shall be defined as the consumer–utility interface or primary side of the main distribution transformer.

10) Start-Up Service

a. The manufacturer shall provide on-site start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system. Provide start-up report to Engineer.

11) Warranty

a. The VFD shall be warranted by the manufacturer for a period of 36 months from date of shipment. The warranty shall include parts, labor, travel costs and living expenses incurred by the manufacturer to provide factory authorized on-site service. The warranty shall be provided by the VFD manufacturer.

12) Examination
HVAC EQUIPMENT

a. Contractor to verify that job site conditions for installation meet factory recommended and code-required conditions for VFD installation prior to start-up, including clearance spacing, temperature, contamination, dust, and moisture of the environment. Separate conduit installation of the motor wiring, power wiring, and control wiring, and installation per the manufacturer’s recommendations shall be verified.

b. The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

3. FACTORY START-UP REPORTS

I. Provide factory start-up on site by a factory representative (not a third-party contractor) for all HVAC equipment, including air handling units, fans, etc. Submit factory start-up reports to the Engineer. The Mechanical Contractor and the Controls Contractor shall have a representative on site to correct all deficiencies noted by the factory representative. For each deficiency noted, documentation of corrective action taken shall be submitted to Engineer.

J. The owner shall withhold 10% of the total equipment cost at time of purchase until the construction project is complete and the system has been started and successfully operating for 2 weeks without issue.

K. At a minimum, the report submitted to the Engineer shall include the following data:

1) Exhaust fans
   a. Fan rotation
   b. Confirm all wiring connections are correct
   c. Confirm all field wiring is correct
   d. Adjust belt tensions and alignments
   e. Confirm sequence of operation is correct
   f. Confirm damper operation

2) Air Handling Units
   a. Verify economizer operation
   b. Verify operating per sequence of control
   c. Discharge air temperature sensor calibration
   d. Discharge static pressure
   e. Dirty filter differential pressure switch function
   f. Outside air temperature sensors calibration
   g. Return air temperature sensor calibration
   h. Airflow monitoring station calibration
   i. VFD response to pressure sensors or other DDC input
   j. Smoke detection shut down
   k. Freeze protection sequence
l. Fan bearings lubrication
m. Fan not vibrating
n. Fan motor volts / amps
o. Check drive belt tension
p. Check sheave alignment
q. Coils clean
r. Dampers operating properly
s. Filters clean
t. Fan rotation direction

END OF SECTION 230200
SECTION 250200 – INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1. RELATED DOCUMENTS:

   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, General Mechanical Provisions and General Requirements, Division 1 Specification Sections apply to the work specified in this section.

   B. The Controls Contractor shall be selected based on this package bid with the contract being awarded to the low bid contractor. The successful bidder will then be assigned as a sub contract to the Mechanical Contractor who will be acting as the General Contractor on the project. The overall project shall include but is not limited to the replacement of air handling units, exhaust fans, ductwork, piping, etc.

2. DESCRIPTION OF WORK:

   A. Furnish a BACnet system compatible with existing University systems. All building controllers, application controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135-2001, BACnet. This system shall communicate with the University of Kentucky Facility Management’s existing BACnet head-end software using BACnet/IP at the tier 1 level and BACnet/MSTP at the tier 2 level. No gateways shall be used for communication to controllers installed under section. BACnet/MSTP or BACnet/IP shall be used for all other tiers of communication. No servers shall be used for communication to controllers installed under this section. If servers are required, all hardware and operating systems must be approved by the Facilities Management Controls Engineering Manager and/or the Facilities Management Information Technology Manager.

   B. The scope included within this specification shall be bid separately prior to the overall project bid. The successful bid will then be assigned to the Contractor as all Controls work shall be completed as a sub-contract to the Mechanical Contractor.

   C. All Building Automation Devices should be located behind the University firewall, but outside of the Medical Center Firewall and on the environmental VLAN.

   D. Provide all necessary hardware and software to meet the system’s functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers. These must be in compliance with Front End systems PICS and BIBBS and attached Tridium PICS and BIBBS. Provide all hardware and software to backup, restore, troubleshoot and install system. Software licensing upgrades will also need to be included to support all new BACnet devices/points added within the project for the University of Kentucky Facilities Management’s head-end system. Software, backups, unitary, and ASC files shall be delivered to UEM (Utilities & Energy Management) for archiving purposes.

   E. Prepare individual hardware layouts, interconnection drawings and software configuration from project design data.
F. Design, provide, and install all equipment cabinets, panels, data communication network cables needed, and all associated hardware.

G. Provide and install all interconnecting cables between supplied cabinets, application controllers, and input/output devices.

H. Provide complete manufacturer’s specifications for all items that are supplied. Include vendor name of every item supplied.

I. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, startup, and commissioning.

J. Provide a comprehensive operator, administrator and technician training program as described herein.

K. Provide as-built documentation, programming software for use site wide, electronic copies of all diagrams, and all other associated project operational documentation (such as technical manuals on approved media, the sum total of which accurately represents the final system.

L. Furnish, install, and fit-up in complete working order, with all accessories required, the automatic temperature control and monitoring systems shown on the Drawings and specified herein. The systems shall be properly connected, piped and wired in a manner conforming to the laws, ordinances and codes now in force in the Commonwealth of Kentucky.

M. The controls and all listed I/O points from this project shall communicate with the University of Kentucky Facilities Management’s existing BACnet software head-end station using BACnet/IP. All BACnet points shall be exposed to the University of Kentucky Facilities Management’s head-end station. Graphics will be installed by UEM on the head-end system. All point and device names shall comply with the University Facilities Management standards and shall be approved before and included in the shop drawings submittal. Cooperate with the Owner (UEM) to ensure that all specified points and alarms communicate and operate on the head-end system. All point and device names shall comply with the University Facilities Management standards (format listed below, consult Utilities and Energy Management (UEM) for the correct abbreviations) and shall be included in the shop drawings submittal for review and approval. Point naming conventions and formats are listed further in this specification in the Direct Digital Controls Equipment section. Refer to University Standard 230553S02 for the AHU Naming Convention.

N. Related to the alarms, the contractor is to set up the alarm parameters specified by the system sequences of operations without enabling the alarms. Contractor is to provide a list of points containing alarm extensions to Owner (UEM). UEM will be responsible for doing the alarm names, alarm texts and enabling the alarm points provided on the list.

O. All work must be coordinated and scheduled with the UEM Controls group prior to any work being done on site.

P. Existing controls equipment (equipment level or building controllers) shall be salvaged and turned over to the University. Honeywell DGP panels can be discarded.
Q. Thermostats: Each terminal unit requires a thermostat for operation, unless specifically indicated on the Drawings to be slaved to another unit. Slaved terminal units shall be controlled to match the CFM and discharge air temperature of the master unit. Thermostat locations have been identified on the Drawings to the extent possible, but all such locations may not be shown. Provide the required thermostats whether or not shown on the Drawings. For those thermostats not shown on the Drawings, work out an acceptable location with the Architect/Engineer. Thermostats are to be provided with no doors.

R. Provide DDC controls for the air terminal units. Provide electronic operators controlled and monitored by direct digital control systems which shall include, but not be limited to, air handling systems, pumps, terminal units, etc.

S. The control equipment shall be complete and shall include, but not be limited to, all necessary valves, damper operators, pipe, fittings, etc.

T. Electronic Control System installer must physically demonstrate to Owner and Owner's representatives (UEM) via software simulations that the proposed building automation system and control sequences will function as outlined in the contract documents prior to field implementation.

U. The control and monitoring system for this project shall be made up using standard materials, equipment and components regularly manufactured for systems of this type. The system shall be complete in every respect and shall be a functioning system.

V. Electrical power wiring and interlock wiring for all controls, signal devices, equipment, alarms, etc., shall be in accordance with diagrams and instructions from the supplier of the systems. All power and control wiring, conduit and wiring connections required for the complete installation, including wiring to smoke dampers and combination fire/smoke dampers and their motors, shall be provided by this Contractor in accordance with Electrical specification requirements. Controls shall be on emergency power.

W. Refer to other Mechanical Division sections for installation of instrument wells, valve bodies, and dampers in mechanical systems; not work of this section.

X. Emergency Electric power for the control panels, modules, unit controller, valve motors, etc., shall be derived from the building emergency electric system. Power shall not be derived from the HVAC equipment power source or equipment low voltage transformers (internal or integral).

   a. All controls panel located in the main mechanical/electrical rooms and penthouses shall be provided with emergency lighting as well. If there is not lighting on emergency power in the area needed to provide a minimum of 30 foot candles lighting, then the controls contractor is responsible for providing at least these panel locations. These shall include control of the following system.

      i. All Air handling unit control systems
      ii. Heating hot water system control
      iii. Chilled water system control
      iv. Emergency generator system control
      v. Communication Room HVAC system control

Y. All exterior electrical work, equipment, etc. shall be waterproofed.
Z. UK Communications department (UK ITS) shall provide all required HUB’s routers and switches required to interface to the campus WAN network. The cost for this work shall be included by the controls manufacturer. The controls contractor is responsible for providing all data drops necessary for their control panels and acquiring all necessary IP addresses from the UK ITS. Obtain pricing from the UK Campus Communication Department prior to bid.

3. QUALITY ASSURANCE:

A. Manufacturer: Subject to compliance with requirements, manufacturers offering controls that may be incorporated into the work at Tier 1 BACnet/IP include the following:

Honeywell  
Johnson Controls  
Vykon

B. Subject to compliance with requirements, manufacturers offering controls that may be incorporated into the work at Tier 2 BACnet/MSTP include the following:

Honeywell  
Johnson Controls  
Alerton  
Distech

C. Acceptable controls manufacturers shall include any controls manufacturers which utilize a BACnet protocol in accordance with the specification. If the bidding manufacturer is not listed above, documentation for approval as an equal must be submitted 10 days prior to the bid opening date to allow for evaluation by the university.

D. Installing Contractor: Installing controls contractors must comply with the following requirements:

E. The installing systems integration contractor has been in the business of installing BACnet controls for the last 5 years minimum. In addition, the installing systems integration contractor needs to demonstrate with documentation that they have provided the controls in a minimum of (3) hospital or university renovation projects of similar size and scope where they utilized a BACnet system.

F. The systems integration contractor must have on staff the following number of key personnel as a minimum, each with a minimum of 5 years of related BACnet controls installation experience: Project Manager - 2, Controls Applications Engineer - 2, Programmer - 2, Installation Supervisor - 2, Controls Technician - 5.

G. Prefer contractor staff to include Niagara Tridium AX/N4 certified technicians.

H. Contractor to have experience with successful integrations of controls with Niagara Tridium systems.

I. Contractor to have a minimum of 3 years of installation history with the brand of controls being bid.
J. Contractor must have a help desk operation or staff available for phone contact 24/7 for providing technical support to university staff. Call forward and emergency service numbers are not acceptable during normal business hours.

4. CODES AND STANDARDS:

A. Electrical Standards: Provide electrical components of pneumatic control systems which have been UL-listed and labeled, and comply with NEMA standards.

B. NFPA Compliance: Comply with NFPA 90A "Standard for the installation of Air Conditioning and Ventilating Systems" where applicable for controls and control sequences.

C. Kentucky Building Code: Comply with requirements where applicable for controls.

D. Provide products of the temperature control system with the following agency approvals:

   UL-916; Energy Management Systems
   UL-873; Temperature Indication and Regulating Equipment
   UL-864; Subcategories UUKL, OUXX, UDTZ; Fire Signaling and Smoke Control Systems
   CSA; Canadian Standards Association
   FCC, Part 15, Subpart J., Class A Computing Devices

E. All products shall be labeled with the appropriate approval markings. System installation shall comply with NFPA, NEMA, NEC, Local and National Codes.

5. SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for each control device furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes, also include installation and start-up instructions.

   A. Shop Drawings, Product Data, and Samples

      1. Each submittal shall have a cover sheet with the following information provided: submittal ID number; date; project name, address, and title; BAS Contractor name, address and phone number; BAS Contractor project manager, quality control manager, and project engineer names and phone numbers.

      2. Each submittal shall include the following information.

         a. BAS riser diagram showing all DDC controllers, network repeaters, and network wiring.

         b. One-line schematics and system flow diagrams showing the location of all control devices.
c. Points list for each DDC controller, including: Tag, Point Type, System Name, Object Name, Expanded ID, Display Units, Controller Type, Address, Cable Destination, Module Type, Terminal ID, Panel, Slot Number, Reference Drawing, and Cable Number. The initial shop drawing submittal for review needs to include all point names meeting the naming convention outlined in this specification for UEM approval at the shop drawing phase prior to the contractor beginning any programming.

d. Vendor’s own written description for each sequence of operations, to include the following:
   - Sequences shall reference input/output and software parameters by name and description.
   - The sequences of operations provided in the submittal by the BAS Contractor shall represent the detailed analysis needed to create actual programming code from the design documents.
   - Points shall be referenced by name, including all software points such as programmable setpoints, range limits, time delays, and so forth.
   - The sequence of operations shall cover normal operation and operation under the various alarm conditions applicable to that system.

e. Detailed Bill of Material list for each panel, identifying: quantity, part number, description, and associated options.

f. Control Damper Schedules. This spreadsheet type schedule shall include a separate line for each damper and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Blade Type, Bearing Type, Seals, Duct Size, Damper Size, Mounting, and Actuator Type.

g. Control Valve Schedules. This spreadsheet type schedule shall include a separate line for each valve and a column for each of the valve attributes, including: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Calc CV, Design Pressure, Actual Pressure, and Actuator Type.

h. Cataloged cut sheets of all equipment used. This includes, but is not limited to, the following: DDC panels, peripherals, sensors, actuators, dampers, and so forth.

i. Range and scale information for all transmitters and sensors. This sheet shall clearly indicate one device and any applicable options. Where more than one device to be used is on a single sheet, submit two sheets, individually marked.
j. Hardware data sheets for all local access panels.

k. Software manuals for all applications programs to be provided as a part of the programming devices, and so forth for evaluation for compliance with the performance requirements of this Specification.

l. The controls contractor shall include their BACnet PICS and BIBB statements (as described in ASHRAE 135-2001) for each device.

3. BAS Contractor shall not order material or begin fabrication or field installation until receiving authorization to proceed in the form of an approved submittal. BAS Contractor shall be solely responsible for the removal and replacement of any item not approved by submittal at no cost to the Owner.

4. Submittal shall have approved point names.

6. Maintenance Data: Submit maintenance instructions and spare parts lists for each type of control device. Include that type data, product and shop drawings in maintenance manual.

7. Operation and Maintenance Instructions:

A. This contractor shall prepare an electronic Operations Manual entitled "Automatic Temperature Control and Monitoring Systems Operation and Maintenance Data." Manual shall be PDF files with separate PDFs for each of the items noted below.

B. Each manual shall contain the following information:

Name and address of Consulting Engineer, Contractor, and index of equipment, including vendor (name and address).

Complete brochures, descriptive data and parts list, etc., on each piece of equipment, including all approved shop drawings.

Complete maintenance and operating instructions, prepared by the manufacturer, on each major piece of equipment, including preventative maintenance instructions.

Complete shop drawing submittal on temperature and monitoring controls including control diagrams updated to reflect "as-built" conditions.

All wiring and component schematics necessary for Owner (UEM) to troubleshoot, repair and expand the system.

All manuals shall be submitted to the Engineer prior to final inspection of the building.

Provide a laminated copy mounted in a sleeve on the outside of the panels for the controls sequences pertinent to equipment supplied by that specific controls panel.
8. Controls Program Backup: At the end of the project, the contractor is to supply digital back-up copies of all final complete operating controls programs. These shall be delivered to UEM for archiving purposes.

9. DELIVERY, STORAGE AND HANDLING:

Provide factory shipping cartons for each piece of equipment and control device. Maintain cartons while shipping, storage and handling as required to prevent equipment damage and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

PART 2 - PRODUCTS

1. DIRECT DIGITAL CONTROL SYSTEM

General: This specification defines the minimum hardware and performance requirements for a computer-based building automation system to be furnished and installed.

SCOPE OF WORK:

2. System Requirements:

A. Contractor shall provide all equipment, engineering and technical specialist time to check the installation required for a complete and functioning system. The contractor shall furnish and install all interconnecting system components. Components to include, but not be limited to: power line conditioners, field panels, sensors, motor starter interfaces, and any other hardware items not mentioned above but required to provide the Owner with a complete workable system.

B. Any feature or item necessary for complete operation, trouble-shooting, and maintenance of the system in accordance with the requirements of this specification shall be incorporated, even though that feature or item may not be specifically described herein. This shall include hardware and software.

C. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. All systems and components shall be thoroughly tested and proven in actual use.

3. Input/Output Summary:

A. The system as specified shall monitor, control and calculate all of the points and functions as listed in the Input/Output Summary.

4. System Start-Up and Acceptance:
A. Upon completion of the installation, the BAS Contractor shall start-up the system and perform all necessary testing and debugging operations. An acceptance test in the presence of the Owner's representative shall be performed. The vendor shall check all sensors that exhibit any problems or faulty reading. When the system performance is deemed satisfactory in whole by UEM, the system parts will be accepted for beneficial use and placed under warranty. The BAS Contractor is to be available for system commissioning at the end of the installation when requested by the Engineer and/or Owner. The contractor is to also be available for seasonal commissioning for the other seasons beyond the initial commissioning.

B. This Contractor shall work with the Owner (UEM), who is developing the graphics, to ensure that all points report, function and alarm as required on the BACnet head-end system. The Contractor will also work with the Project Manager or CNS/MCIS to obtain all necessary IP’s and Ethernet drops needed for BACnet panel. The Owner (UEM) will assign all BACnet/IP instance numbers and all BACnet/MSTP network numbers for use by the Contractor. All BACnet/IP devices will report directly to the head-end system.

C. UEM will be performing their own complete point by point evaluation as part of this project, independently of the commissioning activity. This will occur during the warranty period of the project.

5. Facilities Management’s Instruction:

A. The BAS Contractor shall provide two copies of an electronic version of the operator's manual describing all operating and routine procedures to be used with the system. This user's manual should contain subjects such as: standard operation, error message explanations, software usage, commands, system troubleshooting, etc. The Contractor shall also provide wiring schematics for all system components.

B. The BAS Contractor shall instruct the Owner's designated representatives in these procedures during the start-up and test period. The duration of the instruction period shall be no less than eight (8) hours during four 4 hour sessions. These instructions are to be conducted during normal working hours at the Owner's convenience and are to be prearranged with the Owner. The owner can request this training any time within the one-year warranty period and may request any number of classes adding up to the total number of hours. The contractor shall provide an hourly unit price for additional on-site training.

C. The instructions shall consist of both hands-on at the job site and classroom training at a classroom location on the University of Kentucky campus coordinated with the Project Manager and UEM.

D. Upon completion, the attendees shall be able to operate the system and implement system changes including start-up, boot load, add point to the data base, enter messages, and down line load field units.

E. Prior to the scheduling of the sessions, an agenda outlining the training topics must be submitted for approval. Agenda items shall include, but not be limited to, the following topics:

   1) Explanation of control sequences. Include which sensors are used and how output device operates.
   2) Explanation of control drawings and manuals, including symbols, abbreviations,
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and overall organization.

3) Walk-through of project to identify controller locations and general routing of network cabling.

4) Review of operation and maintenance of hardware devices including air compressor, air dryers, controllers, instruments, and sensors. Include schedule for routine maintenance.

5) Programming Application Specific Controllers
   (a) Backing up and Restoring Application Specific Programming
   (b) Adding/Deleting/Editing points on Application Specific controllers
   (c) Troubleshooting Application Specific controllers (inputs/outputs/logic/master – slave relationships/bus issues)

6) Programming Building Specific Controllers
   (a) Backing up and Restoring Building Specific Controllers Programming
   (b) Adding/Deleting/Editing points on Building Specific Controllers controllers
   (c) Troubleshooting Building Specific Controllers controllers (inputs/outputs/logic/network issues)

7) How to use tools and cables

6. Warranty

The system including all hardware and software components shall be warranted for a period of one year when the system performance is deemed satisfactory in whole by UEM. The system parts will be accepted for beneficial use and placed under warranty at that time. A Certificate of Occupancy does not initiate the control system warranty. Any defects in materials and workmanship arising during this warranty period shall be corrected without cost to the Owner.

All applicable software as detailed in this specification shall be updated by the BAS Contractor free of charge during the warranty period. This will ensure that all system software will be the most up-to-date software available from the BAS Contractor.

7. Direct Digital Control (Ddc) Equipment

System Software

A. All software required for monitoring, modifying, configuring and backup for the system shall be embedded in the controller and accessible via VT terminal, hyper-terminal or the web. This software shall allow any computer with access (and security) to the University’s network to perform the work described above using a web browser or provided software. No software upgrades should be required unless provided at no additional cost to the customer. The software version used for installation of any new devices must either be at the current software version used on the University Facilities Management campus at the current JAVA version or the new software at the most current JAVA version must be installed on all devices and the current system prior to the installation of the new devices. All software is to also operate on the latest version of Microsoft Windows operating system. All configuration and programming tools required for the upgraded version must be provided at the time of installation.

Provide a USB, standard RS-232 9 pin female, Bluetooth, RJ11, RJ12 or RJ45 connection for on-site access.
8. BACnet Conformance

A. Building Controller shall as a minimum support MS/TP and Ethernet BACnet LAN types. It shall communicate directly via these BACnet LANs as a BACnet device and shall support simultaneous routing functions between all supported LAN types. Global controller shall be a BACnet conformance class 3 device and support all BACnet services necessary to provide the following BACnet functional groups:

1. Clock Functional Group
2. Files Functional Group
3. Reinitialize Functional Group
4. Device Communications Functional Group
5. Event Initiation Functional Group

B. Please refer to end of this section for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data.

C. Standard BACnet object types supported shall include as a minimum: Analog Value, Binary Value, Calendar, Device, File, Group, Notification Class, Program and Schedule object types. Alarms should also be setup on this system with limits. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data.

D. The Building Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork. It must support interoperability on the campus area network and function as a BACnet Broadcast Management Device (BBMD) and/or a BACnet router.

9. Building Controller (B-BC)

A. General

B. Building Controller (B-BC) shall be minimum 16 bit microcomputer based, utilizing a multi-tasking, multi-user operating system.

C. The B-BC controllers shall permit the simultaneous operation of all control, communication facilities management and operator interface software, as programmed by the Contractor or User. Modification of the on-board B-BC controller database shall be performed on-line using the built-in software. Systems which require the B-BC to be removed from service while DDC control sequences are modified shall not be acceptable.

D. B-BC controllers shall utilize true floating point arithmetic capabilities.

E. All B-BC controllers shall have open licensing to connect to existing UK UEM Tridium BACnet BAS.

10. Databases and Memory Back-Up
All programming defining the functions to be performed by the B-BC, including but not limited to application programs and point database within each B-BC, shall be protected from loss due to power failure for a minimum of 72 hours. All database and backup shall be provided to the UK UEM Controls group.

11. Service Ports

B-BC controllers shall be equipped with a minimum of one operator service port for the connection of a laptop computer. The service port shall be either a built-in standard RS-232 data terminal port, USB port, CAT5 cable or RJ11/12 connection.

Connection of a service device, to a service port, shall not cause the B-BC controller to lose communications with its peers or other networked device controllers.

12. Display and Readout Capability

The B-BC controller shall additionally provide diagnostic LED indication of device transmit and receive data communications for all communication port and peripheral ports, normal operation, abnormal operation and control relay operation indication.

13. Manual/Auto Control and Notification

The B-BC controller shall provide commanded override capability from the built-in operator interface. Such overrides shall be annunciated to the head-end station. Such overrides shall be valid as long as power is applied to the controller.

14. Adjustments

Every control panel shall provide adjustments for the functions specified. In general, adjustments shall be provided for all setpoints used by controllers within each control panel. In addition, adjustments shall be provided for throttling ranges, mixed air damper minimum positions, or other items as specified. Adjustments shall be integral to each individual B-BC. The built-in operator interfaces shall allow the easy execution of the adjustment through named identifiers within the B-BC. From a single B-BC user interface, any other B-BC shall be accessible and full adjustment capabilities shall be provided.

15. B-BC Naming Convention

B-BC devices shall be named using the following naming convention:

\[
\text{B-BC devices shall be named using the following format:} \\
\text{BuildingName_BuildingNumber_Floor_RoomNumber_B-BC Device Type OR} \\
\text{BuildingNumber_BuildingName_Floor_RoomNumber_B-BC Device Type} \\
\text{All B-AAC points shall be named using the following format:} \\
\text{Building_Floor_RoomNumber_Device Type_Equipment ShortName_Function} \\
\]

Examples:

A B-BC device located in the Pavilion HA mechanical room HA4001 would be named as follows: PAVHA_0293_04_HA4001_JACE
An exhaust fan status point for a fan in Pavilion HA mechanical room HA3001 fed directly from the above panel would be named as follows:

PAVHA_03_HA3001_HVA_EF1_STAT

For function short names and building short names and numbers, contact the University Controls Engineering Department.

16. Advanced Application Controller (B-AAC)

General

A. Controls shall be microprocessor based, Advanced Application Controllers (B-AAC’s). B-AAC’s shall be provided for Air Handling Units, packaged Rooftops, primary and secondary pumping loop systems and other applications as shown on the drawings. B-AAC’s shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the B-AAC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter. All input points shall be universal in nature allowing their individual function definition to be assigned through the application software. All unused input points must be available as universally definable at the discretion of the owner. If the input points are not fully universal in nature, unused points must be equal in quantity between Analog Inputs and Digital Inputs.

B. All B-AAC controllers shall have open licensing to connect to existing UK UEM Tridium BACnet BAS.

C. Contractor shall provide a minimum of one B-AAC controller per air handling or mechanical system as shown on the drawings.

D. The BAS contractor shall provide and field install all B-AAC’s specified under this section. Mechanical equipment manufacturers desiring to provide B-AAC’ type controls as factory mounted equipment, shall provide a separate bid for their products less all controls, actuators, valve assemblies and sensors, which are specified to be provided by the BAS/Temperature control contractor.

E. All input/output signals shall be directly hardwired to the B-AAC. Troubleshooting of input/output signals shall be easily executed with a volt-ohm meter (VOM). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.

F. B-AAC’s shall be in continuous direct communication with the network which forms the facility wide Building Automation System. The B-AAC’s shall communicate with the B-BC at a minimum baud rate of 9,600 baud.

17. Non-Volatile Memory
A. All control sequences programmed into the B-BC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the GDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The B-BC shall allow for the creation of unique application control sequences. Systems that only allow selection of sequences from a library or table are not acceptable.

B. All control sequences shall be fully programmable at the B-AAC, allowing for the creation and editing of an application control sequence, while at the unit.

C. The B-AAC shall be provided with an interface port (standard RS232 data terminal port or USB port) for a laptop computer. The interface port shall allow the laptop to have full functionality as described above. From the interface port or network terminal, the laptop shall be able to directly access any B-AAC or B-ASC in the network.

D. The B-AAC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples, per Input/Output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken. The samples shall be protected against loss due to power interruptions through a battery or capacitor backup method for a minimum of 30 days.

E. Systems unable to provide the above capability shall provide for the individual Input/Output point trending at the B-BC. Specifics as to how each B-AAC point will be trended, at the B-BC, shall be provided in the submittal documents. Included in the explanation shall be the sample intervals, the memory allocation in the B-BC and the number of B-AAC’s per B-BC that can be expected.

F. The B-AAC shall provide LED indication of transmit/receive communications performance, as well as for the proper/improper operation of the controller itself.

G. The B-AAC shall be provided with a battery backed time clock that is capable of maintaining the time of day and calendar for up to thirty days, upon loss of power to the B-AAC, without loss of setting. The battery for the time clock shall be replaceable by the customer. The B-AAC shall be provided with integral time schedules; as a minimum, two seven day schedules with eight on/off periods per day shall be provided. Holiday override of weekly schedules shall be provided for pre-scheduling of holidays, for the year in advance.

18. Controller Location

A. To simplify controls and mechanical service troubleshooting, the B-AAC shall be capable of being mounted directly in or on the controls compartment of the air handling system. The B-AAC shall be housed in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The B-AAC shall be constructed in a modular orientation such that service of the failed components can be done quickly and easily. The modular construction should limit the quantities of printed circuit boards to a maximum of two. All logic, control system, power supply and input/output circuitry shall be contained on a single plug-in circuit board. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. This shall allow all controls maintenance and
troubleshooting to be made while at the air handling unit. The B-AAC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

B. Every controller and control panel shall be labeled with a lamacoid plate permanently secured to the device. Sticky tape or glued labels are not acceptable. The labeling shall describe the device and include related information such as MAC address, IP address, BACnet Instance numbers, etc.

C. All power feeds shall be clearly identified and shall include panel number, breaker and electrical panel location if not in the same room.

D. For compatibility to the environment of the air handling unit, B-AAC’s shall have wide ambient ratings. B-AAC’s shall be rated for service from -40 DegF (Degrees Fahrenheit) to 140 DegF.

E. Contractor shall submit description of location of B-AAC’s on all mechanical and air handling equipment.

19. B-AAC Naming Convention

B-AAC devices shall be named using the following naming convention:

\[
\text{Building}_\text{Floor}_\text{RoomNumber}_\text{B-AAC Device Type}_\text{Equipment Short Name}
\]

All B-AAC points shall be named using the following format:

\[
\text{Function}
\]

Examples:

An Air Handler controller in the Pavilion HA mechanical room HA4001 for AHU7 would be named as follows:

PAVHA_04_HA4001_HVA_AHU7

The mixed air temperature point for the above system would be named as follows:

MAT

Therefore, when this point is learned, the entire point name will be:

PAVHA_04_HA4001_HVA_AHU7_MAT

For function short names and building short names and numbers, contact the University Controls Engineering Department.

20. Application Specific Controller (B-ASC)

General

A. Controls shall be microprocessor based Application Specific Controller (B-ASC). B-ASC’s shall be provided for Unit Ventilators, Fan Coils, Heat Pumps and other applications
as shown on the drawings. B-ASC’s shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the B-ASC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter.

B. Contractor shall provide a minimum of one B-ASC controller per unitary system as shown on the drawings.

C. The BAS contractor shall provide and install all B-ASC’s specified under this section.

D. All input/output signals shall be directly hardwired to the B-ASC. Troubleshooting of input/output signals shall be easily executed with a volt-ohm meter (VOM). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.

E. B-ASC’s shall be in continuous, direct communication with the network which forms the facility wide building automation system. The B-ASC’s shall communicate with the B-BC at a baud rate of no less than 38,400 baud.

21. Non-Volatile Memory

A. All control sequences programmed into the B-ASC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the B-ASC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The B-ASC shall allow for the creation of unique application control sequences.

B. The B-ASC shall be provided with the ability to interface with a laptop computer. The interface port shall be provided at the wall sensor or within the unitary equipment. Connection to the wall sensor must be a standard RJ-45 or USB port.

C. The B-ASC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples per Input/Output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken.

D. Systems unable to provide the above capability shall provide for the individual input/output point trending at the B-BC. Specifics as to how each B-ASC point will be trended, at the B-BC, shall be provided in the submittal documents. Included in the explanation shall be the sample intervals, the memory allocation in the B-BC and the number of B-ASC’s per B-BC that can be expected.

22. Controller Location

A. To simplify controls and mechanical service troubleshooting, the B-ASC shall be mounted directly in the controls compartment of the unitary system. The B-ASC shall be provided with a sheet metal or polymeric enclosure that is constructed of material allowing for the direct mounting within the primary air stream, as defined by UL-465. The direct mounting
shall allow all controls maintenance and troubleshooting to be made while at the unitary equipment. The B-ASC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

B. For compatibility to the environment of the unitary equipment, B-ASC shall have wide ambient ratings. B-ASC’s shall be rated for service from 32 DegF (Degrees Fahrenheit) to 140 DegF.

C. Contractor shall submit description of location of B-ASC’s on all mechanical and unitary equipment.

23. B-ASC Naming Convention

B-ASC devices shall be named using the following naming convention:

\[
B-ASC \text{ devices shall be named using the following format:} \\
\text{Building\_Floor\_RoomNumber\_B-ASC Device Type}
\]

\[
\text{All B-ASC points shall be named using the following format:} \\
\text{Function}
\]

Examples:

A VAV controller in the Pavilion HA room HA498 would be named as follows:

PAVHA_04_HA498_VAV

The discharge air temperature point for the above room would be named as follows:

DAT

Therefore, when this point is learned, the entire point name will be:

PAVHA_04_HA498_VAV_DAT

For function short names and building short names and numbers, contact the University Controls Engineering Department.

24. CONTROL PANELS

A. Panelboard shall contain all instruments and accessories. Provide each item of equipment with an engraved nameplate. Panelboard shall be wall-mounted or stand-mounted and shall be completely enclosed.

B. As far as is practical, the control components for each system shall be grouped. Provide each group of components with identification.

C. The entire panelboard shall be pre-wired and brought to a main terminal strip. All relays, switches, etc., shall be installed, furnished and wired on panelboard. Clearly mark each terminal strip as to which wire from which component is to be connected.
D. Fabricate panels of 0.06-inch- (1.5-mm-) thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock, with manufacturer's standard shop-painted finish and color.

E. Panel-Mounted Equipment: Temperature and humidity controllers, relays, and automatic switches; except safety devices. Mount devices with adjustments accessible through front of panel.

F. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gages.

G. Graphics: Color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.

25. SENSORS

A. Electronic Sensors used in air ducts or liquid lines shall utilize non-adjustable RTD or thermostat sensing elements with + or -0.36°F, accuracy and stability of at least + or -0.05°F per year. All sensors used in liquid line shall be provided with separable stainless steel immersion wells. Averaging sensors shall be a minimum of five (5) feet in length, and shall be installed in such a manner so as to sense representative sample of the medium being controlled.

B. Equipment Operation Sensors: As follows:

Status Inputs for Fans: Differential-pressure switch with adjustable range set to 175 percent of rated fan static pressure. A hawkeye sensor should also be provided so that the owner knows if belts are lost or fans are running backwards.

Status Inputs for Electric Motors: Current-sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.

C. Digital-to-Pneumatic Transducers: Convert plus or minus 12-V dc pulse-width-modulation outputs (preference is 4-20mA or 0-10 Volts), or continuous proportional current or voltage to 0 to 20 psi (0 to 138 kPa).

D. Damper Position Indication: Potentiometer mounted in enclosure with adjustable crank-arm assembly connected to damper to transmit 0 to 100 percent damper travel.

E. Sensor Input and Output Devices:

1. The following sensors and devices, or their equivalents, shall be considered acceptable. Other sensors and devices required for this specification are outlined in their respective subsystem.

2. Analog sensing elements for remote indication shall be independent of local pneumatic sensors used for local control loops.

3. System Accuracy: The system shall maintain an end-to-end accuracy for one year from sensor to operator’s console display for the application specified.

<table>
<thead>
<tr>
<th>STANDARD</th>
<th>Temperature Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>Electronic</td>
</tr>
</tbody>
</table>

INSTRUMENTATION AND CONTROL FOR HVAC 250200 -18
<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>BAS, HVAC, BTU, Boiler Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDARD</td>
<td>100 or 1000 ohm platinum wire wound RTD element</td>
</tr>
<tr>
<td></td>
<td>Standard J (3 wire) configuration</td>
</tr>
<tr>
<td></td>
<td>European curve, Alpha = .00385</td>
</tr>
<tr>
<td></td>
<td>Ohms/Ohm/deg.C., meets DIN SID 43760</td>
</tr>
<tr>
<td></td>
<td>Wire in conduit</td>
</tr>
<tr>
<td>MECHANICAL</td>
<td>1/4&quot; stainless steel sheath</td>
</tr>
<tr>
<td>SPACE TEMPERATURE</td>
<td>Sensor housing to be similar in appearance to existing thermostats except that thermometers are not required. Similarity to be Owner's decision. Locate on an outside wall if possible.</td>
</tr>
<tr>
<td>DUCT TEMPERATURE</td>
<td>Standard lengths -- 5.5&quot;, 11.5&quot; and 17.5&quot;</td>
</tr>
<tr>
<td></td>
<td>Other lengths with owner's written approval.</td>
</tr>
<tr>
<td></td>
<td>Locate in central area of airstream at minimum of 18&quot; from reheat coil.</td>
</tr>
<tr>
<td></td>
<td>1/2&quot; NPT mounting thread and flange and conduit connection.</td>
</tr>
<tr>
<td></td>
<td>Glass encapsulated element unless otherwise approved.</td>
</tr>
<tr>
<td>THERMOWELL</td>
<td>Drilled brass or stainless steel or brass fitting with stainless steel sheath built-up well with Owner approval.</td>
</tr>
<tr>
<td></td>
<td>Glass encapsulated element unless otherwise approved.</td>
</tr>
<tr>
<td></td>
<td>3/4&quot; process connection with drilled wells.</td>
</tr>
<tr>
<td></td>
<td>1/2&quot; NPT process connection on built-up wells.</td>
</tr>
<tr>
<td></td>
<td>Insertion into measured medium - 1&quot; + 1/2&quot; diameter of pipe.</td>
</tr>
<tr>
<td></td>
<td>Cast iron connector head - 1/2&quot; NPT process connection and conduit connection.</td>
</tr>
<tr>
<td></td>
<td>Rated thermowell pressure = 250 psi.</td>
</tr>
<tr>
<td>ELEMENT ACCURACY</td>
<td>must meet .1% DIN and the DIN 43760 standard.</td>
</tr>
<tr>
<td>OVERALL ACCURACY</td>
<td>+ 1 deg.F. General duct, space and thermowell temperatures.</td>
</tr>
<tr>
<td></td>
<td>+ .75 deg.F. for thermowell ele. on 4&quot; or larger pipes.</td>
</tr>
<tr>
<td></td>
<td>+ .5 deg.F. for thermowell ele. on 8&quot; or larger pipes.</td>
</tr>
<tr>
<td>OVERALL RANGE</td>
<td>-20% to 120% of possible operating conditions.</td>
</tr>
</tbody>
</table>
GENERAL NOTE

If wires from RTD probe to DGP are to be more than 200 feet long, provide extra large cast iron connector head (nominal size 2-11/16 x 1/4) or junction box to accommodate a resistance to 4-20 mA convertor transmitter.

STANDARD

Pressure Sensor

TYPE

Electronic with LVDT element.

APPLICATION

4-20 mA Output (2 wire)
Wire in conduit
Input voltage 10-35 volts DC
Loop resistance greater than or equal to 500 ohms

MECHANICAL

Linear variable differential transformer (LVDT) element
Allowable Standard Ranges
0-30 PSI
0-100 PSI
0-200 PSI
Other ranges with Owner written approval
1/2" NPT input thread and conduit connection.
Provide differential inputs unless otherwise approved.
Provide an air filter on unused differential ports.
Provide with a NEMA 4 watertight enclosure unless otherwise approved.
Min. rate pressure - 150% FS proof and 450 PSI static.

OVERALL ACCURACY

+ 0.5% F.S. including Linearity, hysteresis and repeatability.

ACCURACY NOTE:

If pressure transducer is used to calculate flow with a pilot tube, then the accuracy of the pressure sensor should be dictated by the overall accuracy requirement of the system and would probably require a high accuracy sensor.

This section covers all new transducers provided. All new transducers provided shall be of the following type:

<table>
<thead>
<tr>
<th>INPUT</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (deg.F.)</td>
<td>4-20 mA, 2 wire</td>
</tr>
<tr>
<td>Temperature (deg.F.)</td>
<td>100 ohm platinum wire RTD</td>
</tr>
<tr>
<td>Pressure</td>
<td>4-20 mA, 2 wire</td>
</tr>
<tr>
<td>Flow Instantaneous</td>
<td>4-20 mA, 2 wire</td>
</tr>
<tr>
<td>Flow Integrated</td>
<td>Pulse 10 PPS Max A25</td>
</tr>
<tr>
<td></td>
<td>msec open (min.) 40 msec</td>
</tr>
<tr>
<td></td>
<td>closed (min.)</td>
</tr>
<tr>
<td>KW Instantaneous</td>
<td>4-20 mA, 2 wire</td>
</tr>
</tbody>
</table>
6. KWH - Integrated Pulse – 10 PPS Max A25
msec open (min.) 40 msec closed (min.)

Digital inputs from devices with isolated, dry type contacts (no grounds, no voltage) of either normally open (N.O.) or normally closed (N.C.) configuration. Live contact inputs, those that have voltage present, shall be provided with isolating devices to meet dry contact requirement.

26. THERMOSTATS

A. Room Thermostats: Provide room thermostats that work in conjunction with the B-AAC and B-ASC terminal unit controllers. Thermostats shall have visible thermometers, setpoint indication and exposed setpoint adjustment in all areas except public spaces. Thermostats are to have push buttons on the front face for adjusting the temperature setpoints. Thermostats are to have no doors.

B. In cases where a single room sensor is to be shared by multiple controllers the slave box reheat control valves and dampers shall be individually controlled to track the discharge temperature of the master unit. The Master shall be identified locally and on the FMS.

C. An RJ-11 type connection to serial port shall allow a local portable operator or programmer’s terminal to access all program blocks and attributes for complete programmability.

D. Room Thermostat Accessories: As follows:

E. Insulating Bases: For all thermostat installations.

F. Thermostat Guards: Locking transparent-plastic mounted on separate base.

G. Adjusting Key: As required for device.

H. Aspirating Boxes: Where indicated for thermostats requiring flush installation.

27. DAMPERS:

A. Provide automatic control dampers as indicated, with damper frames not less than 13-gage galvanized steel. Provide mounting holes for enclosed duct mounting. Provide damper blades not less than formed 16-gage galvanized steel, with maximum blade width of 8”.

B. Secure blades to 1/2” diameter zinc-plated axles using zinc-plated hardware. Seal off against spring stainless steel blade bearings. Provide blade bearings of nylon and provide thrust bearings at each end of every blade. Construct blade linkage hardware of zinc-plated steel and brass. Submit leakage and flow characteristics plus size schedule for controlled dampers.

C. Do not exceed maximum 48”x48” damper size. For sizes larger than this maximum in either dimension, use multiple dampers with a separate operator for each damper. Do not link separate dampers together.
D. Operating Temperature Range: From -20 degrees to 200 degrees F. (-29 degrees to 93 degrees C.). The occupant shall have an operation local range of 68 degrees and 74 degrees on rooms with Occupancy sensors.

E. For standard applications as indicated, provide parallel or opposed blade design (as selected by manufacturer's sizing techniques) with inflatable steel blade edging, or replaceable rubber seals, rated for leakage less than 10 CFM/sq.ft. of damper area, at differential pressure of 4" w.g. when damper is being held by torque of 50 inch-pounds.

F. Smoke Dampers: Provide smoke and combination fire/smoke dampers in accordance with applicable requirements of Specification Section "Ductwork Accessories".

28. ACTUATORS:

A. Electric Valve and Damper Motors: Size each motor to operate dampers or valves with sufficient reserve power to provide smooth modulating action or 2-position action as specified.

B. For reheat coils in branch ductwork and heating coils for air terminal units and fan terminal units, provide non-spring return, fully proportional, floating valve actuators.

C. For all other applications, provide permanent split-capacitor or shaded pole type motors with gear trains completely oil-immersed and sealed. Equip spring-return motors, with integral spiral-spring mechanism. Furnish entire spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

D. Equip motors for outdoor locations and for outside air intakes with "O ring" gaskets designed to make motors completely weatherproof, and equip with internal heaters to permit normal operation at -40 degrees F. (-40 degrees C.)

E. Provide separate motor for each outside air, return air and exhaust air damper. Do not link dampers with different functions together on one damper motor.

F. Provide separate motor for each damper when overall damper size exceeds 48" in either dimension. Do not link different dampers together on one damper motor.

G. Binary backed-up motors are not acceptable.

29. MISCELLANEOUS:

A. Wells for Pipe Mounted Sensor: Wells shall have minimum working pressure of 150 WOG psig. Wells shall be brass or stainless steel.

B. Lightning Protection: All electric/electronic equipment supplied must be internally or externally lightning/transient surge voltage protected on all external power feeder and input/output connections which are subject to surge voltage transients. Provide high speed clamping elements which meet IEEE. STD. 472 (SWC) on all digital or analog date channels.

C. Pressure Instruments:
1. Differential Pressure and Pressure Sensors: Sensors shall have 4-20 mA output proportional signal with provisions for field checking. Sensors shall withstand up to 150% of rated pressure, without damaging device. Accuracy shall be within 2% of full scale.

2. Pressure Switches: Pressure switches shall have repetitive accuracy of ±2% of range and withstand up to 150% of rated pressure. Sensors shall be diaphragm or bourdon tube design. Switch operation shall be adjustable over operating pressure range. Switch shall have application rated Form C, snap-acting, self-wiping contact of platinum alloy, silver alloy or gold plating.

D. Current Sensing Relays: Relays shall monitor status of motor loads. Switch shall have self-wiping, snap-acting Form C contacts rated for application. Setpoint of contact operation shall be field adjustable.

E. Low Voltage Wiring: Control wiring for analog functions shall be 18 AWG minimum with 600 volt insulation, twisted and shielded, 2 or 3 wire to match analog function hardware.

F. Low Voltage Wiring: Wiring for electric or electronic circuits less than 25 volts shall be cabling manufactured for express use in air plenums. The plenum cable shall be 24 gauge or larger as required, tinned copper, Teflon insulated, twisted pairs, shielded or unshielded, as required, a color coded, overall tape wrap, with transparent Teflon jacket, 150V., NEC725, Class 2 classified for use in air plenum non-conduit signaling application.

G. Manual Override Switches: In case of failure of the DDC system, provide override switches to operate fans, pumps, air handling units, cooling tower, heat exchangers, etc., manually in local interface control panel. Also for temperature and pressure control provide switches to allow supply temperatures, water temperatures, supply air pressure and fans to be manually regulated. All switches shall be located in locked panel to prevent unauthorized use of the manual override switches.

PART 3 - EXECUTION

1. INSPECTION:
Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

2. INSTALLATION OF AUTOMATIC TEMPERATURE CONTROLS
General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on the Drawings.

3. CONTROL WIRING:
   A. Contact the project manager for all required Ethernet connections for this project.
   B. Install control wiring, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code. Install wiring in electrical conduit in all areas. All controls conduit shall be green in color.
C. Conceal conduit, except in mechanical rooms and areas where other conduit and piping are exposed.

D. Install all control wiring with color-coded wire in ¾” minimum size conduit. Wire gauge to be in accordance with National Electrical Code.

F. Connect electrical components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.

4. POWER WIRING:

A. Provide power wiring and conduit to air terminal units (if required) and to smoke dampers and combination fire/smoke dampers and their damper motors.

B. Furnish and install power cabling and conduit for temperature controls panels and equipment from emergency power panels. Each temperature control panel shall be connected to a separate circuit. Conduits shall connect to panels at the locations directed by the Contractor under Division 26. Final connection in the power panels shall be by Temperature Control Contractor in coordination with Division 26 Contractor.

C. Every controller and control panel shall be labeled with a lamacoid plate permanently secured to the device. Sticky tape or glued labels are not acceptable. The labeling shall describe device and include all pertinent information such as MAC address, IP address, instance # etc. All power feeds shall be clearly identified and shall include panel number and electrical panel location if not in the same room. The tag labeling shall match the following image.

D. The TCC shall install all temperature control interlock wiring required.

E. The TCC shall be responsible for any power required for the unitary controls or control panels. This includes circuit breakers, wiring, conduit, etc. installed in strict accordance with NEC. The TCC may contract with the electrical contractor for the power wiring installation.

F. Provide a 110 VAC emergency power duplex receptacle for all temperature control and master control panels. Provide a ups power supply for the main building control unit.
G. STANDARDS

NFPA Compliance: Comply with requirements where applicable for controls

Kentucky Building Code (includes energy code requirements): Comply with requirements where applicable for controls.


Provide products of the temperature control system with the following agency approvals:

- UL-873 – Temperature Indication and Regulating Equipment.
- UL-864 – Subcategories UUKL, OUXX, UDTZ, Fire Signaling and Smoke Control Systems.

All products shall be labeled with the appropriate approval markings. System installation shall comply with NFPA, NEMA, NEC, Local and National Codes.

SENSORS

1.1 SENSOR RESOLUTION: All temperature sensors shall have a minimum resolution of 1/10th of 1 degree F. (0.1 degree F.) Sensor stability shall be .24 degrees over a year period. Space sensors must be tested and accurate to within 0.75 degrees F. Outside air, water and duct sensors must be tested and accurate to within 1.0 degree F.

SPACE SENSORS: Wireless thermostats for unitary/terminal equipment are acceptable in lieu of conduit and wire. All thermostat/sensor's must be provided with temperature indication. Programmed set-point shall be locally adjustable limited to 5 degrees above set-point and 5 degrees below set-point (in one degree increments) for supervised areas. Unsupervised areas shall have non-adjustable set-point. Doors will not be allowed on sensors. All thermostats shall include a push-button override feature.

All analog input devices shall utilize the 1000 ohm platinum standard.

Thermostats shall be installed 48" above the finished floor. Except where mounted next to a light switch. At this location, the thermostat shall be mounted at the same height as the light switch. If there is a question consult engineer prior to rough-in. Proper ADA heights must be maintained at all times and shall set precedent over any stated mounting height. All thermostats shall be labeled on the inside cover with the name of the controller and room location.

Temperature sensors in public areas ie. Corridors lobbies etc shall be installed at 84" AFF.

HUMIDITY SENSORS: These devices shall be 100% solid state, linear and temperature compensated with scaling 0-100% RH range with LED or LCD Display. Accuracy at 25°C from 10-80% RH* ±2%, operating Humidity Range 0 to 100% RH (non-condensing), Stability ±1% @ 20°C (68°F) annually, for two years, Hysteresis 1.5% typical, Temperature Effect ±0.1% RH/°C above or below 25°C (typical), 1% accuracy between 0% - 90% RH, Operating Temperature Range -40° to 50°C (-40° to 122°F) +/- 1%.-Do not submit products that do not meet this range. The output of the device shall utilize an analog output 4-20 mA, 2-wire, polarity insensitive, (clipped and capped), The device shall use a power supply of 24 VAC or VDC. Duct mounted sensors shall have at least 4" insertion probe with a 16 gauge steel enclosure. NIST traceable certification shall be provided to the Engineer as part of the shop drawings. For wall mounted sensors the enclosure shall be polystyrene plastic mounted next to and at the same height as the
temperature sensor in that area. Both shall have the same appearance. Provide protective cages in fitness and common areas.

5. MISCELLANEOUS:

A. Software Programming: All software programs shall be programmed by this Contractor.

B. Installation of Mechanical Devices: Refer to Mechanical Division sections for installation of valve bodies, control wells and dampers; not work of this section.

6. ADJUSTMENT AND SERVICE:

A. After completion of the installation, the automatic temperature control manufacturer shall regulate and adjust all thermostats, control valves, motors, and other equipment provided under his contract and shall place them in complete operating condition, subject to approval by the Engineer and Owner.

B. This shall include but not be limited to “tuning” of all control systems. Systems shall be tuned for decaying wave response and minimal overshoot of setpoint. Contractor is to not leave any system in an Auto Tune mode.

C. Room temperature controls shall have one temperature setpoint with less than a 0.5˚F between calculated heating and cooling temperatures.

D. This Contractor shall work with Balancing Contractor to provide verification of CFM reading from the DDC terminal unit controllers.

E. Final adjustment shall be performed by specially trained personnel in direct employ of manufacturer of primary temperature control system.

F. After completion of installation, perform the following:

1. Installation.
   Check proper installation and connection of each control device.
   Verify electric power.
   Verify each sensor and actuator connection to field computer.

2. Field Computer Operation.
   Point Test.
   - check of wiring of each sensor and actuator end-to-end
   - verify calibration of each sensor.
   - verify manual operation of each actuator.

   Local loop control.
   - bring each local loop under control.
   - check response to upset, change in setpoint.
   - check full and partial load operation.

3. Supervisory functions.
   - verify time clock schedules.
   - verify reset control.
4. Verify communication with each field device.
   - perform end-to-end sensor and actuator checks.
   - verify that the database is correct.

5. Test other software.
   - Trend Logging.
   - Report Generation.
   - Remote Access.
   - System Documentation.

6. Verify proper operation of every control point in the presence of the Engineer.
   Include point-by-point checkout.

7. The control manufacturer shall provide a period of free service extending through
   one complete heating season and one complete cooling season, after acceptance of
   the control system, and shall report the condition of the control equipment to the
   Owner and the Architect.

PART 4 - SEQUENCE OF OPERATION:

A. Refer to the IC and Mechanical Drawings for the sequences of operation as well as
   necessary system components.

PART 5 - WARRANTY/DELIVERY/STORAGE

1. Labor and Material Warranty - The Control System shall be free from defects in material
   and workmanship under normal use and service. If within twenty four (24) months from
   the date of ACCEPTED COMMISSIONING AND FUNCTIONING DATE - NOT
   SUBSTANTIAL COMPLETION DATE, any of the manufacturers equipment herein
   described is defective in operation, workmanship or materials, it will be replaced,
   repaired or adjusted by the TCC Contractor free of charge.

2. The TCC shall include service required for start-up and calibration of all installed
   equipment for one season of heating and one season of cooling. A confirmation letter to
   the Engineer will be required for this work.

3. Delivery, Storage and Handling - Provide factory shipping cartons for each piece of
   equipment and control device. Maintain cartons while shipping, storage and handling as
   required to prevent equipment damage and to eliminate dirt and moisture from
   equipment. Store equipment and materials inside and protect from weather.

PART 6 - SYSTEM START-UP AND ACCEPTANCE

1. Commissioning: This section specifies a system or a component of a system being
   commissioned as defined in Section 01 91 13 Commissioning. Testing of these systems
   is required, in cooperation with the Owner and the Commissioning Authority. Refer to
   Section 01 91 13 Commissioning for detailed commissioning requirements.

2. The CONTROL SYSTEM CHECKOUT AND TESTING - PRIOR TO
   COMMISSIONING
A. Startup Testing. Complete startup testing to verify operational control system before notifying Owner of system demonstration. Provide Owner with schedule for startup testing. Owner may have representative present during any of all startup testing.
- Calibrate and prepare for service each instrument, control, and accessory equipment furnished.
- Verify that control wiring is properly connected and free of shorts and ground faults.
- Enable control systems and verify each input device’s calibration. Calibrate each device according to manufacturer’s recommendations.
- Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, starters, operate properly and that normal positions are correct.
- Verify that analog output devices such as I/Ps and actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.
- Prepare a log documenting startup testing of each input and output device, with technician’s initials certifying each device has been tested and calibrated. Submit log to Engineer for review.
- Verify that system operates according to sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.
  - Alarms and Interlocks.
    - Check each alarm with an appropriate signal at a value that will trip the alarm.
    - Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
    - Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

3. CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration: Prior to acceptance, perform the following performance tests to demonstrate system operation and compliance with specification after and in addition to tests specified in Control System Checkout and Testing. Provide Engineer with log documenting completion of startup tests. Refer to Section 230200 HVAC Equipment for other start-up requirements.
- Engineer will be present to observe and review system demonstration. Notify Engineer at least 14 days before system demonstration begins. Systems balancing shall be complete prior to demonstration, coordinate scheduling with TAB agency accordingly.
- Demonstrate actual field operation of each sequence of operation as specified in these specifications. Provide at least two persons to demonstrate calibration and response of any input and output points requested by Engineer. Provide and operate test equipment required to prove proper system operation.
- Demonstrate complete operation of operator interface.
- Demonstrate all alarms, including external alarms to Owner selected pagers, phones, e-mail accounts, etc.
- Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.
• Provide all required tools to perform demonstration (drills, duct plugs, thermometers, hygrometers, carbon dioxide sensors, smoke test aerosol smoke, 2-way radios, water probes, etc.)

B. Acceptance: After tests described in this specification are performed to the satisfaction of both Engineer and Owner, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor’s control. Engineer will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.

• System shall not be accepted until completed demonstration forms and checklists are submitted and approved as required in these specifications. Warrantee will not start until acceptance by Owner, Engineer and Commissioning Agent if applicable.

• Upon completion of the installation, the Controls Contractor and a factory authorized representative shall start-up the system and perform all necessary testing and debugging operations. An acceptance test in the presence of the Owner’s representative shall be performed. The vendor shall check all sensors that exhibit any problems or faulty reading. When the system performance is deemed satisfactory in whole, the system parts will be accepted for beneficial use and placed under warranty.

• This Contractor shall work with the Owner, who is developing the graphics, to ensure that all point report, function and alarm as required on the BACnet head-in system. The Contractor will also work with the Project Manager or CNS/MCIS to obtain all necessary IP’s and Ethernet drops needed for BACnet panel. The Contractor shall contact UK Delta Room for BACnet instance number prior to connecting to existing BACnet network. No exceptions.

4. DELTA ROOM COMMISSIONING

A. PPD will be performing their own complete point by point evaluation as part of this project independently of the commissioning activity. This will occur during the warranty period of the project. The controls contractor shall be a part of this process and shall include in their bid to have a controls technician in the Delta Room to adjust and modify the control system as part of the point by point evaluation. Include 40 hours of technician time to be performed after 5:00 PM. This will be coordinated by the Delta Room.

PART 7 - BACnet Protocol Implementation Conformance Statement:

A. The controls contactor shall include their BACnet PICS and BIBB statements (as described in ASHRAE 135-2001) for their BACnet Interface with their shop drawings. The interface shall comply with the following as a minimum.

B. Vendor Name: Tridum, Inc.
   Product Family: Niagara Framework, including N4Web Supervisor, JACE 6XX at Release 3.8 JACE 8XXX at release 4.6 or greater using the most current version of JAVA or HTML 5. All control work associated with this project must be fully compatible with this version of Tridium such that all alarms, points, etc. communicate and clear alarms seamlessly with the existing system.
C. Description: This product family provides bi-directional communication between Tridium Niagara Framework and a BACnet system operating at BACnet Conformance Class 3, over Ethernet media.

BACnet Protocols are documented in Appendices A, B & C.

D. REQUIRED SUBMITTALS:

The following chart is supplied for the benefit of the Owner, Architect, Engineer and contractor to assure a complete submission of required information. It is a reference listing of documents required by the Specifications under this Section. Refer to Specifications Section - General Provisions for the general requirements of submittals.

<table>
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<tr>
<th>ITEM</th>
<th>SHOP DRAWING</th>
<th>M&amp;O MANUAL</th>
<th>PARTS LIST</th>
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Print and Save Excel I/O Summary Sheet in Spec Directory *(Add general IO Point list)*
Appendix A – Vykon Niagara Compatibility Statement (NiCS)

Vykon Niagara AX Compatibility Statement (NiCS)

Includes all Vykon branded JACE and Software Products

The following information describes Tridium’s Vykon branded Niagara product licensing.

Tridium’s Vykon AX branded products utilize an open access licensing procedure. Vykon AX branded products can be connected to and managed by any Niagara based tools or systems without the need to modify the license. This means the end user does not have to authorize changes to a Vykon AX license for another systems integrator to gain access to the system. The end user does need to have the necessary user names and passwords installed by the original system integrator so they can be used by another Niagara trained systems integrator.

The following is an explanation of the Vykon licensing schema.

BrandID

Every licensed station and tool has a Brand Identifier (BrandID). This field holds a text descriptor that the OEM chooses as the identifier for its product line. Each station or tool can have only one BrandID entry.

Tridium’s Vykon products have the following:

BrandID = Vykon

Station Compatibility In

This field is a list of brands that this local station will allow Niagara AX data to come in from. Simply stated from the point of view of a JACE, “this is the list of brands that can I accept data from”. Tridium’s Vykon products contain:

Station Compatibility In = All (in actual license ALL is defined as *)

Note: The compatibility fields can contain a single brand “ABC”, a list of multiple brands “ABC, XYZ”, no brand “None” or all brands “All”.

Station Compatibility Out

This field is a list of brands that this local station will allow Niagara AX data to be shared with. Simply stated “This is the list of brands that I can share data with”. Tridium’s Vykon products contain:

Station Compatibility Out = All
Tool Compatibility In

This field is a list of brands that this station will allow to be connected to it for engineering of its application. Simply stated, “This is the list of brands that can engineer me.” Tridium’s VYKON products contain:

Tool Compatibility In – All

Tool Compatibility Out

This field is a list of brands that this tool is allowed to connect to and engineer. Simply stated, “This is the list of brands that I can engineer”. Tridium’s VYKON products contain:

Tool Compatibility Out – All

As long as VYKON branded products are purchased by the end user any Tridium Certified (TCP) system integrator can provide support for the end user without the need for the owner to be involved in the licensing process. For more information on Niagara Connectivity and Security visit our website library at: http://www.vykon.com/cu/library/White_papers

Management Contacts:
Scott Boehm
Director, VYKON Automation Energy Security
SBoehm@tridium.com

Ed Merwin
Director, VYKON Automation Energy Security
Ed.L.Merwin@tridium.com

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Suite 350
Richmond, VA 23233
804.747.4771
Appendix B – Tridium Niagara 3.8 BACnet PICS

TRIDIUM NIAGARA®X 3.8
BACnet PICS

BACnet Protocol Implementation Conformance Statement

Date: August 31, 2016
Vendor Name: Tridium
Product Name: Niagara AX BACnet Integration
Product Model Number: Tridium JACE models
Application Software Version: 3.6.112 or higher
Firmware Revision: 3.8.112.1 or higher
BACnet Protocol Revision: 7

Product Description:
Niagara AX provides the ability to view, monitor, and control BACnet devices over IP, raw Ethernet, or MS/TP media. Devices, points, schedules, alarms, and logs can be learned and managed from Niagara AX. In addition, Niagara points, schedules, histories, and alarming can be exposed to BACnet for monitor and control by foreign BACnet clients.

BACnet Standardized Device Profile (Aanez L):

☐ BACnet Advanced Operator Workstation (B-AWS)
☐ BACnet Operator Workstation (B-OWS)
☐ BACnet Operator Display (B-OD)
☐ BACnet Building Controller (B-BC)
☐ BACnet Advanced Application Controller (B-AAC)
☐ BACnet Application Specific Controller (B-ASC)
☐ BACnet Smart Sensor (B-SS)
☐ BACnet Smart Actuator (B-SA)
### Additional BACnet Interoperability Building Blocks Supported (Annex K):

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<td>AE-INFO-B</td>
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<td>AE-VN-A</td>
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<td>AE-VM-A</td>
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<tr>
<td>Receive Segmented Messages</td>
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<td>any</td>
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</table>

Standard Object Types Supported:

- The CreateObject and DeleteObject services are not supported, so no objects are dynamically createable or deletable through BACnet service requests, although these objects are dynamically createable and deletable through Niagara.
- No general range restrictions exist; however, certain specific applications may have specific range restrictions.
- All potentially available properties are listed for each object type.
- Optional properties are listed in *italics*. Not all instances support all optional properties.
- Writable properties are listed in *bold*. Any range limitations are expressed in parentheses following the property name.

Notes from Table

1. The File_Size property of File objects is only writable if the underlying system file is changeable.
2. The Setpoint property of Loop objects is writable only if the setpoint is not linked from within Niagara.
3. The Recipient_List property of the Notification Class object will maintain entries that are internally configured within Niagara.
4. The List_Of_Object_Property_References property of the Schedule object will maintain entries that are internally configured within Niagara.
5. The Priority_For_Writing property of Schedule objects is not important for internal Niagara operation, as the priority at which a point is commanded is determined by the input to which the Schedule output is linked.
6. These Trend Log object properties are not writable if the backing history for the exported Trend Log is a Niagara-generated history. If the history is created as a BACnet Trend Log, then they are writable.
7. Trend Logs in Niagara use internal triggering and are either COV or Interval. So the Log_Interval property cannot be written from BACnet.
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<tr>
<th>Object Type</th>
<th>Properties</th>
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<td><strong>Analog Input</strong></td>
<td>Object_Identifier&lt;br&gt;Object_Name&lt;br&gt;Object_Type&lt;br&gt;Present_Value&lt;br&gt;Description&lt;br&gt;Device_Type&lt;br&gt;Status_Flags&lt;br&gt;Event_State&lt;br&gt;Reliability&lt;br&gt;Out_Of_Service&lt;br&gt;Units&lt;br&gt;Min_Pres_Value&lt;br&gt;Max_Pres_Value&lt;br&gt;Resolution&lt;br&gt;COV_Increment&lt;br&gt;Time_Delay&lt;br&gt;Notification_Class&lt;br&gt;High_Limit&lt;br&gt;Low_Limit&lt;br&gt;Deadband&lt;br&gt;Limit_Enable&lt;br&gt;Event_Enable&lt;br&gt;Acted_Transitions&lt;br&gt;Notify_Type&lt;br&gt;Event_Time_Stamp</td>
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| Binary Input | Object_Identifier  
Object_Name  
Object_Type  
Present_Value  
Description  
Device_Type  
Status_Flags  
Event_State  
Reliability  
Out_Of_Service  
Polarity  
Inactive_Text  
Active_Text  
| Change_Of_State_Time  
Change_Of_State_Count (0)  
Time_Of_State_Count_Reset  
Elapsed_Active_Time (0)  
Time_Of_Active_Time_Reset  
Time_Delay  
Notification_Class  
Alarm_Value  
Event_Enable  
Acked_Transitions  
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| Binary Output | Object_Identifier  
Object_Name  
Object_Type  
Present_Value  
Description  
Device_Type  
Status_Flags  
Event_State  
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Active_Text  
| Time_Of_State_Count_Reset  
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Object_Name  
Object_Type  
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INSTRUMENTATION AND CONTROL FOR HVAC  
250200-40
Data Link Layer Options:

- BACnet IP, (Annex J)
- BACnet IP, (Annex J), Foreign Device
- ISO 8802-3, Ethernet (Clause 7)
- ANSI/ATA 878.1, 2.5 Mb. ARCNET (Clause 8)
- ANSI/ATA 878.1, RS-485 ARCNET (Clause 8), baud rate(s) _________
- MS/TP master (Clause 9), baud rate(s): 9600, 19200, 38400, 76800
- MS/TP slave (Clause 9), baud rate(s) _________
- Point-To-Point, EIA 232 (Clause 10), baud rate(s): _________
- Point-To-Point, modem, (Clause 10), baud rate(s): _________
- LonTalk, (Clause 11), medium: _________
- Other: _________

Device Address Binding:

Is static device binding supported? (This is currently necessary for two-way communication with MS/TP slaves and other devices.) □ Yes □ No

Networking Options:

- Router, Clause 6 – Routing configurations: Ethernet-IP, Ethernet-MS/TP, IP-MS/TP
- Annex H, BACnet Tunneling Router over IP
- BACnet/IP Broadcast Management Device (BBMD)
  Does the BBMD support registrations by Foreign Devices? □ Yes □ No

Character Set Supported:

Indicating support for multiple character sets does not imply that they can all be supported simultaneously.

- ANSI X3.4 □ IBM®/Microsoft® DBCS □ ISO 8859-1
- ISO 10646 (UCS-2) □ ISO 10646 (UCS-4) □ JIS C 6226

If this product is a communication gateway, describe the types of non-BACnet equipment/networks(0) that the gateway supports:

This product supports communications between BACnet and any third-party system to which Niagara can connect. Contact Tridium for a list of supported protocols.

9 of 9

Tridium NiagaraAX-3.8 August 31, 2016
BACnet PICS
BACnet Testing Laboratories
Product Listing

This product has been tested at a qualified BACnet Testing Laboratory and found to comply with all the necessary interoperability requirements in place on the published test date. This listing represents the tested capability of the Listed Product. For information on additional functionality that was not covered in the test process, refer to the Manufacturer’s PICS statement on the BTL website.

### Listing Information

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### Device Profiles

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### BIBBs Supported

#### Data Sharing

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### INSTRUMENTATION AND CONTROL FOR HVAC

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### Character Set Support

- ANSI X3.4
- ISO 10646 (UCS-2)