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SECTION 009100 - GENERAL COMMISSIONING REQUIREMENTS

1. GENERAL

a. RELATED DOCUMENTS

1) Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

2) OPR and BoD documentation are defined by the construction documents and technical specifications.

3) Division 01 General Requirements

4) Division 22 Plumbing

5) Division 23 HVAC

6) Division 26 Electrical

7) Division 28 Fire Alarm System

b. SUMMARY

1) **The commissioning agent is being procured by the University of Kentucky Independent of this bid package.**

2) Section includes general requirements that apply to implementation of commissioning without regard to specific systems, assemblies, or components.

3) Related Sections:

(a) Division of General Requirements Section

(b) Division 204100 Section "Commissioning of HVAC and Automation Controls" for commissioning process activities for HVAC&R systems, assemblies, equipment, controls, and components.

(c) Division 266100 Section "Electrical Lighting Controls Systems Commissioning Process Requirements" for commissioning process activities for electrical lighting systems, assemblies, equipment, and components.

c. DEFINITIONS

1) Commissioning (Cx): A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems and assemblies are installed, tested, operated, and maintained to meet the Owner’s Project Requirements and Design Intent.

2) Commissioning Authority (CA or CxA): The designated person, company, agent, or combination thereof that will will lead, plan, schedule, and coordinate the Commissioning Team in implementing the overall Commissioning Process.

3) Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Commissioning Process. It includes a schedule of Commissioning Process activities, individual responsibilities, documentation requirements, communication and reporting protocols, and evaluation procedures. Communication and reporting protocols, and evaluation procedures. This document is updated throughout the project by the CA/CxA.

4) Functional Test (FT): A written protocol that defines methods, personnel, and specifications for test conducted on components, equipment, assemblies, systems, and interfaces among systems.

5) Owner's Project Requirements (OPR): A written document that details the functional requirements of a project and the expectations of how it will be used and operated. This includes project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information. This document is updated throughout the project.

6) Pre-functional Checklist (PC): A form used by the Contractor to verify that appropriate components are on-site, ready for installation, correctly installed, and functional. Checklists also include manufacturer's installation start-up and checkout data. The Contractor is responsible for incorporating manufacturer's information into the preliminary checklists provided by the Commissioning Authority.

7) Systems Basis of Design (SboD): A document that identities the design parameters of a project and how each criterion in the Owner's Project Requirements will be addressed. The document records the concepts, calculations, decisions, and product selections used to meet the Owner's Project Requirements and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process. This document is updated throughout the project.

8) Systems, Subsystems, Equipment, and Components: here these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

d. COMMISSIONING TEAM

1) Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, representatives of each Contractor, including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA. At a minimum, this shall include the Mechanical Contractor, HVAC Equipment Vendor, BAS Installer, TAB Contractor, Electrical Contractor, and Lighting Controls Vendor, Dry Room Contractor, Contractor, Funnelhood Installer.

2) Members Approved by Owner:

(a) CxA: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process.

e. OWNER'S RESPONSIBILITIES

1) Assign operation and maintenance personnel and schedule them to participate in commissioning team activities.

f. EACH CONTRACTOR'S RESPONSIBILITIES

1) Each Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:

(a) Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
(b) Cooperate with the CxA for resolution of issues recorded in the Issues Log.
(c) Attend commissioning team meetings held on a monthly basis.
(d) Integrate and coordinate commissioning process activities with construction schedule.
(e) Review and accept construction checklists provided by the CxA.
(f) Complete paper or electronic construction checklists as Work is completed and provide to the Commissioning Authority on a monthly basis.
(g) Review and accept commissioning process test procedures provided by the Commissioning Authority.
(h) Complete commissioning process test procedures.
(i) Assist the CxA in system verification and performance testing.
(j) Assure participation of all major equipment manufacturer's in appropriate start-up, training, and testing activities.
(k) Provide all required O & M data, and submittal data.
(l) Provide all required O & M training as required by the specifications.
(m) Work closely with the TAB Contractor to verify all systems are complete and appropriately balanced.
(n) Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC & R systems at the direction CxA.
(o) Include cost for commissioning requirements in their contract price.

g. CA (CxA) RESPONSIBILITIES

1) Commissioning authority works under direct contract with the Owner.

2) Organize and lead the commissioning team in accordance with ASHRAE Guideline 0-2005, ASHRAE Guideline 1-1996, ACG Commissioning Guideline – 2005, and NECA 90-2004: Recommended practices for Commissioning Building Electrical Systems.

3) Provide commissioning plan acceptable with the Architect and Engineer.

4) Convene commissioning team meetings.

5) Provide Project-specific pre-functional checklists and functional test procedures acceptable by the Engineer.

6) Verify the execution of commissioning process activities using random sampling. The sampling rate may vary from 20 to 100 percent. Verification will include, but is not limited to, equipment submittals, construction checklists, training, operating and maintenance data, tests, and test reports to verify compliance with the OPR. When a random sample does not meet the requirement, the CxA will report the failure in the Issues Log.

7) Prepare and maintain the Issues Log.

8) Prepare and maintain completed log of Pre-functional Checklist.

9) Witness systems, assemblies, equipment, and component startup.

10) Compile test data, inspection reports, and certificates; include them in the systems manual and commissioning process report.

11) Convene and lead commissioning related meetings defining Contractor expectations and documenting same in meeting minutes published to the Architect and Owner.

2. PRODUCTS (Not Used)

3. EXECUTION

a. PRE-FUNCTIONAL CHECKLIST CREATION

1) Pre-functional Checklists consist of CA created draft checklists, manufacturer installation, start-up, and checkout data, and important instructional data and procedures not covered in manufacturer field checkout sheets. Refer to ASHRAE and ACG Commissioning Guideline for level of detail required.

2) The CA shall distribute Pre-functional Checklist drafts after submittal reviews are complete.

3) The following process will be used for this project to develop and approve the Pre-functional Checklists.

(a) Those executing the checklists are only responsible to perform items that apply to the specific application at hand. These checklists do not take the place of the manufacturer's recommended checkout and start-up procedures or report. There may be redundancy between checklist procedures and typical factory field checkout sheets. Double documentation is required in those cases.
(b) The CA transmits draft Pre-functional Checklists to the CM who designates which trade or sub-contractor is responsible to fill out each line item Mark in the ":Contr" column).
(c) The CA then transmits the draft Pre-functional Checklist(s) to the responsible Sub-contractors.
(d) The Sub-contractor designated to execute the Pre-functional Checklists obtains manufacturer installation, start-up and checkout data, including actual field checkout sheets used by the field technicians.
(e) The Sub-contractor transmits the full Pre-functional Checklists to the CA.
(f) The CA reviews and approves the Pre-functional Checklists and the format for documenting them, noting any procedures that need to be added, and conveys to the appropriate Contractor.

b. EXECUTION OF THE PRE-FUNCTIONAL CHECKLISTS

1) The Pre-functional Checklists are directed and executed by the Sub-contractor or Vendor for 100% of all commissioned equipment and systems.

2) The CA will create and verify these plans.

3) Four (4) weeks prior to startup, the Sub-contractors and Vendors schedule startup and initial checkout with the CA.

4) The Subs shall provide Pre-functional Checklists to the CA at least three (3) weeks prior to the performance of the associated test. Subject to conformance with the specifications and project schedule, the CA will approve the Pre-functional Checklists.

5) The Sub-contractors shall execute the Pre-functional Checklists and record the test results. To document the process of startup and checkout, the site technician performing the line item task shall initial and date each paragraph of procedures in the "Pre-functional Checklist" and check off items on the pre-functional and manufacturer field checkout sheets as they are completed. Only individuals having direct knowledge of a line item being completed shall check or initial the forms.

6) Within one (1) week after completion of start-up tests, the Sub-contractors shall forward the applicable test results to the CA. The CA will approve or disapprove the test results based on methods, results, and completeness of the specific data collected.

c. FUNCTIONAL TESTING

1) The CA will prepare and finalize the tests with information such as: change orders, updated points list, control sequences and setpoints, input from contractors, and input from the A/E.

END OF GENERAL COMMISSIONING

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. Each Proposer shall also be governed by any unit prices and Addenda insofar as they may affect his part of the work or services.

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

D. 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.

E. It is not the intent of this section of the specifications to make any Contractor, other than thr Construction Manager responsible to the Owner, Architect and Engineer. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be routed through the Construction Manager to the Architect then to the Engineer. Also, this section of the specifications shall not be construed as an attempt to arbitrarily assign responsibility of work, material, equipment or services to a particular trade or Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be optional.

F. 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.

G. In general, and to the extent possible, all work shall be accomplished without interruption of existing facilities operations. The Contractor shall advise the Owners at least two weeks prior to the interruption of any services or utilities. The Owners shall be advised of the exact time that interruption will occur and the length of time the interruption will last. Failure to comply with this requirement may result in complete work stoppage by the Contractors involved until a complete schedule of interruptions can be developed.

H. 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.

(15) NFPA - National Fire Protection Association.

(16) ASME - American Society of Mechanical Engineers.

(17) AGA - American Gas Association.

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

(19) ANSI - American National Standards Institute.

(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.

(25) IECC - International Energy Conservation Code.

(26) IFGC - International Fuel Gas Code.

I. 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.

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 insure no conflict with other work.

H. Each Proposer shall review all drawings including Architectural, Mechanical, Electrical, Fire Protection, Landscaping, Structural, Surveys, etc., to insure 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 insure 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 insure 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 insure 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. EXAMINATION OF SITE AND CONDITIONS

A. Each Proposer shall inform himself of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work. Each Proposer shall also fully acquaint himself with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of utilities, etc. His proposal shall cover all expenses or disbursements in connection with such matters and conditions. No allowance will be made for lack of knowledge concerning such conditions after bids are accepted.

5. 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 insure 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.

6. SUPERVISION OF WORK

A. The Contractor shall personally supervise the work for which he is responsible or have a competent superintendent, approved by the Engineers, on the work at all times during progress with full authority to act for him.

7. CODES, RULES, PERMITS, FEES, INSPECTIONS, REGULATIONS, ETC.

A. The Contractor shall give all necessary notices, obtain and pay for all permits, government sales taxes, fees, inspections and other costs, including all utility connections, meters, meter settings, taps, tap fees, extensions, water and/or sewer system development charge, etc. in connection with his work. He shall also file all necessary plans, prepare all documents and obtain all necessary approvals of all governmental departments and/or the appropriate municipality or utility company having jurisdiction, whether indicated or specified or not. He shall hire an independent Registered Engineer to witness installations and provide necessary certifications where required by utility companies, municipal agencies or others that have review authority. He shall also obtain all required certificates of inspection for his work and deliver same to the Engineers before request for acceptance and final payment for the work. Ignorance of Codes, Rules, Regulations, Laws, etc. shall not render the Contractor irresponsible for compliance. The Contractor shall also be versed in all Codes, Rules and Regulations pertinent to his part of the work prior to submission of a proposal.

B. The Contractor shall include in his work, without extra cost, any labor, materials, services, apparatus and drawings in order to comply with all applicable laws, ordinances, rules and regulations, whether or not indicated or specified.

C. All materials furnished and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, with the requirements of local utility companies, or municipalities and with the requirements of all governmental agencies having jurisdiction.

D. All materials and equipment so indicated and all equipment and materials for the electrical portion of the mechanical systems shall bear the approval label of, or shall be listed by the Underwriters' Laboratories (UL), Incorporated. Each packaged assembly shall be approved as a package. Approval of components of a package shall not be acceptable.

E. All plumbing work is to be constructed and installed in accordance with plans and specifications which have been approved in their entirety and/or reflect any changes requested by the State Department of Health. Plumbing work shall not commence until such plans are in the hands of the Contractor.

F. All Heating, Ventilation and Air Conditioning work shall be accomplished in accordance with the Kentucky Building Code (KBC) and amendments thereto, the latest standards recognized by the American Society of Heating, Refrigerating and Air Conditioning and the National Fire Protection Association.

G. All pressure vessel installations shall comply with the State, and/or Federal Code applicable. A Certificate of Final Boiler Inspection shall be required.

H. The Contractor shall furnish three (3) copies of all Final Inspection Certificates obtained to the Engineer when work is complete. Final payment for work will be contingent upon compliance with this requirement.

I. Where minimum code requirements are exceeded in the Design, the Design shall govern.

J. The Contractor shall insure that his work is accomplished in accord with the OSHA Standards and that he conducts his work and the work of his personnel in accord with same.

K. The installation of all fuel storage tanks and associated piping, whether interior or exterior, shall be inspected by the State Fire Marshal, Hazardous Materials Section, before backfill. Submit certificate of this inspection to the Engineers.

L. Work in elevators, elevator shafts and elevator equipment rooms shall comply with the Elevator Code enforced by the Commonwealth of Kentucky.

M. All work relating to the handicapped shall be in accord with regulations currently enforced by the Department of Housing, Buildings and Construction, Commonwealth of Kentucky and the American Disabilities Act.

N. All work in conjunction with a natural gas installation shall, in addition to all other Codes, Rules, Regulations, Standards, etc., comply with the requirements of the local gas supplier and/or standards and recommendations of the American Gas Association.

O. All work in relation to domestic water systems shall, in addition to all other Codes, Rules, Regulations and Standards, be in compliance with the requirements of the local water utility company and the adopted edition of the 10 States Standards.

P. All work in relation to the installation of sanitary or storm sewers shall, in addition to all other Codes, Rules, Regulations and Standards, be in compliance with the local agency governing such installations and the adopted edition of the 10 States Standards.

Q. UL Labeled Systems: Where required by the Code and/or the Authority Having Jurisdiction, provide the services of a field labeling agency to provide a UL label for the entire system in the field under evaluation.

R. All work relating to the handicapped shall be in accord with regulations currently enforced by the Department of Housing, Buildings, and Construction, Commonwealth of Kentucky and the American Disabilities Act.

8. EQUIPMENT AND PIPING SUPPORT

A. Each piece of equipment, apparatus, piping, or conduit suspended from the structure or mounted above the floor level shall be provided with suitable structural support, pipe stand, platform or carrier in accordance with the best recognized practice. Such supporting or mounting means shall be provided by the Contractor for all equipment and piping. Exercise extreme care that structural members of building are not overloaded by such equipment. Provide any required additional bracing, cross members, angles, support, etc., as indicated or required by the Structural Engineer. This, in some instances, will require the Contractor to add an angle to a joist to transfer the load to a panel point. If in doubt, contact the Structural Engineer.

9. DUCT AND PIPE MOUNTING HEIGHTS

A. All exposed or concealed ductwork, piping, etc., shall be held as high as possible unless otherwise noted and coordinated with all other trades. Exposed piping and ductwork shall, insofar as possible, run perpendicular or parallel to the building structure.

10. COST BREAKDOWNS (SCHEDULE OF VALUES)

A. Within thirty days after acceptance of the Contract, the Contractor shall furnish to the Engineer, one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made in a format approved by the Engineer. Payments will not be made until satisfactory cost breakdowns are submitted.

11. 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 Architect's or 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.

C. All gas fired heat exchangers shall have 20 year warranty.

D. All compressors shall have five year warranty.

12. COMPUTER-BASED SYSTEM SOFTWARE

A. For all equipment, controls, hardware, computer-based systems, programmable logic controllers, and other materials provided as a part of the work, software that is installed shall be certified in writing to the Engineer and Owner by the manufacturer and/or writer to be free of programming errors that might affect the functionality of the intended use.

13. CHANGES IN MECHANICAL WORK

REFER TO GENERAL AND SPECIAL CONDITIONS.

14. CLAIMS FOR EXTRA COST

REFER TO GENERAL AND SPECIAL CONDITIONS.

15. SURVEY, MEASUREMENTS AND GRADE

A. The Contractor shall lay out his work and be responsible for all necessary lines, levels, elevations and measurements. He must verify the figures shown on the drawings before laying out the work and will be held responsible for any error resulting from his failure to do so.

B. The Contractor shall base all measurements, both horizontal and vertical from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the work.

C. Should the Contractor discover any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the contract documents, he shall promptly notify the Engineer and shall not proceed with this work until he has received instructions from the Engineer on the disposition of the work.

16. TEMPORARY USE OF EQUIPMENT

A. The permanent heating and plumbing equipment, when installed, may be used for temporary services, with the consent of the Engineers provided the following requirements were met. Should the permanent systems be used for this purpose the Contractors shall make all temporary connections required at their expense. They shall also make any replacement required due to damage wear and tear, etc., leaving the same in "as new" condition.

B. Permission to use the permanent equipment does not relieve the Contractors from the responsibility for any damages to the building construction and/or equipment which might result because of its use.

C. A pre-start-up conference shall be held with the Engineer, Owner, Construction Manager and the Mechanical Contractor to discuss temporary conditioning. Equipment shall not be started until after this meeting.

D. During all phases of construction:

(1) Air Handling Units (OA-1):

a. OA-3 shall not be used for space tempering during construction.

b. At a minimum, four complete sets of filter media are required for each unit. In each unit, install two sets of filter media during construction (more shall be required if construction activities dictate more frequent changes). In each unit, install one set of filter media at substantial completion. Leave one set of filter media in boxes in appropriate mechanical room as a spare set for the Owner. All other filters shall be used by the Contractor during construction. Dispose of all construction filter media.

c. On the outside of all return exhaust air openings install a minimum of two sets of fiberglass filter media, such as cheesecloth, to be utilized as pre-filters for the "construction" filters. Install first set upon start-up and then install second set when first set is dirty. Dispose of all dirty construction filters. Change filters as often as necessary to keep units from becoming dirty at no additional cost.

d. At substantial completion of the project the entire unit shall be cleaned to present a like "new" unit for the Owner and all filters shall be replaced with new.

(2) Heat Pump Units:

a. These units shall not be used for space conditioning prior to receiving written permission from the Engineer. Prior to these units being started, the building shall be clean. These units shall not run while any dust producing activity is ongoing such as drywall finishing. The floors shall be vacuumed prior to unit start-up.

b. At a minimum, four complete sets of filter media are required for each unit. In each unit, install two sets of filter media during construction (more shall be required if construction activities dictate more frequent changes). In each unit, install one set of filter media at substantial completion. Leave one set of filter media in boxes in appropriate mechanical room as a spare set for the Owner. All other filters shall be used by the Contractor during construction. Dispose of all construction filter media.

c. On the outside of all return air openings install a minimum of two sets of fiberglass filter media, such as cheesecloth, to be utilized as pre-filters for the "construction" filters. Install first set upon start-up and then install second set when first set is dirty. Dispose of all dirty construction filters. Change filters as often as necessary to keep units from becoming dirty at no additional cost.

d. At substantial completion of the project the entire unit shall be cleaned to present a like "new" unit for the Owner and all filters shall be replaced with new.

17. TEMPORARY SERVICES

A. The Contractor shall arrange any temporary water, electrical and other services which he may require to accomplish his work. Refer also to General and Special Conditions.

18. RECORD DRAWINGS

A. The Contractor shall insure that any deviations from the Design are as they occur recorded in red, erasable pencil on record drawings kept at the jobsite. The Engineer shall review the record documents from time to time to insure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control

Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose. Deliver these record drawings electronically in AutoCAD 2000 format along with the hand marked field set to the Engineer. Electronic bid drawings will be furnished to the Contractor for his use.

19. 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). Insure, 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. Use extreme care in the selection of equipment and its installation to insure that noise and vibration are kept at a minimum. The Engineer's determination shall be final and corrections to such discrepancies shall be made at the cost of the Contractor.

D. Each length of pipe, fitting, trap, fixture and device used in the plumbing or drainage systems shall be stamped or indelibly marked with the weight or quality thereof and with the manufacturer's mark or name.

E. 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.

20. COOPERATION AND COORDINATION WITH OTHER TRADES

A. The Contractor shall give full cooperation to all other trades and shall furnish in writing with copies to the Engineer, any information necessary to permit the work of other trades to be installed satisfactorily and with the least possible interference or delay.

B. Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If so directed by the Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than 1/4” = 1'-0”, clearly indicating how his work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. He shall make the necessary changes in his work to correct the condition without extra charge.

C. The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

21. QUALIFICATIONS OF WORKMEN

A. All mechanical work shall be accomplished by qualified workmen competent in the area of work for which they are responsible. Untrained and incompetent workmen, as evidenced by their workmanship, shall be summarily relieved of their responsibilities in areas of incompetency. The Engineer shall reserve the right to determine the quality of workmanship of any workman and unqualified or incompetent workman shall refrain from work in areas not satisfactory to him. Requests for relief of a workman shall be made through the normal channels of Architect, Contractor, etc.

B. All plumbing work shall be accomplished by Journeymen Plumbers under the direct supervision of a Master Plumber as defined and clarified under Kentucky State Plumbing Law Regulations and Code. Proof and Certification may be requested by the Engineer.

C. All sheet metal, insulation and pipe fitting work shall be installed by workmen normally engaged or employed in these respective trades, except where only small amounts of such work are required and are within the competency of workmen directly employed by the Contractor involved.

D. All automatic control systems shall be installed by workmen normally engaged or employed in this type work, except in the case of minor control requirements (residential type furnaces, packaged HVAC equipment with integral controls, etc.) in which case, if a competent workman is the employee of this Contractor, he may be utilized subject to review of his qualifications by the Engineer and after written approval from same.

E. All special systems (Automatic Sprinkler Equipment, etc.) shall be installed only by workmen normally engaged in such services. Exception to this specification may only be made in writing by the Engineer.

F. All electrical work shall be installed only by competent workmen under direct supervision of a fully qualified Electrician.

22. CONDUCT OF WORKMEN

A. The Contractor shall be responsible for the conduct of all workmen under his supervision. Misconduct on the part of any workman to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt relief of that workman. The consumption of alcoholic beverages or other intoxicants, narcotics, barbiturates, hallucinogens or debilitating drugs on the job site is strictly forbidden.

23. PROTECTION OF EQUIPMENT

A. The Contractor shall be entirely responsible for all material and equipment furnished by him in connection with his work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. All rough-in soil, waste, vent and storm piping, ductwork, etc., shall be properly plugged or capped during construction in a manner approved by the Engineer. Equipment damaged stolen or vandalized while stored on site, either before or after installation, shall be repaired or replaced by the Contractor at his own expense.

24. SCAFFOLDING, RIGGING AND HOISTING

A. The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery onto the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OSHA Standards and Requirements. Remove same from premises when no longer required.

25. BROKEN LINES AND PROTECTION AGAINST FREEZING

A. No conduits, piping, troughs, etc. carrying water or any other fluid subject to freezing shall be installed in any part of the building where danger of freezing may exist without adequate protection being given by the Contractor whether or not insulation is specified or indicated on the particular piping. All damages resulting from broken and/or leaking lines shall be replaced or repaired at the Contractor's own expense. If in doubt, contact the Engineer. Do not install piping across or near openings to the outside whether they are carrying static or moving fluids or not. Special Note: Insulation on piping does not necessarily insure that freezing will not occur.

26. CLEANING

A. The Contractor shall, at all times, keep the area of his work presentable to the public and clean of rubbish and debris caused by his operations; and at the completion of the work, shall remove all rubbish, debris, all of his tools, equipment, temporary work and surplus materials from and about the premises, and shall leave the area clean and ready for use. If the Contractor does not attend to such cleaning upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the Contractor. The Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of his rubbish or debris.

B. After completion of all work and before final acceptance of the work, the Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of piping, equipment, fixtures and all other associated or adjacent fabrication.

27. CONCRETE WORK

A. The Contractor shall be finally responsible for the provisions of all concrete work required for the installation of any of his systems or equipment. He may, at his option, arrange with the others to provide the work. This option, however, will not relieve the Contractor of his responsibilities relative to dimensions, quality of workmanship, locations, etc. In the absence of other concrete specifications, all concrete related to Mechanical work shall be 3000 psi minimum compression strength at 28 days curing and shall conform to the standards of the American Concrete Institute Publication AC1-318. Heavy equipment shall not be set on pads for at least seven (7) days after pour. Insert 6-inch steel dowel rods into floors to anchor pads.

B. All mechanical equipment (tanks, heaters, chillers, boilers, pumps, air handling units, etc.) shall be set on a minimum of 4” tall concrete pads. Pads shall be taller where required for condensate traps. All concrete pads shall be complete with all pipe sleeves, anchor bolts, reinforcing steel, concrete, etc. as required. Pads larger than 18” in width shall be reinforced with ½” round bars on 6” centers both ways. Bars shall be approximately 3” above the bottom of the pad. All parts of pads and foundations shall be properly rodded or vibrated. If exposed parts of the pads and foundations are rough or show honeycomb after removing forms, all surfaces shall be rubbed to a smooth surface. Chamfer all square edges one-half inch.

C. In general, concrete pads for equipment shall extend four (4) inches beyond the equipment's base dimensions. Where necessary, extend pads 30 inches beyond base or overall dimensions to allow walking and servicing space.

D. Exterior concrete pads shall be four (4) inches minimum above grade and four (4) inches below grade on a tamped four (4) inch dense grade rock base unless otherwise indicated or specified. Surfaces of all foundations and bases shall have a smooth finish with one-half (1/2) inch chamfer on exposed edges.

28. NOISE, VIBRATION OR OSCILLATION

A. All work shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Engineer. In case of moving machinery, sound or vibration noticeable outside of room in which it is installed, or annoyingly noticeable inside its own room, will be considered objectionable. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor at his expense.

B. All equipment subject to vibration and/or oscillation shall be mounted on vibration supports whether indicated or not suitable for the purpose of minimizing noise and vibration transmission, and shall be isolated from external connections such as piping, ducts, etc. by means of flexible connectors, vibration absorbers, or other approved means. Unitary equipment, such as small room heating units, small exhaust fans, etc., shall be rigidly braced and mounted to wall, floor or ceiling as required and tightly gasketed and sealed to mounting surface to prevent air leakage and to obtain quiet operation. Flush and surface mounted equipment such as diffusers, grilles, etc., shall be gasketed and affixed tightly to their mounting surface.

C. The Contractor shall provide supports for all equipment furnished by him. Supports shall be liberally sized and adequate to carry the load of the equipment and the loads of attached equipment, piping, etc. All equipment shall be securely fastened to the structure either directly or indirectly through supporting members by means of bolts or equally effective means. If strength of supporting structural members is questionable, contact Engineers.

29. ACCESSIBILITY

A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in double partitions and hung ceilings for the proper installation of his work. He shall cooperate with all others whose work is in the same space. Such spaces and clearances shall, however, be kept to the minimum size required.

B. The Contractor shall locate and install all equipment so that it may be serviced, and maintained as recommended by the manufacturer. Allow ready access and removal of the entire unit and/or parts such as valves, filters, fan belts, motors, prime shafts, etc.

C. The Contractor shall provide access panels for each concealed valve, control damper or other device requiring service as shown on engineer's plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work.

30. RESTORATION OF NEW OR EXISTING SHRUBS, PAVING, SURFACES, ETC.

A. The Contractor shall at his expense restore to their original conditions all paving, curbing, surfaces, drainage ditches, structures, fences, shrubs, existing or new building surfaces and appurtenances, and any other items damaged or removed by his operations. Replacement and repairs shall be in accordance with good construction practice and shall match materials employed in the original construction of the item and shall be to the satisfaction of the Architect and/or Engineer.

31. MAINTENANCE OF EXISTING UTILITIES AND LINES

A. The locations of all piping, conduits, cables, utilities and manholes existing, or otherwise, that comes within the contract construction site, shall be subject to continuous uninterrupted service with no other exception than the Owner of the utilities permission to interrupt same temporarily.

B. Utilities and lines, where known, are indicated on the drawings. Locations and sizes are approximate. Prior to any excavation being performed, the Contractor shall ascertain that no utilities or lines are endangered by new excavation. Exercise extreme caution in all excavation work.

C. If utilities or lines occur in the earth within the construction site, the Contractor shall probe and locate the lines prior to machine excavation or blasting in the respective area.

D. Cutting into existing utilities and services where required shall be done in coordination with and only at times designated by the Owner of the utility.

E. The Contractor shall repair to the satisfaction of the Engineer, any surfaces or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.

F. Machine excavation shall not be permitted with ten feet of electrical lines or lines carrying combustible and/or explosive materials. Hand excavate only.

G. Protect all new or existing lines from damage by traffic, etc. during construction. Repairs or replacement of such damage shall be at the sole expense of the party responsible.

32. SMOKE AND FIRE PROOFING

A. The Contractor shall repair, fire and smoke stop all openings made in fire rated walls, chases, ceilings and floors in accord with the KBC. Patch all openings around ductwork and piping with appropriate type material to stop smoke at smoke walls and provide commensurate fire rating at fire walls, floors, ceilings, roofs, etc.

B. The Contractor shall take care not to damage fire proofing on steel strtuctural members. Structural members may be fire proofed prior to Bid Package #3 contractors commencing work.

33. 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 16 of Specifications for further requirements related to installation of motors.

34. CUTTING AND PATCHING

A. The Contractor shall provide his own cutting and patching necessary to install his work. Patching shall match adjacent surfaces and shall be to the satisfaction of the Architect and Engineer.

B. No structural members shall be cut without the approval of the Engineer and all such cutting shall be done in a manner directed by him.

35. CURBS, PLATES, ESCUTCHEONS & AIR TIGHT PENETRATIONS

A. In all areas where ducts are exposed and ducts pass thru floors, the opening shall be surrounded by a 4 inch high by 3 inch wide concrete curb.

B. Escutcheon plates shall be provided for all pipes and conduit passing thru walls, floors and ceilings. Plates shall be nickel plated, of the split ring type, of size to match the pipe or conduit. Where plates are provided for pipes passing thru sleeves which extend above the floor surface, provide deep recessed plates to conceal the pipe sleeves.

C. Seal all duct, pipe, conduit, etc., penetrations through walls and floors air tight. If wall or floor assembly is rated then use similarly rated sealing method.

36. WEATHERPROOFING

A. Where any work pierces waterproofing including waterproof concrete, the method of installation shall be as approved by the Engineer before work is done. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings permanently watertight.

37. OPERATING INSTRUCTIONS, MAINTENANCE MANUALS AND PARTS LISTS

A. Upon completion of all work tests, the Contractor 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 Contractor 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. Ther shall also be submittal electronically through Constructware. 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.

D. The Contractor shall frame under Lexan in the main mechanical room all temperature control diagrams and all piping diagrams.

38. PAINTING

A. In general, all finish painting shall be accomplished under the Painting Section of the specifications by the Contractor; however, unless otherwise specified under other sections of these specifications, the following items shall be painted:

(1) All exposed piping, valve bodies and fittings (bare and insulated), including hangers, platforms, etc.

(2) All mechanical equipment not factory finished. Aluminum and stainless steel equipment, motors, identification plates, tags, etc. shall not be painted. All rust and foreign matter shall be thoroughly removed from surfaces prior to painting. All baked enamel factory finish of equipment which may have been scratched or chipped shall be touched up with the proper paint as recommended and supplied by the manufacturer.

(3) All ductwork exposed in finished areas (bare and insulated), all grilles, diffusers, etc. not factory finished. Paint the inside surfaces of all interior duct surfaces visible from any register, grille or diffuser opening on all jobs; surfaces shall receive one (1) prime coat of Rustoleum 1225 red "galvinoleum" or other approved equivalent primer and rust inhibitor and one (1) coat of Rustoleum 1579 jet black "Speedy Dry" enamel or approved equivalent applied in accordance with the manufacturer's recommendations.

(4) All insulated piping, ductwork and equipment shall be properly prepared for painting by the Contractor where mechanical items are to be painted. In the case of externally insulated duct and pipe, the Contractor shall provide 6 oz. canvas jacket with fire retardant lagging. The jacket shall be allowed to dry properly before applying paint to avoid shrinking after painting and exposing unpainted surfaces. The Contractor, at his option, may provide double wall ductwork in lieu of externally insulated ductwork with canvas jacket and lagging.

39. ELECTRICAL CONNECTIONS

A. The Contractor shall furnish and install all (1) temperature control wiring; (2) equipment control wiring and (3) interlock wiring. The Contractor shall furnish and install all power wiring complete from power source to motor or equipment junction box, including power wiring thru starters, and shall furnish and install all required starters not factory mounted on equipment.

B. The Contractor shall, regardless of voltage, furnish and install all temperature control wiring and all associated interlock wiring, all equipment control wiring and conduit for the equipment that the Contractor furnishes. He may, at his option, employ at his own expense, the Electrical Contractor to accomplish this work.

C. After all circuits are energized and completed, the Contractor shall be responsible for all power wiring, and all control wiring shall be the responsibility of the Contractor. Motors and equipment shall be provided for current characteristics as shown on the drawings.

D. The Contractor shall furnish motor starters of the type and size required by the manufacturer for all equipment provided by him, where such starters are necessary. Starters shall have overloads for each phase.

40. FINAL CONNECTIONS TO EQUIPMENT

A. The Contractor shall finally connect to mechanical services, any terminal equipment, appliances, etc., provided under this and other divisions of the work. Such connections shall be made in strict accord with current codes, safety regulations and the equipment manufacturer's recommendations. If in doubt, contact the Engineers prior to installation.

41. TRAINING AND RELATED SUBMITTALS

(1) Contractor shall provide classroom and in the field training for each type and/or model of equipment installed. Training shall be led by qualified factory certified technician. Contractor shall submit a request to schedule training sessions a minimum of two weeks in advance. Submission shall include qualifications of instructor as well as a syllabus that the Owner will add/deduct to as they see fit. Each individual listed as an "Attendee" on the roster submitted shall receive a copy of the maintenance manual to review during training. All training sessions shall be recorded and a DVD with proper labels identifying the date, equipment, and project shall be delivered prior to Completion of the project. If the audio from the recording is unclear, narration shall be added.

(2) Systems/Components which require owner training. The training shall be accomplished by a factory trained representative. Include (8) hours minimum for each system described here-in. Each equipment representative shall be represented wherever their equipment is used.

a. Geothermal System.
b. Water source heat pumps.
c. Air handling units including miscellaneous fan coil units, controls, sequences, etc.
d. Complete control system including all sequences, hardware, software, etc.
e. Plumbing and Fire Protection Systems

(3) At completion of training, submit two complete training manual(s) for Owner's use.

a. Transcript: Prepared on 8-1/2-by-11-inch paper, punched and bound in heavy duty, 3-ring, vinyl-covered binders. Mark appropriate identification on front and spine of each binder. Include a cover sheet with same label information as the corresponding video. Include name of Project and date of video on each page.

42. REQUIRED CLEARANCE FOR ELECTRICAL EQUIPMENT

A. The NEC has specific required clearances above, in front, and around electrical gear, panels etc. The Contractor shall not install any piping, ductwork, etc., in the required clearance. If any appurtenance is located in the NEC required clearance, it shall be relocated at no additional cost.

43. 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.

44. LEED REQUIREMENTS

Credit 3.1 – Construction IAQ Management Plan During Construction

1. The contractor shall meet or exceed the recommended Design Approaches for the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings Under Construction, 1995 Chapter 3. The five requirements under this guideline are as follows:

    a. HVAC Protection
    b. Source Control
    c. Pathway Interruption
    d. Housekeeping
    e. Scheduling

2. Protect Stored on-site or installed absorptive materials from moisture damage.
3. If air handlers must be used during construction, filtration media with a Minimum Efficiency Reporting Value (MERV) of 8 must be used at each return air grill as determined by ASHRAE 52.2-1999
4. Replace all filtration media immediately prior to occupancy. Filtration media shall have a MERV of 13 as determined by ASHRAE 52.2-1999 for media installed at the end of construction.
5. The Mechanical Contractor and General Contractor is responsible for completeing the LEED Letter Template for Credit 3.1

B. Credit 3.2 – Construction IAQ Management Pre-Occupancy

1. The contractor has the option of either performing a Full Building Flushout in which they must provide the flushout prior to Occupancy or a modified flushout that occurs during Occupancy. Under the Full Building Flush Out, the contractor shall perform one of the following.

    The contractor shall provide a minimum of 3,500 cu. Ft. of outdoor air per square foot of floor space. Once a space is occupied it shall be ventilated at a minimum rate of 0.3 cfm/sq. ft of outside air or the design minimum outside air which ever is greater. During each day of the flush-out period, ventilation shall begin a minimum of three hours prior to occupancy and continue during occupancy. These conditions shall be maintained until a total of 14,000 cu. Ft. per square foot of outside air has been delivered to the space.

    Or

    After construction ends, prior to occupancy and with all interior finishes installed, install new filtration media and perform a building flush out by supplying a total air volume of 14,000 cubic feet of outdoor air per square foot of building space while maintaining an internal temperature of at least 60 F and a relative humidity no higher than 60%.

45. HAZARDOUS MATERIALS

A. The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building(s). Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of his work, insure that his workers are aware of this potential and what they are to do in the event of suspicion. He shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.

B. CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling or disposal of such material.

C. If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise him immediately.

D. The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents or consultants. Also, the Contractor further agrees to defend, indemnify and hold CMTA, its principals, employees, agents and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.

46. ABOVE-CEILING AND FINAL PUNCH LISTS

A. The Contractor shall review each area and prepare a punch list for each of the subcontractors, as applicable, for at least two stages of the project:

(1) For review of above-ceiling work that will be concealed by tile or other materials well before substantial completion.
(2) For review of all other work as the project nears substantial completion.

B. When all work from the Contractor's punch list is complete at each of these stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing seven days prior to the proposed date. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review.

C. If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor at a rate of $125.00 per hour for extra trips required to complete either of the above-ceiling or final punch lists.

END OF GENERAL PROVISIONS-MECHANICAL

SECTION 200200- SCOPE OF THE MECHANICAL WORK

1. GENERAL

A. The Mechanical work for this Contract shall include all labor, materials, equipment, fixtures, excavation, backfill and related items required to completely install, test, place in service and deliver to the Owner the complete mechanical systems in accordance with the accompanying plans and all provisions of these specifications. This work shall primarily include, but is not necessarily limited to the following:

(1) Plumbing Systems.

(2) All mechanical exhaust systems.

(3) All insulation associated with mechanical systems.

(4) Complete heating, ventilation and air conditioning systems.

(5) Final connection of all mechanical equipment furnished by others (e.g., Kitchen).

(6) Coordination with the State provided Test and Balance Contractor.

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

(8) All specified or required control work.

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

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

(11) Thorough instruction of the owners maintenance personnel in the operation and maintenance of all mechanical equipment.

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

(13) Approved supervision of the mechanical work.

(14) Excavation, backfilling, cutting, patching, sleeving, concrete work, etc., required to construct the mechanical systems.

(15) Prior to submitting a bid, the Contractor shall contact all serving utility companies to determine exactly what each utility company will provide and exactly what is required of the Contractor and shall include such requirements in his base bid.

(16) Procurement of all required permits and inspections, including fees for all permits and inspection services and submission of final certificates of inspection to the Engineers (Plumbing, Boiler, etc.).

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

END OF SCOPE OF MECHANICAL WORK

SECTION 200300 - REQUIRED SHOP DRAWINGS, DESCRIPTIVE LITERATURE, MAINTENANCE MANUALS, PARTS LISTS, SPECIAL KEYS & TOOLS

1. GENERAL

A. The Contractor's attention is directed also to the General and Special Conditions and Section 200100 - General Provisions - Mechanical as well as to all other Contract Documents as they may apply to his work.

B. The Contractor shall prepare and submit to the Engineer, through the General Contractor and the Architect (where applicable) within thirty (30) days after the date of the Contract, all shop drawings, certified equipment drawings, installation, operating and maintenance instructions, samples, wiring diagrams, etc. on all items of equipment specified hereinafter through Constructware. In addition to the electronic submittal, hard copies of the Fire Protection drawings shall be submitted.

C. Submittal data shall include specification data including metal gauges, finishes, accessories, etc. Also, the submittal data shall include certified performance data, wiring diagrams, dimensional data, and a spare parts list. Submittal data shall be reviewed by the Engineer before any equipment or materials is ordered or any work is begun in the area requiring the equipment.

D. All submittal data shall have the stamp of approval of the Contractor submitting the data as well as the General Contractor and the Architect (if applicable) to show that the drawings have been reviewed by the Contractor. Any drawings submitted without these stamps of approval may not be considered and will be returned for proper resubmission.

E. It shall be noted that review of shop drawings by the Engineer applies only to conformance with the design concept of the project and general compliance with the information given in the contract documents. In all cases, the Contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located.

F. The Engineers review of shop drawings, schedules or other required submittal data shall not relieve the Contractor from responsibility for: adaptability of the item to the project; compliance with applicable codes, rules, regulations and information that pertains to fabrication and installation; dimensions and quantities; electrical characteristics; and coordination of the work with all other trades involved in this project. Any items that differ from the Drawings or Specifications shall be flagged by the Contractor so the Engineer will be sure to see the item. Do not rely on the Engineer to “catch” items that do not comply with the Drawings or Specifications. The Contractor is responsible for meeting the Drawings and Specification requirements, regardless of whether or not something does not get caught by the Contractor or Engineer during shop drawing reviews.

G. Equipment shall not be ordered and no final rough-in connections, etc., shall be accomplished until reviewed equipment shop drawings are in the hands of the Contractor. It shall be the Contractor's responsibility to obtain reviewed shop drawings and to make all connections, etc. in the neatest and most workmanlike manner possible. The Contractor shall coordinate with all the other trades having any connections, roughing-in, etc. to the equipment.

H. If the Contractor fails to comply with the requirements set forth above, the Engineer shall have the option of selecting any or all items listed in the Specifications or on the drawings; and the Contractor shall be required to furnish all materials in accordance with this list.

I. Colors for equipment in other than mechanical spaces shall be selected from the Manufacturer's standard and factory optional colors. Color samples shall be furnished with the shop drawing submission for such equipment.

J. All Submittals shall include documentation that the product complies with the Buy American Clause described within the Specifications or shall be rejected.

K. Shop Drawing Submittals

(1) All submittals for HVAC equipment shall include all information specified. This shall include air and water pressure drops, RPM, noise data, face velocities, horsepower, voltage motor type, steel or aluminum construction, and all accessories clearly marked.
(2) All items listed in the schedules shall be submitted for review in a tabular form similar to the equipment schedule.

(3) All items submitted shall be designated with the same identifying tag as specified on each sheet.

(4) Any submittals received in an unorganized manner without options listed and with incomplete data will be returned for resubmittal.

(5) All shop drawings shall include a separate sheet indicating that the submitted products comply with the project's Buy American requirements. Any submittal that does not include this documentation may be rejected.

2. SHOP DRAWINGS

Shop Drawings, descriptive literature, technical data and required schedules shall be submitted on the following:

Duct Insulation (External)
Pipe Insulation
Hydronic Specialties
(2) Chemical Treatment System
(1) Pumps and Circulators (HVAC)
(1) Exhaust Fan
(1) Registers, Diffusers, Grilles, Ductwork
(1) Water Source Heat Pumps
(1) Air Handling Unit
(2) Controls, Building Management System
(3) Fire Protection System
(1) Baseboard Heater

SPECIAL NOTES:

(1) Upon substantial completion of the project, the Contractor shall deliver to the Engineers (in addition to the required Shop Drawings) three (3) complete copies of operation and maintenance instructions and parts lists for each item marked (1) above. These documents shall include at least:

(a) Detailed operating instructions
(b) Detailed maintenance instructions including preventive maintenance schedules.
(c) Addresses and phone numbers indicating where parts may be purchased.

(2) Shop drawings for the Control Systems shall include detailed, scaled plans and schematic diagrams indicating the function and operation of the system.

(3) Shop drawings for the Building Fire Protection System shall be prepared and stamped by a Certified Contractor and shall meet the criteria of the Department of Housing, Buildings and Construction and submitted to the Engineer. After the Engineer's review, they shall be submitted by the Contractor to the proper state authorities along with the required State review fee.

(4) The Contractor shall submit to the Boiler Inspector's Office the required documentation and review fees for a boiler permit. The boiler permit shall be submitted to the Engineer along with the Boiler Shop Drawings.

(6) The Contractor shall submit Material Safety Data sheets for all chemical treatment and anti-freeze solutions.

3. SPECIAL WRENCHES, TOOLS, ETC.

(1) The Contractor shall furnish, along with equipment provided, any special wrenches or tools necessary to dismantle or service equipment or appliances installed under the Contract. Wrenches shall include necessary keys, handles and operators for valves, cocks, hydrants, etc. A reasonable number of each shall be furnished.

4. BALANCE REPORTS

A. Upon substantial completion of the project, the Contractor shall submit to the Engineers four (4) bound copies of the Certified Air and Hydronic Balance Report.

END OF REQUIRED SHOP DRAWINGS

SECTION 201100 - SLEEVING, CUTTING, PATCHING AND REPAIRING

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 in this section.

B. The Contractor shall be responsible for all openings, sleeves, trenches, etc., that he may require in floors, roofs, ceilings, walls, etc., and shall coordinate all such work with the General Contractor and all other trades. Coordinate with the General Contractor, any openings which he is to provide before submitting a bid proposal in order to avoid conflict and disagreement during construction. Improperly located openings shall be reworked at the expense of the Contractor.

C. The Contractor shall plan his work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for piping, ductwork, conduit, etc., to go through; however, when this is not done, the Contractor shall do all cutting and patching required for the installation of his work, or he shall pay other trades for doing this work when so directed by the Engineer. Any damage caused to the buildings by the workmen of the responsible Contractor must be corrected or rectified by him at is own expense.

D. The Contractor shall notify other trades in due time where he will require openings or chases in new concrete or masonry. He shall set all concrete inserts and sleeves for his work. Failing to do this, he shall cut openings for his work and patch same as required at his own expense.

E. The Contractor shall be responsible for properly shoring, bracing, supporting, etc., any existing and/or new construction to guard against cracking, settling, collapsing, displacing or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements shall be promptly and properly made good to the satisfaction of the Engineer.

F. All work improperly done or not done at all as required by the Mechanical Trades in this section, will be performed by the Contractor at the direction of the trade whose work is affected.

2. SLEEVES, PLATES AND ESCUTCHEONS

A. The Contractor shall provide and locate all sleeves and inserts required for his work before the floors and surface being penetrated are built, otherwise the Contractor shall core drill for pipes where sleeves and inserts were not installed, or where incorrectly located. Core drilling is the only acceptable alternative to sleeves. Do not chisel openings. Where sleeves are placed in exterior walls or in slabs on grade, the space between the pipe or conduit and the sleeves shall be made completely and permanently water tight.

B. Pipe that penetrates fire and/or smoke rated assemblies shall have sleeves installed as required by the manufacturer of the rating seal used.

C. At all other locations either pipe sleeves or core drilled openings are acceptable.

D. Where thermal expansion does not occur, the wall may be sealed tight to the pipe or insulation.

E. Insulation, that requires a vapor barrier (i.e., cold water or refrigerant piping, etc.), must be continuous through the sleeve/cored hole. For other piping, insulation may stop on either side of the sleeve.

F. Sleeves shall be constructed of 24 gauge galvanized sheet steel with lock seam joints or Schedule 40 pipe. Sleeves in floors shall extend 1" above finished floor level.

G. Fasten sleeves securely in floors, walls, so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster or other materials being forced into the space between pipe and sleeve during construction.

H. In all areas where ducts are exposed and ducts pass thru floors, the opening shall be surrounded by a 4 inch high by 3 inch wide concrete curb.

I. Escutcheon plates shall be provided for all pipes and conduit passing thru walls, floors and ceilings. Plates shall be nickel plated, of the split ring type, of size to match the pipe or conduit. Where plates are provided for pipes passing thru sleeves which extend above the floor surface, provide deep recessed plates to conceal the pipe sleeves.

3. CUTTING

A. All rectangular or special shaped openings in plaster, stucco or similar materials, including gypsum board, shall be framed by means of plaster frames, casing beads, wood or metal angle members as required. The intent of this requirement is to provide smooth even termination of wall, floor and ceiling finishes as well as to provide a fastening means for grilles, diffusers, lighting fixtures, etc.

B. Mechanical, plumbing, and fire protection contractors shall coordinate all openings in new and existing masonry walls with the General Contractor; and, unless otherwise indicated on the Architectural drawings, provide lintels for all openings required for the work (Louvers, etc.). Lintels shall be sized as follows:

(1) New Openings under 48" in width: Provide one 3-1/2"x3-1/2"x3/8" steel angle for each 4" of masonry width. Lintel shall have 8" bearing on either side.

(2) New Openings 48" to 96" in width: Provide one 3-1/2"x6"x3/8" steel angle for each 4" of masonry width. Lintel shall have 8" bearing on either side.

(3) New Openings over 96" in width: Consult the Project Structural Engineer.

C. No cutting is to be done at points or in a manner that will weaken the structure and unnecessary cutting must be avoided. If in doubt, contact the Engineer.

D. Pipe openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edges of trenches and large openings shall be scribe cut with a masonry saw.

E. Openings in metal building walls shall be made in strict accord with building suppliers recommendations.

4. PATCHING AND REPAIRING

A. Patching and repairing made necessary by work performed under this division shall be included as a part of the work and shall be done by skilled mechanics of the trade or trades for work cut or damaged, in strict accordance with the provisions herein before specified for work of like type to match adjacent surfaces and in a manner acceptable to the Engineer.

B. Where portions of existing lawns, shrubs, paving, etc. are disturbed for installation of work of this Division, such items shall be repaired and/or replaced to the satisfaction of the Engineer.

C. Where the installation of conduit, ducts, piping, etc. requires the penetration of fire or smoke rated walls, ceilings or floors, the space around such conduit, duct, pipe, etc., shall be tightly filled with an approved non-combustible fire insulating material satisfactory to maintain the rating integrity of the wall, floor or ceilings affected.

D. Where ducts penetrate fire rated assemblies, fire dampers shall be provided with an appropriate access door.

E. Piping passing through floors, ceilings and walls in finished areas, unless otherwise specified, shall be fitted with chrome plated brass escutcheons of sufficient outside diameter to amply cover the sleeved openings and an inside diameter to closely fit the pipe around which it is installed.

F. Stainless steel collars shall be provided around all ducts, large pipes, etc., at all wall penetrations; both sides where exposed.

G. Where ducts, pipes, and conduits pass through interior or exterior walls, the wall openings shall be sealed air tight. This shall include sealing on both sides of the wall to insure air does not enter or exit the wall cavity. This is especially critical on exterior walls where the wall cavity may be vented to the exterior.

END OF SLEEVING, CUTTING, PATCHING

SECTION 201200 - EXCAVATION, TRENCHING, BACKFILLING AND GRADING

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 in this section.

B. The Contractor shall include all excavating, filling, grading, and related items required to complete his work as shown on the drawings and specified herein or as required to complete, connect and place all mechanical systems in satisfactory operation.

C. Unless otherwise shown or required, provide separate trenches for sewers, water lines and other underground raceways, with a minimum of 10 feet measured from outside diameter between pipes. In locations, such as close to buildings where separate trenches for sewers and water lines are impractical, lay the water pipe on a solid shelf at least 2'-0" above the top of the sewer and 2-0" to the side. Electric and fuel lines shall always be placed in a separate trench. All exterior lines shall have a minimum earth cover of thirty (30) inches to top of pipe, unless otherwise indicated.

D. Water lines crossing under sewer lines, or crossing less than 2 feet above sewer lines, must be encased for a distance not less than 5 feet on either side of the point of crossover.

2. SUBSURFACE DATA

A. Materials to be excavated shall be unclassified, and shall include earth, rock, or any other material encountered in the excavating to the depth and extent indicated on the drawings and specified herein. No adjustment in the Contract sum will be made on account of the presence or absence of rock, shale, or other materials encountered in the excavating. This paragraph is written to include the removal of all rock with no extras, whether rock is indicated or not.

3. BENCH MARKS AND MONUMENTS

A. Maintain carefully all bench marks, monuments and other reference points. If disturbed or destroyed, replace as directed.

4. EXCAVATION

A. Excavate trenches of sufficient width for proper installation of the work. When the depth of backfill over sewer pipe exceeds 10 feet, keep the trench at the level of the top of the pipe as narrow as practicable. Trench excavation for piping eight inches and smaller shall not exceed thirty inch width for exterior lines and twenty-four inch width for interior lines.

B. Sheet and brace trenches as necessary to protect workmen and adjacent structures. Comply with local regulations or, in the absence thereof, with the "Manual of Accident Prevention in Construction" of the Associated General Contractors of America, Inc., and current OSHA Standards. Do not remove sheeting until trench is backfilled sufficiently to protect pipe and prevent injurious caving. Where removal of sheeting and/or bracing is hazardous, leave in place. Cut off such sheeting not to be removed at least 3 feet below finished grade.

C. Rules and regulations governing the respective utilities shall be observed in executing all work under this heading. Active utilities discovered in the course of excavation shall be protected or relocated in accordance with written instructions from the Engineer. Inactive and abandoned utilities encountered in trenching operations shall be removed and abandoned with ends plugged or capped in accord with current codes and safe practice. If in doubt,

contact Engineers. Machine excavation shall not be allowed within ten (10) feet of existing electric lines or lines carrying combustible materials. Use only hand tools.

D. The removal of rock shall be accomplished by use of hand or power tools only. Blasting shall not be permitted unless authorized in writing by the Engineer. Any damage to existing structures, exterior services, or rock intended for bearing, shall be corrected at the Contractor's expense.

E. Perform final grading of trench bottoms by hand tools; carry machine excavation only to such depth that soil bearing for pipes and raceways will not be disturbed. Grade the bottom of trenches evenly to insure uniform bearing for all piping and raceways. Cut bell holes as necessary for joints and jointmaking. Except as hereinafter specified, bottom of trenches for bell and spigot pipe, flanged pipe, etc. shall be shaped to the lower quadrant of pipe with additional excavation for bell or flange. Piping installed where it rests on bell, or flange and/or is supported with blocks or wedges will not be accepted.

F. Keep trenches free from water while construction therein is in progress. Under no circumstances lay pipe or appurtenances in water. Pump or bail water from bell holes to permit proper jointing of pipe. Any water pumping from this Contractor's trenches which is required during construction, shall be included in this Contract.

G. In no case shall excavation work be accomplished that will damage in any way the new structure, existing structures, equipment, utility lines, large trees to remain, etc. The Contractors shall take the necessary steps to prevent flow of eroded earth by water or landslide onto the property of others, or against the structures. The repair of all such damage or any other damage incurred in the course of excavation shall be borne by the responsible Contractor.

H. Use surveyor's level to establish elevations and grades.

I. The Contractor shall accept the site as he finds it and remove all trash, rubbish and material from the site prior to starting excavation of his work.

J. The Contractor shall provide and maintain barricades and temporary bridges around excavations as required for safety. Temporary bridges shall be provided where excavations cross paved areas and walks. The Contractor shall maintain these bridges in a safe and passable condition for all traffic until removal. Refer to OSHA Standards for such installations and comply with same in all details.

K. Pay particular attention to existing utilities and lines to avoid damage. The locations of existing lines which are indicated on the plans were taken unconfirmed from drawings prepared for previous construction and locations are approximate only. Also, certain water, gas, electric, storm and sanitary sewer lines and other underground appurtenances, active or abandoned, may not appear on the drawings. It shall be each Mechanical Contractor's responsibility to ascertain the location of all lines and excavate with caution in their area.

5. BACKFILL AND SURFACE REPAIR

A. Backfilling for mechanical work shall include all trenches, manhole pits, storage tank pits, and/or any other earth and/or rock openings which are excavated under this Contract. Backfilling shall be carefully performed and the surface restored to its original level to receive new finish. Wherever trenches and earth openings have not been properly filled and/or settlement occurs, they shall be re-excavated, re-filled and properly compacted, smoothed off and finally made to conform to the level of the original ground surface.

B. Unless otherwise indicated or specified, all piping shall be bedded on four (4) inches minimum of compacted naturally or artificially graded mixture of crushed gravel, crushed stone, or crushed sand with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve on undisturbed soil excavated as described hereinbefore. Install tracer wire above pipe. Cover the pipe with twelve (12) inches of compacted backfill to prevent settlement above and around the new pipe. The backfill shall be naturally or artificially graded mixture of crushed gravel, crushed stone, or crushed sand with 100 percent passing a 1-inch sieve and not more than 8 percent

passing a No. 200 sieve. Prior to placing this second level of backfill, apply all required coatings and coverings to pipe, apply required tests and check the grading of the pipe to insure that it is correct and that the pipe is free of swags, bows or bends. Also check lines for leaks at this point and repair as required. Once all of the preceding is accomplished, continue backfill with clean, debris and rock free earth tamped at six (6) inch intervals. Finish the backfill as specified following. Note: Water settling of backfill will be permitted only as an aid to mechanical compacting.

(1) When running any type of pipe below a footer, parallel or perpendicular to the footer, the area underneath the footer and in the zone of influence shall be backfilled with cementitious flowable fill. The zone of influence is the area within a 45 degree angle projecting down from the bottom edge of footers on all sides of the footer. Where PVC piping is used within flowable fill, the pipe shall be isolated from the fill by a layer of heavy duty felt paper or cast iron piping may be used without a barrier. Piping installed in trenches backfilled with flowable fill shall be anchored to the soil below prior to backfilling.

C. Backfill beneath areas to be seeded or sodded within six (6) inches of finished grade. The remaining six (6) inches shall be backfilled with clean top soil.

D. Backfill beneath paved areas, walks, etc. shall be brought to proper grade to receive the sub-base and paving. No paving shall be placed on uncompacted fill or unstable soil.

E. Backfill for natural gas lines shall be in strict accordance with the utility company or local municipalities requirements. If in doubt, contact the utility company or local municipality and/or the Engineer.

F. Wherever, in the opinion of the Engineer, the soil at or below the requisite pipe grade is unsuitable for supporting piping, special support shall be provided as directed by the Engineer.

G. Unsuitable material and surplus excavated material not required for backfill shall be removed from the site. The location of dump and length of haul shall be the affected Contractor's responsibility.

H. Provide and place any additional fill material from off the site as may be required for backfill. Fill obtained from off site shall be of kind and quality as specified for backfill and the source approved by the Engineer and shall be brought to the site by the Contractor requiring the fill.

I. In the absence (if not specified or indicated elsewhere in the drawings or specifications to be done by others) of such work by others, the Contractor shall lay new sod over his excavation work. Level, compress and water in accord with sound sodding practice.

J. When running any type of piping below a footer or in the zone of influence the piping shall be backfilled with cementitious flowable fill. The zone of influence is the area under the footer within a 45 degree angle projecting down from the bottom edge of the footer on all sides of the footer. Additionally, grease traps, manholes, vaults, and other underground structures shall be held away from building walls far enough to be outside of the zone of influence.

K. Warning Tape and Tracer Wire

Provide a yellow and black plastic tape in all trenches 6" above the buried utility that identifies the utility about to be encountered. For non-metallic pipe a #12 copper wire shall also be laid in the trench to aid in future location of the piping. A foil faced warning tape may be used in lieu of the plastic tape and wire.

L. All manholes, vaults, and similar underground structures shall have the top elevation set flush with finished grade unless specifically noted otherwise.

6. MINIMUM DEPTHS OF BURY (TO TOP OF PIPE)

In the absence of other indication, the following shall be the minimum depth of bury of exterior utility lines. (Check drawings for variations).

A. Fire Protection Lines ..... 42 inches.

B. Geothermal Lines ..... 42 inches.

END OF EXCAVATION

SECTION 201300 - PIPE, PIPE FITTINGS AND PIPE SUPPORT

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 in this section.

B. When a pipe size is not indicated, the Contractor shall request the pipe size from the Engineers. All piping shall be installed straight and true, parallel or perpendicular to the building construction. Piping shall be installed so as to allow for expansion without damage to the building finishes, structure, pipe, equipment, etc., use offsets, U-bends or expansion joints as required. Where a section of piping is not indicated but is obviously required for completion of the system, the Contractor shall provide same at no additional cost to the project. No mitered joints or field fabricated pipe bends shall be accepted. Pipe shall clear all windows, doors, louvers and other building openings.

C. All pipe shall be supported in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on trapeze type hangers. Vertical risers shall be supported at each floor line with approved steel pipe riser clamps. The use of wire or perforated metal to support pipes will not be permitted. Hanging pipes from other pipes shall not be permitted. Spacing of pipe supports shall not exceed eight feet for pipes up to 1-1/4 inches and ten feet on all other piping. Small vertical pipes (1 inch and less) shall be bracketed to walls, structural members, etc. at four (4) foot intervals so as to prevent vibration or damage by occupants. Insulated piping shall be supported on a rigid insulation block at each hanger so as to prevent crushing of insulation by hangers. Hangers shall pass completely around the insulation jacket and a steel protective saddle shall be applied to prevent compression of the insulation. (Refer to Specifications Section entitled INSULATION-MECHANICAL).

D. Where piping rests directly on a hanger, clip, bracket or other means of support, the support element shall be of the same material as the pipe, (e.g., copper to copper, ferrous to ferrous, etc.) or shall be electrically isolated one from the other so as to prevent pipe damage by electrolysis. Pay particular attention and do not allow copper pipe to rest on ferrous structural members, equipment, etc. without electrolytic isolation.

E. In general, piping shall be installed concealed except in Mechanical, Janitor Rooms, etc. unless otherwise indicated, and shall be installed underground or beneath concrete slabs only where indicated. All lines at ceilings shall be held as high as possible and shall run so as to avoid conflicts with other trades, and to facilitate the Owner's use and maintenance. Location of pipe in interior partitions shall be carefully coordinated with whoever will construct the partitions after the piping is in place. Where exposed risers occur they shall be kept as close to walls as possible.

F. Installation of pipe shall be in such a manner as to provide complete drainage of the system toward the source. Drain valves shall be provided at all drainage points on pipes. Drain valves shall be 1/2" size gate type with 3/4" hose thread end and vacuum breaker. Label each drain valve.

G. All hot and cold water piping shall be kept a sufficient distance apart so as to prevent heat transfer between them. Cold water piping shall also be kept apart from refrigerant hot gas lines.

H. Piping carrying water or other fluids subject to freezing shall not be installed in locations subject to freezing; if in doubt, consult Engineer.

I. Piping for all drainage systems shall be installed to permit flow, trapping, and venting in accord with current codes and sound practice.

J. All cast iron soil pipe and fittings shall be coated inside and out with coal tar varnish.

K. Non-metallic piping shall be installed in strict accordance with the manufacturer's instructions. If no such instructions are available, consult Engineers.

L. Nipples shall be of the same material, composition and weight classification as pipe with which installed.

M. Where piping is not indicated on the plans, but is obviously or apparently required, contact the Engineers prior to submission of a bid proposal.

N. Pay particular attention to conflict of piping with other work. Do not install until conflict is resolved. If necessary, contact Engineers.

O. Piping materials in each system shall, to the extent practicable, be of the same material. Frequent changes of material (for example, from copper to steel) shall be avoided and in no case shall be accomplished without use of insulating unions and permission of the Engineers.

P. Apply approved pipe dope (for service intended) to all male threaded joints. Pay particular attention to dope for fuel gas lines. The dope shall be listed for such use.

Q. High points of closed loop hot water heating systems shall have manual or automatic air vents as indicated or required unless automatic air vents are specifically indicated. Pipe to suitable drainage point.

R. All piping shall be capped or plugged during erection as required to keep clean and debris and moisture free.

S. The entire domestic hot, cold and recirculating hot water piping system shall be sterilized in strict accord with requirements of the Department of Health Codes, Rules and Regulations for the State which the work is being accomplished in.

T. Provide expansion joints where shown on the plans and where required by good practice. Expansion joints shall be guided and anchored in accordance with the recommendations of the Expansion Joint Manufacturer's Association.

U. Where plastic pipe penetrates a fire rated assembly, it shall be replaced with a metal threaded adapter and a metal pipe per code.

V. Where piping penetrates interior or exterior walls, the wall shall be sealed air tight. Refer to the sleeving, cutting, patching and repairing section of the specifications for additional requirements.

W. Provide thrust blocks on all storm, sanitary, water, steam, hot, chilled , condenser, etc., and any other piping subject to hammering. Thrust blocks shall be provided at all turns.

X. All piping to hydronic coils shall be full size all the way to the coil connection on the unit. If control valve is smaller than pipe size indicated, transition immediately before and after control valve. Also, if coil connection at unit is a different size than the branch pipe size indicated, provide transition at coil connection to unit. On 3-way valve applications, the coil bypass pipe shall be full size.

Y. Provide check valves on individual hot and cold water supplies to each mixing valve (including each sensor style faucet, safety shower, etc.) and each showerhead with a diverter valve (including all ADA showers).

2. UNIONS AND FLANGES AND WELDED TEES

A. Screwed unions, soldered unions or bolted flanges shall be provided as required to permit removal of equipment, valves and piping accessories from the piping system. Keep adequate clearances for coil removal, rodding, tube replacement, motor lubrication, filter replacement, etc. Flanged joints shall be assembled with appropriate flanges, gaskets and bolting. Gaskets for steam piping systems shall be flexitalic spiral wound type. The clearance between

flange faces shall be such that the connections can be gasketed and bolted tight without imposing undue strain on the piping system.

B. Dielectric insulating unions or couplings shall be used wherever the adjoining materials being connected are of dissimilar metals such as connections between copper and steel pipe.

C. Tee connections for welded pipe shall be made up with welding fittings. Where the size of the side outlet is such that a different connection technique than on the run is required, a weldolet, sockolet, or threadolet type fitting may be used for the branch in place of reducing tees only where the branch is 2/3 the run size or smaller.

3. SPECIFICATIONS STANDARDS

All piping and material shall be new, made in the United States and shall conform to the following minimum applicable standards:

A. Steel pipe; ASTM A-120, A-53 Grade A, A-53 Grade B.

B. Copper tube; Type K, L, M; ASTM B88-62; Type DWV ASTM B306-62.

C. Cast iron soil pipe; ASA A-40.l and CS 188-59.

D. Cast iron drainage fittings; ASA B16.12.

E. Cast iron screwed fittings; ASA B16.4.

F. Welding fittings; ASA B16.9.

G. Cast brass and wrought copper fittings; ASA B16.18.

H. Cast brass drainage fittings; ASA B16.23.

I. Reinforced concrete pipe; ASTM-C-76-64T.

J. Solder; Handy and Harmon, United Wire and Supply; Air Reduction Co. or equivalent.

K. CPVC Plastic pipe; ASTM D2846.

L. PVC plastic pipe; ASTM D1785.

4. PITCH OF PIPING

All piping systems shall be installed so as to drain to a low point. Certain minimum pitches shall be required for this drainage. For proper flow and/or for proper operation, the following pitches shall be required:

A. Interior Soil, Waste and Vent Piping:

1/4 inch per foot in direction of flow where possible but in no case less than 1/8" per foot.

B. Roof Leaders:

1/8 inch per foot where possible. Where not possible, run dead level.

C. Condensate Drain Lines From Cooling Equipment:

Not less than 1/4 inch per foot in direction of flow.

D. All Other Lines:

Provide ample pitch to a low point to allow 100 percent drainage of the system.

5. APPLICATIONS

A. General Notes

(1) Where plastic piping penetrates a fire rated assembly, it shall be replaced with a threaded metal adapter and metal pipe or whatever means necessary to maintain the separation rating in accordance with local plumbing and fire codes.

(2) Plastic piping or any materials with a flame and smoke spread rating not approved for plenum use shall not be permitted in supply, return, relief or exhaust plenums.

(3) PVC or plastic piping whether specifically listed or not may not be used in high rise buildings or anywhere else prohibited by code.

B. Fire Protection - Exterior and Interior

Refer to the Fire Protection System section of these specifications.

C. Soil Waste and Vent Piping - General Requirements

(1) Water closet floor flanges and ells shall be cast iron regardless whether PVC piping is allowed or not.

(2) Soil and waste piping serving mechanical rooms, shall be cast iron regardless whether PVC piping is allowed or not. Cast iron will also be required at any other location where waste water temperature can exceed 120°F. Cast iron shall extend a minimum of 35' past last waste inlet.

D. Soil, Waste and Vent Piping (Below Slab)

(1) Schedule 40 PVC pipe with drainage pattern fittings and solvent cement joints made in accordance with the Kentucky Plumbing Code.

(2) Service weight hubless cast iron with manufacturer's approved bands.

E. Soil, Waste and Vent Piping (Above Slab)

(1) Service weight hubless cast iron pipe with manufacturer's approved bands.

(2) Service weight cast iron hub and spigot piping with lead and oakum joints or compression gasket joints.

(3) Schedule 40 PVC pipe with drainage pattern fittings and solvent cement joints made in accordance with the Kentucky Plumbing code.

F. Roof Leaders/Interior Storm Sewer Piping

(1) Service weight hubless cast iron pipe with manufacturers approved bands.

(2) Schedule 40 PVC pipe with drainage pattern fittings and solvent cement joints.

G. Sump Pump Discharge

(1) Type “M” copper with solder joints.

H. Natural Gas Piping – Interior

(1) Schedule 40 black steel pipe with malleable iron threaded fittings for pipe sizes 2" and smaller.

(2) Schedule 40 black steel pipe with wrought steel buttwelded fittings for pipe sizes 2-1/2" and larger.

NOTES:

(1) All gas piping shall be installed per NFPA 54.

(2) Unions or valves shall not be installed in an air plenum.

(3) Piping below slab must be sleeved and vented.

(4) Piping installed in concealed locations shall not have mechanical joints.

I. Domestic Cold, Hot and Recirculating Hot Water Piping (Above Slab)

(1) Type "L" hard copper tubing with wrought copper fittings with lead free solder equivalent in performance to 95/5. Lead free solder.

J. Domestic Cold, Hot and Recirculating Hot Water Piping (Below Slab)

Type "K" hard or soft copper tubing with wrought copper fittings and brazed joints. There shall be no joints beneath slabs.

K. Hydronic Piping (Hot, Chilled, Condenser Systems)

(1) 2" and Smaller: Schedule 40 black steel pipe with screwed fittings or Type "L" hard copper tubing with wrought copper fittings and 95/5 solder.

(2) 2-1/2" and Larger: Schedule 40 black steel pipe with 125# welded or flanged joints. Weldolets may be used for branch line connections to pipe mains. Type "L" hard copper piping with wrought copper fittings and 95/5 solder may be installed.

(3) Special Notes:

a. Dielectric unions shall be provided at all connections of dissimilar materials.

b. Copper and steel piping shall not be mixed in the mechanical room.

c. Takeoffs and branch piping to individual coils or heat pumps shall not be connected to the bottom of hydronic mains. Connection to mains shall be at the side of the main. Also refer to details on the drawings.

L. Air Vent Discharge Lines

Type "L" soft copper; wrought copper fittings, 95/5 solder.

M. Geothermal / Heat pump loop piping (Interior)

(1) Mains– Piping shall be virgin polyethylene with a PE 3408 piping formaulation and 345464C or greater cell classification. Pipe shall be SDR 15.5, minimum pressure rating of 110 psi at 73.4°F. Branches may be copper or HDPE. Copper piping shall be insulated per Specifications. All HDPE piping 3 inch and smaller shall be installed in a metal "V" channel with hangers intended for a "V" channel.

(2) Transitions from polyethylene to copper – refer to detail on drawings. **Factory manufactured transition required** with brass threads. No metal threads shall be inserted into polyethylene piping, and no polyethylene threads shall be inserted into metal piping.

(3) The only acceptable method for joining pipe is by a heat fusion process. Pipe shall be butt or socket fused in accordance with pipe manufacturer's procedures. Installers shall have heat fusion school certification per geothermal specifications. Provide copy of heat fusion card to Engineer for review.

(4) Special Notes:

a. Takeoffs and branch piping to individual coils or heat pumps shall not be connected to the bottom of hydronic mains. Connection to mains shall be at the side of the main. Also refer to details on the drawings.

N. Condensate Drain Lines

(1) Type "DWV" copper, wrought copper, lead free solder.

(2) Schedule 40 PVC with solvent welded fittings.

O. Water Heater Relief Line

Type "M" copper tubing with sweat fittings and 95/5 solder.

P. LP Gas Piping

Same as specified for natural gas piping.

END OF PIPES

SECTION 201320 - GEOTHERMAL (EARTH COUPLED) LOOP PIPING SYSTEM

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.

2. INSTALLATION PERSONNEL AND TRAINING REQUIRED

   A. The loop installer, must have a current International Ground Source Heat Pump Association (IGSHPA) certification, having completed an IGSHPA training course in the fundamentals of design, installation, and operation of ground source systems, and having passed the IGSHPA certification examination.

   B. Ground heat exchanger fabricators must have completed a heat fusion school in which each participant has performed a heat fusion procedure under direct supervision of a IGSHPA Certified Heat Fusion Technician. The Fusion Technician must be thoroughly familiar with heat fusion procedures, and have had formal training at a heat fusion school under direct supervision of an IGSHPA certified instructor.

   C. Local and state laws, ordinances, and regulations as they pertain to buried pipe systems shall be strictly followed.

3. GROUND HEAT EXCHANGER MATERIALS

   A. Piping shall be virgin polyethylene with a PE 4710 piping formulation and cell classification of 445576C or E per ASTM D 3350. Pressure ratings are at 73.4° F.

   B. 2" and smaller shall be SDR 9. Pressure rating of 255 PSI.

   C. 3" and larger shall be SDR 15.5 or Schedule 40. Pressure rating of 135 PSI.

   D. Markings

      (1) Sufficient information shall be permanently marked on the length of the pipe as defined by the appropriate ASTM pipe standard.

      (2) Piping shall also have permanent factory length markings.

   E. Certification

      (1) Manufacturer shall supply a notarized document confirming compliance with the above standards.

   F. Manufacturers

      (1) Centennial Plastics, Charter Plastics, Flying W Plastics, Lamson Vylon Plastics, Chevron Phillips, or Polypipe

   G. Warranty

      (1) Manufacturer shall supply a written warranty of 25 years or greater, specifying material replacement and labor allowance. This applies to all pipe, fittings, transitions, valves, etc.

4. PIPE JOINING METHODS

   A. The only acceptable method for joining buried pipe systems is by a heat fusion process.

B. Polyethylene pipe shall be butt or socket fused in accordance with pipe manufacturer's procedures.

C. Factory installed "U" bends shall be used at the bottom well bend.

5. CASING

A. Casing shall be steel. PVC casing is not acceptable.

B. The Contractor shall include in the bid an allowance for 20 feet of permanent left-in-place steel casing per each new geothermal well indicated on the drawings (excluding the previously installed test wells). The actual amount of casing used per hole shall be tracked with a casing log and wellfield schematic. Schematic shall depict geothermal wells and provide labels for each. Log shall state the bore hole number (as depicted on the schematic), date and time casing was installed, and linear feet of casing left in place for **each** bore hole. For example:

Bore hole # 1	8/1/09	2 P.M.	30 feet of casing installed
Bore hole # 2	8/2/09	9 A.M.	10 feet of casing installed

This log shall be kept current at all times and be **signed daily during drilling** by the well field installer, mechanical contractor, General Contractor and Owner's representative.

C. Contractor shall submit a unit price for steel casing left in place on the Bid Form. In no case will a unit price greater than $19 / linear foot be accepted and no unit price less than $10/ft will be accepted. Bids not complying with this requirement may be rejected.

D. The casing log and the submitted casing unit price will be used to reconcile the Contract Amount with the actual amount of casing installed. The Contractor will only be paid the full unit price for casing left in place. Push and pull casing (temporary casing) will be paid at half the rate for casing left in place.

6. GEOTHERMAL VAULT

A. General

This specification designates the requirements for the geothermal vault including internal pipe, fittings, and valves.

B. External Shell

Shall be constructed of a high density polyethylene flat stock having a cell classification of 345444 with a UV stabilizer of C. All materials used shall have a minimum thickness of 1". Internal and external seams are heat welded using high density polyethylene welding rods having a cell classification of 345444C. Provide with a 30" manhole. The manhole lid is connected with 8-3/8" stainless steel counter sunk bolts. Lid to have 5000 pound load bearing capacity.

C. Internal Bracing

Shall be spaced at a maximum of 30" and constructed of a minimum of 1" thick high density polyethylene flat stock heat welded to the external shell with high density polyethylene welding rods.

D. Internal Piping

Shall be constructed of Drisoplex 5300 Climate Guard High Density Polyethylene SDR 15.5 pipe having a cell classification of 345444 with a UV stabilizer of C. This internal pipe is constructed in an offset, over and under, model for supply and return lines. All joints to be heat fused. The entire piping system to be tested using 150 psi

nitrogen. The main supply and return pipe to be shipped with cap butt welded to pipe. All pipe penetrating the vault walls shall be SDR9 and heat welded to external shell.

E. Fittings

P/T Plugs: Shall be constructed of solid brass and have a dual seal core of Nordel, good up to 350ºF for water. Plugs shall be rated zero leakage from vacuum to 1000 psgi and are capable of receiving a pressure or temperature probe. Each HPS & R pipe to the well field shall have a P & T port.

Butterfly Valve: Shall be constructed of a cast iron body, 416 stainless steel stem with a lever shut off system.

90º Elbows: Shall be molded out of high density polyethylene resins in accordance with the requirements of ASTM 3261.

Branch and Service Saddles: Shall be molded out of high density polyethylene resins in accordance with the requirements of ASTM 3261.

Valving: Each row of 10 wells shall have HPS & R shut off butterfly valve and each return line shall have a bell & gossett circuit setter for balancing.
Drain: Provide a 4" floor drain in each vault.

F. Installation

The vault shall be lowered into a pit with a 6" bed of #57 gravel. Once the vault is in its place, concrete is poured as recommended by the manufacturer in and around the vault to balance buoyancy pressure and allow for anchoring. The manhole shall be flush with finished grade.

7. FLUSHING, PURGING, PRESSURE AND FLOW TESTING

A. General

(1) Coordinate this section with the cleaning and flushing listed in Section 230200 - HVAC Equipment.

(2) All fusion joints and loop lengths shall be checked to verify that no leaks have occurred due to fusion joining or shipping damage.

B. Pressure Testing

(1) Vertical loops shall be pressure tested before installation. All horizontal components of the ground heat exchanger will be flushed, pressure and flow tested prior to backfilling. Pipes must contain fluid under pressure during backfilling.

(2) Heat exchangers shall be tested hydrostatically at 150% of the pipe design rating or 300% of the system operating pressure if this value is the smaller of the two. No leaks shall occur within a 48 hour period. Engineer shall be notified when system is to be placed under pressure test.

C. Flushing and Purging

(1) Notify the Engineer a minimum of 2 weeks in advance of system flushing. The Engineer, Mechanical Contractor, Heat Pump Supplier, Test and Balance Contractor, and Well Field Installer shall all be present to observe system flushing and purging. Schedule the system flushing to occur the same day as a regularly scheduled progress meeting. The Engineer MUST BE PRESENT. Failure to notify the Engineer in advance will result in the Contractor having to flush the system a second time.

(2) Flow rates shall be compared to calculated values to assure that there is no blockage or kinking of any pipe. Submit this in writing to the Engineer. Balance Contractor to verify.

(3) A minimum velocity of 3 ft/sec in each piping section must be maintained until all air is removed. Piping 8" and larger shall be purged at 4 ft/s minimum. The system shall also be forward and reverse flushed to remove all debris. The building shall be flushed in sections as required to maintain high velocities. Building mains shall be flushed separate from branches to maintain high velocity when flushing the mains.

(4) Final purging of air from the entire building and loop field shall be performed by the Well Field Installer so that air in building piping will not be transferred to the well field.

(5) The Balance Contractor must witness and confirm all pressure tests and flushing velocities along with confirm pressure drop for each geothermal well zone.

(6) Contractor shall provide full size connection ports and valves as required to purge wellfield and building separately.

(7) After the heat pump bypasses are flushed and the piping network is determined to be clean and free of air, the heat pumps themselves shall be flushed.

(8) The system flushing device shall be equal to a Purge Pro Max distributed by Geothermal Supply Company. The flushing pump shall provide performance equal to or exceeding the following values: 550 GPM at 117 PSI, 500 GPM at 115 PSI, 300 GPM at 125 PSI, dead head pressure of 128 PSI. SUBMIT PUMP CURVE to Engineer for review and approval prior to system flush. The flushing device shall provide means to release entrained air to the atmosphere and shall filter the water. Filter shall be 50 micron. Water shall be circulated and filters shall be changed until debris is no longer visible on filter. Contractor shall provide filter media as required.

8. HORIZONTAL PIPING SYSTEMS

A. Sharp bending of pipe around trench and bore hole corners must be prevented by using a shovel to round corners. Manufacturer's procedures must be followed.

B. Backfilling procedure will include prevention of any sharp-edged rocks from coming into contact with the pipe by removal of the rocks before backfilling, backfilling through a coarse screen for a 6 inch cover, or use of a 6 inch cover of rock-free soil. Clods resulting from use of a backhoe must be broken up so as not to form air pockets around the pipe which will reduce heat conduction between the earth and the pipe. The flow of backfill soil must be controlled to prevent bridging and the formation of air pockets. Several slow passes with an angled backfill blade are required. Flooding is required to assure removal or air pockets. Since most of the horizontal piping is below the parking lot, the backfill shall support the expected bus traffic. Backfill load bearing capacity shall meet the Architect's specification.

C. Horizontal return bends must be backfilled by hand to properly support the pipes and prevent kinking.

D. All horizontal piping shall be a minimum of 42 inches below finished grade.

9. BORE HOLE

A. The Contractor shall bore wells of a sufficient diameter to allow installation of the piping and U-bend, but shall be no less than 4-1/2".

B. The entire bore shall be grouted as recommended by IGSHPA with a thermally enhanced grout mixture with a thermal conductivity of 1.00 Btu/hr-ft-˚F. Grout shall be GeoPro Thermal Grout Lite 100 bentonite mixture or approved equal. Mixture shall be field mixed in strict accordance with manufacturer's recommendations. Grout mixture shall be mechanically pumped with a positive displacement pump into bore hole from bottom to top utilizing a tremie tube. Through the course of the project, three sample grout specimens shall be taken of the mixed grouting material by this contractor. An analysis shall be performed by the grout manufacturer to verify proper thermal

performance and grout mixture. This contractor shall submit these reports to the Owner, Architect and Engineer to verify compliance with the installation specifications.

C. If large water seams are encountered, bridging across water seams with #7 or #9 rock, or GeoPro Black Hills 3/8 inch Bentonite Plug, is acceptable. The maximum height of the rock or bentonite bridge shall not exceed 8 feet. The remainder of the vertical bore hole shall be grouted per the above specification. Bore holes with water seams shall be monitored for settling of grout. After a period of one week, all holes shall be topped off with grout as needed. The Contractor shall continue to monitor holes that experience grout settling and continue to top off with grout throughout the warranty period. Bore holes that are unable to hold grout shall be replaced with new bore holes at no cost.

D. The Contractor shall accept the site as-is and is responsible for any and all required casings. If an area of voids is encountered, the Contractor shall either fill or re-drill wells in an approved area and extend piping to them.

E. No night drilling will be allowed.

10. DUST CONTROL

A. The Contractor is responsible for and shall provide dust control. Dust shall not be allowed to leave the construction site boundaries, and furthermore, shall not be allowed to enter the building or accumulate on the building exterior. When needed to meet these requirements, the Contractor shall provide and operate a mechanical dust collection system to control dust at the source. Mechanical dust collection system shall consist of collection hood at the source ducted to a dust collector which separates dust from the airstream. Dust shall be collected into sealed containers for disposal by the Contractor.

B. Water spraying may be used but shall not be considered a substitute for mechanical dust collection at the source when required.

11. SURFACE WATER / MUD / SLURRY CONTROL

A. The Contractor is responsible for and shall provide control of all ground flowing fluids resulting from drilling operations. The Contractor shall erect silt fences or other structures as required to contain drill cuttings, mud, slurry, etc. within the construction site boundaries. In the event this requirement is not met, the Contractor shall provide all remediation measures as required by all authorities having jurisdiction over such events.

12. WARRANTY

A. The entire ground loop system and backfill from a point 5 feet inside the building shall be warranted for **five (5) years** from date of substantial completion against any leakage or failure. Warranty service for a pipe leak shall include recharging system with heat transfer fluid as originally specified, including glycol or ethyl alcohol if originally specified, as well as corrosion inhibitors.

13. BALANCE

The Contractor shall assist the Balance Contractor in balancing the geothermal well zones to obtain the specified flows.

14. SUBMITTALS

A. Submit manufacturer's specification sheets and installation instruction for each component of the system, showing manufacturer, pipe or tube weight, pressure rating, fitting type and joint type for each piping system.

B. Submit manufacturer's mechanical data for valves.

C. Submit a drawing indicating the system layout and pipe sizes.

D. Provide a copy of the technician's certification, and International Ground Source Heat Pump Association Certification.

15. TEST BORES

A. Typical test bore is provided on the plans.

B. The Contractor may visit the site prior to bid and perform their own test boring if additional information is required. This shall be coordinated with the Owner.

END OF GEOTHERMAL

SECTION 202100 - VALVES AND COCKS

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. The Contractor shall provide all valves required to control, maintain and direct flow of all fluid systems indicated or specified. This shall include, but may not be limited to all valves of all types including balancing cocks, air cocks, lubricated plug cocks, packed plug cocks, special valves for special systems, etc., for all Mechanical Systems.

C. All valves shall be designed and rated for the service to which they are applied.

D. The following type valves shall not be acceptable: Zinc, plastic, fiber or non-metallic.

E. Ball valves with temperature and pressure ports are not an acceptable alternative to the balancing valves specified herein. Valves that do not comply with these specifications shall be removed and replaced by the Contractor with no increase in contract price.

F. Each type of valve shall be of one manufacturer, i.e., gate valves, one manufacturer, globe valves, one manufacturer, silent check valves, one manufacturer, etc. The following valve manufacturers shall be acceptable: Lunkenheimer, Tour & Anderssen, Powell, Nibco, Crane, Jenkins, T & S Brass, Walworth, Milwaukee, DeZurik, Consolidated Valve Industries, Inc., Victaulic, Bell & Gossett, Flow Design, Watts.

G. All valves shall comply with current Federal, State and Local Codes.

H. All valves shall be new and of first quality.

I. All valves shall be full line size. Valves and hydronic specialties shall not be reduced to coil or equipment connection size. Size reductions shall be made at the connection to the equipment.

J. Angle stops for plumbing fixtures shall be quarter turn ball type.

2. LOCATION OF MAINTENANCE VALVES

Maintenance valves and unions, installed so as to isolate equipment from the system shall be installed at the following locations:

A. At each plumbing fixture.

B. At each air handling unit, and make–up air unit.

C. At each unit heater.

D. At each heating or cooling coil.

E. At all other locations indicated on the drawings.

3. WORKMANSHIP AND DESIGN

A. Handwheels for valves shall be of a suitable diameter to allow tight closure by hand with the application of reasonable force without additional leverage and without damage to stem, seat and disc. Seating surfaces shall be machined and finished to insure tightness against leakage for service specified and shall seat freely. All screwed valves shall be so designed that when the screwed connection is properly made, no interference with, nor damage to the working parts of the valve shall occur. The same shall be true for sweat valves when solder or brazing is applied.

4. TYPES AND APPLICATION

A. GATE VALVES

Gate Valves shall be of the wedge disc type, permit straight line flow, complete shut-off and designed so that when the valve is wide open, it can be packed under pressure. Valves 1-1/2 inches and smaller shall be bronze, with ends to suit piping and non-rising stem. The valve shall have a deep stuffing box for long contact with the stem, packing gland and filled with high quality packing. Valves 2 inches thru 4 inches shall be iron body bronze mounted with flanged ends and non-rising stem. Boiler stop valves and valves larger than 4 inches shall be iron body bronze mounted flanged ends with outside screw and yoke with rising stem. Working pressure for bronze valves shall be 150 pounds and iron valves 125 pounds when installed in piping with system pressures up to 100 pounds per square inch and 250 pounds for 100 pounds per square inch and over. 2" and under NIBCO T133, greater than 2" NIBCO F619.

B. GLOBE VALVES

Globe Valves shall permit control of flow rate from full flow to complete shut-off and designed that when the valve is wide open it can be repacked under pressure, and have a deep stuffing box with gland and filled with high quality packing. Valves 1-1/2 inches and smaller shall be bronze with ends to suit piping union bonnet, and with stainless steel plug type disc and seat of not less than 500 Brinnell hardness. Valves 2 inches and larger shall be iron body bronze mounted with flanged ends, yoke bonnet, and disc guide. Working pressure for bronze valves shall be 150 pounds and iron valves 125 pounds when installed in piping with system pressures up to 100 pounds per square inch and 250 pounds for 100 pounds per square inch and over. 1-1/2" and under NIBCO T256AP, greater than 1-1/2" NIBCO F768B.

C. CHECK VALVES

Check Valves shall be horizontal swing type with two piece hinges, disc construction seats to be bronze and bronze discs or with composition face depending on service and provide silent operation. Valves 1-1/2 inches and smaller shall be bronze with ends to suit piping, have full area "Y" pattern body and integral seats. Valves 2 inches and larger shall be iron body brass mounted and with flanged ends. Working pressure for bronze valves shall be 150 psi and iron valves 125 psi when installed in piping with system pressures up to 100 psi and 250 psi for 100 psi and over. 3" and under NIBCO T433Y, greater than 3" NIBCO F918B (for less than 100 psi systems) greater than 3” NIBCO F968B (for 100 psi or greater systems).

D. BALL VALVES

Ball Valves shall have removable lever handle with vinyl grip, adjustable stem gland screw, reinforced Teflon stuffing box ring, blow out proof stem, bronze body, reinforced Teflon seats, chrome plated steel ball as manufactured by Consolidated Valve Industries, Inc., Lunkenheimer, Apollo, Jenkins, Nibco or equivalent. Provide a stem extension so that the base of the handle is 1/4" above the insulation. NIBCO T5800-70.

E. BUTTERFLY VALVES

Butterfly valves shall be line sized cast iron body, lug style, 200 PSI rating (bubble tight) EPT or Viton seat, cartridge type; high strength stem. Disc to have ground and polished seating surface. Operator shall be locking lever style. Quality equivalent to Crane Monarch series. 3" and under NIBCO LD3222-3, greater than 3" NIBCO LD3222-5.

F. BALANCING VALVES

Bell & Gossett, Model CB circuit setter balancing valve or approved equivalent. Calibrated balancing valve shall have flanged connections suitable for 125# working pressure at 250°F. 4" and up shall be rated at 175# at 250°F working pressure. Provide with brass readout valves fitted with an integral EPT insert and check valve. Each balance valve shall have a calibrated nameplate to assure specific valve settings and be constructed with internal seals to prevent leakage.

G. AIR COCKS

Straight nose; Lunkenheimer Fig. 476; bronze; tee handle; bent nose; Lunkenheimer Fig. 478, 125#; bronze; tee handle.

H. GAUGE COCKS

Straight, Lunkenheimer, Fig. 1178; 125#; bronze; tee handle. FIP.

I. LUBRICATED PLUG COCKS

2" and under; Homestead Fig. 601; 150#; semi-steel; screwed; 2-1/2" and over; Homestead Fig. 602; ±50#; semi-steel; flanged.

J. PACKED PLUG COCKS

2" and under; DeZurik Fig. 425-S; 175#; semi-steel; screwed. 2-1/2" and over; DeZurik Fig. 425-F; 175#; semi-steel; flanged.

END OF VALVES AND COCKS

SECTION 202110 - ACCESS TO VALVES, EQUIPMENT, FILTERS, ETC.

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Requirements-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. All mechanical equipment shall be installed in a manner which allows ready access to all components requiring service, adjustments, shutoff, etc.

C. Filters shall be accessible, removable and replaceable without disconnecting mounting brackets, piping, wiring, etc.

D. All oil cups, grease cups, grease fittings, etc. shall be accessible without disassembly of equipment, piping, ductwork, etc. (Extended oilers or grease fittings may be required).

E. Provide access doors or panels for all equipment, valves, dampers, filters, fire dampers, etc. in concealed spaces not otherwise provided with suitable access. (Lay-in ceilings shall be considered acceptable access; splined or drywall ceilings shall not).

F. All valves, unions, strainers, cleanouts, and test points shall be accessible.

G. Access panels in lay-in ceilings shall be marked with colored tacks to indicate location of equipment, filters, valves, etc.

H. Access panels in fire rated walls shall bear the same rating as the wall.

I. Each fire damper shall be provided access through the duct to allow reset of the damper. This may be either a gasketed sheet metal panel over a suitable opening or a factory built access panel. The panel shall be at least one and one-half (12) inch larger than the opening all around and shall be held in place with sheet metal screws sufficiently to insure that it is air tight. Manually check the size and location of each of these openings to insure that the fire damper may be manually reset by use of hand only.

2. ACCESS DOORS

Refer to Sheet Metal and Flexible Duct section of the specifications.

END OF ACCESS TO VALVES AND COCKS

SECTION 202200 - INSULATION - MECHANICAL

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. Work under this section shall include all labor, equipment, accessories, materials and services required to furnish and install all insulation, fittings and finishes for all mechanical systems specified herein and/or as indicated.

C. Application of insulation materials shall be done in accordance with manufacturer's written recommendations. Where thickness of insulation is not specified, use applicable thickness recommended by manufacturer for specific use. Insulation shall be applied by a company regularly engaged in the application of insulation and any work deemed unacceptable by the Engineers shall be removed and properly installed at the expense of the Contractor.

2. MANUFACTURERS

A. Insulation shall be as manufactured by Manville, Knauf, Owens-Corning, Armacell or other approved equivalent. Insulation sundries and adhesives shall be as made by Benjamin Foster, Childers, Vimasco or approved equivalent.

3. FIRE RATINGS AND STANDARDS

A. Insulations, jackets and facings shall have composite fire and smoke hazard ratings as tested by ASTM E-84, NFPA 255 and UL 723 procedures not exceeding Flame Spread 25, Smoke Developed 50.

B. Adhesives, mastics, tapes and fitting materials shall have component ratings as listed above.

C. All products and their packaging shall bear a label indicating above requirements are not exceeded.

4. GENERAL APPLICATION REQUIREMENTS

A. Insulation shall be applied on clean, dry surfaces in a neat and workmanlike manner reflecting the best current practices in the trade. Insulation shall not be applied to piping, ductwork or equipment until tested, inspected and released for insulation.

B. All insulation shall be continuous through walls, ceiling openings and sleeves. However, insulation shall be broken through fire walls. All covered pipe and ductwork is to be located a sufficient distance from walls, other pipe, ductwork and other obstacles to permit the application of the full thickness of insulation specified. If necessary, extra fittings and pipe are to be used. No noticeable deformation of insulation or discontinuity of vaporseal, where required, will be accepted.

C. "Concealed", where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, pipe shafts, or above hung finished ceilings. "Exposed" shall mean that piping or equipment is not "concealed" as defined above. Piping and equipment in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered as "exposed".

D. Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced as directed by the Engineer.

E. Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples thru the jacket. NO EXCEPTIONS!

F. All insulation shall be installed with joints butted firmly together.

G. The Contractor shall insure that all insulation (piping, ductwork, equipment, etc.) is completely continuous along all conduits, equipment, connection routes, etc. carrying cold fluids (air, water, other) and that condensation can, in no way, collect in or on the insulation, equipment, conduits, etc. Any such occurrence of condensation collection and/or damage therefrom shall be repaired solely at the expense of the Contractor.

5. PIPING SYSTEMS

A. GENERAL

(1) Bevel insulation and jacket at all points where insulation terminates at unions, flanges, valves and equipment. Note: Applies to hot water lines only; cold water lines require continuous insulation.

(2) Pipe insulation shall extend around valve bodies to above drain pans in hydronic equipment over pumps, etc. to insure no condensation drip or collection.

(3) Factory molded fittings may be installed in lieu of built-up fittings. Jackets to be the same as adjoining insulation. Insulated fittings must have same or better K factors than adjoining straight run insulation.

(4) Valves, flanges and unions shall only be insulated when installed on piping whose surface temperature will be at or below the dew point temperature of the ambient air.

(5) Insulation shall not extend through fire and smoke walls. A UL-listed penetration system shall be used for each fire or smoke wall penetration in accordance with KBC. Materials used such as caulk, sleeves, etc. shall be manufactured by 3M, Hilti, or equal.

B. INSULATION SHIELDS

(1) Metal insulation shields are required at all pipe hangers where the piping is insulated. Metal shields shall be constructed of galvanized steel, formed to a 180 degree arc. Insulation shields shall be the following size:

PIPE SIZE	SHIELD GAUGE	SHIELD LENGTH
2" AND LESS	20	12"
2 1/2" TO 4"	18	12"
5" TO 10"	16	18"
12" AND GREATER	14	24"

C. INSULATION MATERIAL (FOR THE FOLLOWING SYSTEMS)

Insulation shall be Owens-Corning Model 25ASJ/SSL or approved equivalent fiberglass pipe insulation with an all service jacket. The insulation shall be a heavy density, pipe insulation with a K factor .23 at 75°F mean temperature. The insulation shall be wrapped with a vapor barrier jacket. The jacket shall have an inside foil surface with self sealing lap and a water vapor permeability of .02 perm/inch. All circumferential joints shall be vapor sealed with butt strips. All insulation shall be installed in strict accordance with the manufacturers' recommendations. The following pipes shall be insulated with the thickness of insulation as noted.

(1) Domestic Cold Water

a. Piping 3'' or less – use 1/2" thick insulation

b. Piping 4'' or greater – use 1'' thick insulation

(2) Hydronic System Fill Lines From Domestic Cold Water - 1/2" thick.

(3) Domestic 110°F Hot Water and 110°F Recirculating Hot Water.

a. Piping 1 ½'' or less – use 1" thick insulation

b. Piping 2'' or greater – use 2'' thick insulation

(4) Hydronic Hot Water or Geothermal. Geothermal Mains (HPS/HPR) are HDPE and not required to be insulated. Branch piping may be copper. All non-HDPE Geothermal piping shall be insulated. Where a transition occurs, the insulation shall continue 6" beyond the end of the copper piping and onto the HDPE.

a. Piping 1 ½'' or less – use 1" thick insulation

b. Piping 2'' or greater – use 2'' thick insulation

(5) Horizontal Roof Leaders.

a. Piping 3'' or less – use 1/2" thick insulation

b. Piping 4'' or greater – use 1'' thick insulation

(6) Sanitary Sewer and plumbing fixture P-traps to waste stack – see schedule below. Insulate horizontal runs which receive air conditioning condensate and which are not located below slab or grade.

a. Piping 3'' or less – use 1/2" thick insulation

b. Piping 4'' or greater – use 1'' thick insulation

(7) Condensate Drain Lines.

a. Piping 1 1/2'' or less – use 1/2" thick insulation

b. Piping 2'' or greater – use 1'' thick insulation

D. JACKETS

(1) Exposed (Mechanical Rooms)

All insulated piping installed in the above areas shall have a canvas or PVC jacket up to 7 feet A.F.F.

a. 6 oz. canvas jacket with fire retardant lagging. Apply to the insulation specified for the piping.

6. DUCTWORK SYSTEMS

A. GENERAL

(1) Duct sizes indicated are the net free area inside clear dimensions; where ducts are internally lined, overall dimensions shall be increased accordingly.

(2) Duct insulation shall extend completely to all registers, grilles, diffusers, and louver outlets, etc., to insure no condensation drip or collection. The backs of all supply diffusers, plenums, grilles, etc. shall be insulated only if indicated by details on the drawings.

(3) All flexible duct connections on insulated ductwork shall be externally insulated.

B. EXTERNAL INSULATION

(1) Supply Air
(2) Outside Air
(3) Exhaust/Relief Duct from the AHU to the point of exhaust.

Owens/Corning, "Faced Duct Wrap - Type 150" or approved equivalent, 1-1/2" thick fiberglass duct wrap, **1-1/2 lb.** density factory laminated to a reinforced foil kraft vapor barrier facing (FRK) with a 2" stapling flange at one edge. Flame spread 24, smoke developed 50, vapor barrier performance 0.02 perms per inch. K factor shall not exceed .26 at 75°F. mean temperature.

Note: Do not provide externally insulated duct per the above specification for any duct that is to be painted. Insulated duct that is to be painted shall be dual wall ductwork per specification Section 231200, Sheet Metal and Flexible Duct.

7. MECHANICAL EQUIPMENT

A. ROOF DRAIN SUMPS

(1) Owens-Corning Model 475-FR or approved equivalent rigid board insulation with exterior vapor barrier jacket formed to bottom of sump basin. Insulation shall have a K factor of .22 at 75°F. mean temperature. Insulation shall be 1" thick. Insulation shall be formed to roof drain sump. Vapor barrier shall remain continuous.

B. FLOOR DRAIN SUMPS (Applies to all Floor Drains which Receive Air Conditioning Condensate and which are Installed in Locations **Other Than** Slab on Grade)

(1) Owens-Corning Model 475-FR or approved equivalent rigid board insulation with exterior vapor barrier jacket formed to bottom of sump basin. Insulation shall have a K factor of .22 at 75°F. mean temperature. Insulation shall be 1" thick. Insulation shall be formed to roof drain sump. Vapor barrier shall remain continuous.

C. EXPANSION TANK, COMPRESSION TANK, AIR SEPARATOR

(1) Owens-Corning "Tank Wrap I" or approved equivalent. Insulation shall be constructed of non-combustible, flexible wool. Insulation shall be 2" thick. K factor shall be .29 at 100°F. mean temperature. Insulation shall be attached in strict accordance with the manufacturer's recommendations. All insulation shall be jacketed with 6 oz. canvas with fire retardant lagging. Coordinate with mechanical contractor to extend all piping connections, blowdown ports, etc. outside of the insulation. Additionally for loop filters and other equipment requiring periodic service, provide removable insulated covers.

END OF SECTION INSULATION

SECTION 202400 – IDENTIFICATIONS, TAGS, CHARTS, ETC.

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 Contract Documents which affect the work of this section and which are hereby made a part of the work specified herein.

2. VALVE TAGS AND CHARTS

A. Standard for Lettering:
Attach Seton-Ply Discs to ceiling grid under equipment or to access doors in non-accessible ceiling. Discs shall be applied with glue and not pinned to the grid.

EQUIPMENT: COLOR:	ENGRAVES:
Valve Yellow	V.
Fire Damper Black	F.D.
Smoke Damper Black	SM.D.
Volume Damper Black	V.D.
Terminal Unit Red	T.
Variable Volume Unit Red	V.V.
Heating Coil Blue	H.C.
Airflow Control Valve Red	A.V.
Heat Pump	H.P.

3. PIPING IDENTIFICATION

A. GENERAL

(1) All exposed piping installed shall be prepared for painting in finished areas (not mechanical rooms). Exposed piping, ducts, etc shall be painted per Architectural drawings. Provide black stenciled markers and arrows indicating direction of flow on all piping installed under this Contract after the piping has been painted. Markers and arrows shall be painted on the piping using machine cut stencils. All letters shall be sprayed using fast drying lacquer paint. All markers and arrows shall be properly oriented so that descriptive name may be easily read from the floor and in exposed areas shall be arranged in a neat and orderly manner. This shall include all piping and ducts to be labeled at the same point, every 15', in the corridor with each label oriented in the same direction. The contractor shall install the labels in an exposed corridor area at one location for approval prior to proceeding. At the Contractor's option, Setmark or equivalent manufactured marking system may be substituted for field marking. The following table describes the size of the color field and size of the identification letter which shall be used for pipes of different outside pipe diameters.

OUTSIDE DIAMETER OF PIPE OR COVERING	LENGTH OF COLOR FIELD	SIZE OF LETTERS
INCHES	INCHES	INCHES
3/4 TO 1-1/4	8	1/2
1-1/2 TO 2	8	3/4
2-1/2 TO 6	12	1-1/4
8 TO 10	24	2-1/2
OVER 10	32	3-1/2

(2) "Concealed", where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, pipe shafts, or above hung finished hard ceilings. "Exposed" shall mean that piping or equipment is not "concealed" as defined above. Pipng and equipment in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered as "exposed".

B. PAINTING (REFER ALSO TO ARCHITECTURAL SECTION ON PAINTING)

(1) Paint all equipment and metal surfaces which are not factory finished (and all damaged or rusted surfaces) in high grade rust proofing machinery enamel. Pay particular attention to flanges, valves, unions, etc., where condensation may collect.

(2) Paint exposed pipe (whether insulated or bare) and exposed surfaces (tanks, etc.).

(3) All piping labels shall be a single color that is selected during the shop drawing phase.

(4) Piping:
All plumbing and mechanical piping must be color coded and labeled, including sprinkler lines, every 15 feet above a ceiling system and every 10 feet in an open mechanical room.

C. Water heaters, storage tanks, heat exchangers, etc., shall be painted light gray.

D. Piping, whether exposed or concealed, shall be marked not less than every 15 linear feet and at the points where the piping passes through wall or floors.

E. In mechanical rooms, piping shall be labeled every 10 feet with identification as well as direction of flow arrows.

4. EQUIPMENT IDENTIFICATION

A. All equipment shall be labeled with a lamacoid plate. The engraving shall match the equipment tag on the construction documents.

5. DUCTWORK IDENTIFICATION

A. All ductwork shall be identified as to the service of the duct and direction of flow. The letters shall be at least two inches high and the flow arrow shall be at least six inches long. The letters and flow arrow shall be made by precut stencils and black oil base paint with aerosol can. Ducts located above lay-in ceilings and exposed duct shall be labeled. Ductwork above hard ceilings is not required to be labeled.

END OF IDENTIFICATIONS

SECTION 202500 - HANGERS, CLAMPS, ATTACHMENTS, ETC.

1. GENERAL

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

B. Each Contractor's attention is also directed to Section 201300, Pipe, Pipe Fittings and Pipe Support.

C. This section includes, but is not limited to, furnishing and installing dampers, supports, anchors, and accessories for piping, ductwork, equipment, etc. Furnishing and installing shall be by each trade for the completion of their work.

D. Power driven anchors and expansion anchors shall be permitted only when permission is granted in writing by the Architect and Engineer.

E. It is the responsibility of each Product Manufacturer listed to confirm their product meets the requirements of the "Buy American Clause" included elsewhere in this Specification Manual. Effort has been made to identify appropriate products, however, the listing of a Manufacturer or Product above does NOT excuse the Product Manufacturer from reviewing the "Buy American Clause" and confirming their compliance before submitting their Product for bid / use on this Project.

2. MATERIALS AND EQUIPMENT

A. Hangers, Clamps, Attachments, Etc.:

	SIZE	SPECIFICATION
1. Pipe Rings	2" pipe and smaller	Adjustable swivel split ring or split pipe ring, Grinnell Figures 104 and 108, Elcen, Fee & Mason, or approved equivalent.
2. Pipe Clevis	2-1/2" pipe and larger	Adjustable wrought Clevis type, Grinnell Figure 260, Elcen, Fee & Mason, or approved equivalent.
3. Pipe Clevis	All	Steel Clevis for insulated pipe, Elcen Figure 12A, Grinnell, Fee & Mason or approved equivalent.
4. Rise Clamps	All	Extension pipe or riser clamp, Grinnell Figure 261, Elcen, Fee & Mason or approved equivalent.
5. Beam Clamps and Attachments	All	Grinnell Figure numbers listed or, Elcen, Fee & Mason, or approved equivalent. Malleable beam clamp with extension piece figure 229; I-beam clamp figure 131; C-clamp figures 83, 84, 85, 86, 87, and 88.
6. Brackets	All	Welded steel brackets medium weight, Grinnell Figure 195, Elcen, Fee & Mason or approved equivalent.

7. Concrete Inserts	All	Grinnell Figure numbers listed or, Elcen, Fee & Mason or approved equivalent. Wrought steel insert Figure 280 and wedge type insert Figure 281.
8. Concrete Fasteners	All	Self-drilling concrete inserts, Phillips, Grinnell, Elcen or approved equivalent.
9. Ceiling	All	Grinnel Figure numbers listed or Elcen, Fee & Mason, or approved equivalent. Pipe hanger flange Figure 153, adjustable swinging hanger flange Figure 155, ceiling flanges Figures 128 and 128R, and adjustable ceiling flange Figure 116.
10. Rod Attachments	All	Grinnel Figure numbers listed or Elcen, Fee & Mason, or approved equivalent. Extension piece Figure 157, rod coupling Figure 136, and forged steel turnbuckle Figure 230.
11. U-Bolts	All	Standard, U-bolt, Grinnell Figure 137, Elcen, Fee & Mason, or approved equivalent.
12. Welded Pipe Saddles	All	Pipe covering protection saddle sized for thickness of insulation, Grinnell Figure 186, Elcen, Fee & Mason or approved equivalent.
13. Pipe Roll	All	Adjustable swivel pipe roll, Grinnell Figure 174, Elcen, Fee & Mason, or approved equivalent.
14. Protection Saddle	All	18 gauge sheet metal pipe protection saddle, Elcen Figure 219, Fee & Mason, Power Strut, or approved equivalent.
15. Hanger Rods	All	Steel, diameter of the hanger threading, ASTM A-107.
16. Miscellaneous Steel	All	Steel angles, rods, bars, channels, etc., used in framing for supports and fabricated brackets, anchors, etc., shall conform to ASTM-A-7.
17. Concrete Channel Inserts	All	Continuous slot inserts, Unistrut, or approved equivalent. Heavy duty Series P-3200 or Light Duty Series P-3300 as required.
18. Adjustable Spot Insert	All	Adjustable spot insert Unistrut, or approved equivalent, P-3245. Design load 1000 lbs.

3. INSTALLATION

A. Unless otherwise specifically indicated or hereinafter specified in the specifications, all supporting, hanging and anchoring of piping, ductwork, equipment, etc., shall be done by each trade as is necessary for completion of the work and shall be as directed in the following paragraphs:

(1) The building structure and fireproofing may be in place prior to Bid Package #3 being awarded. Supports and anchors shall be coordinated with the fireproofing to minimize impact.

(2) Supporting and hanging shall be done so that excessive load will not be placed on any one hangers so as to allow for proper pitch and expansion of piping. Hangers and supports shall be placed as near as possible to joints, turns and branches.

(3) For concrete construction, utilize adjustable concrete inserts for fasteners. Expansion anchors and power driven devices may be used when approved in writing by the Architect/Engineer. Utilize beam clamps for fastening to steel joists and beams and expansion anchors in masonry construction. When piping is run in joists, piping shall be top mounted on trapeze type hangers with each pipe individually clamped to trapeze hanger.

(4) Trapeze hangers shall be supported by steel rods of sufficient diameter to support piping from joists or concrete construction. Where desired or required, piping may be double mounted on trapeze hangers. Where conditions permit, trapeze hangers may be surface mounted on exposed joists by means of approved beam clamps, or to concrete construction by means of approved adjustable inserts or expansion anchors.

(5) Install all miscellaneous steel other than designed building structural members as required to provide means of securing hangers, supports, etc., where piping does not pass directly below or cross steel joists.

(6) Piping shall not be supported by the equipment to which it is connected. Support all piping so as to remove any load or stress from the equipment.

(7) Where piping, etc., is run vertically, approved riser clamps, brackets or other means shall be utilized at approximately 10'-0" center to center minimum and an approved adjustable base stand or fitting on concrete support base shall be utilized at the base of the vertical run.

(8) Where piping is run along walls, knee braced angle frames or pipe brackets with saddles, clamps, and rollers (where required) mounted on structural brackets fastened to walls or columns shall be used.

(9) Support all ceiling hung equipment, with approved vibration isolators.

(10) Where copper tubing is specified, hangers shall be of copper clad type when piping is uninsulated.

(11) Uninsulated piping hung from above shall be supported with ring and clevis type pipe hangers. Uninsulated piping mounted on trapeze and wall bracket type support shall be held in place with U-bolts. U-bolts shall allow for axial movement in the piping.

(12) All insulated piping shall be supported with clevis type and/or pipe roll hangers. Hangers shall be sized to allow the pipe insulation to pass through the hangers. Install insulation protection saddles at all hanger locations. Welded pipe saddles shall be installed at all hangers on piping 5" and larger. The pipe saddles shall be sized for the thickness of insulation used. Hangers shall fit snugly around outside of insulation saddles.

(13) Under no conditions will perforated band iron or steel wire driven hangers be permitted.

(14) In general, support piping at the following spacing:

a. Steel and copper piping - 8 foot intervals for piping 3" and smaller; 10 foot intervals for larger piping.

b. Polyethylene piping – 4 foot intervals for piping 2” and smaller. 5 foot intervals for 3” pipe. 6 foot intervals for 4”, 6”, and 8” pipe.

c. PVC piping – 4 foot intervals for piping 1 1/2" and smaller. 5 foot intervals for 2 and 2 ½" piping. 6 foot intervals for 3" pipe and larger.

d. Where the manufacturer of the pipe has more strict guidelines, the manufacturer's recommendations shall be followed.

END OF HANGERS AND CLAMPS

SECTION 203100 - TESTING, BALANCING, LUBRICATION AND ADJUSTMENTS

1. GENERAL

A. The General Conditions, Instructions to Bidders, Section 200100, and other Contract Documents are a part of this specification and shall be binding on all Mechanical Contractors. It shall be each Contractor's responsibility to apprise himself of all information pertinent to his work prior to submitting his proposal. No adjustments will be made in this Contract which are a result of failure to comply with this requirement.

B. The Engineer, or his authorized representative, shall be notified by the Contractor twenty-four (24) hours in advance of any tests called for in these specifications or required by others. Any leaks or imperfections found shall be corrected and a new test run to the satisfaction of the Engineer or his authorized representative. Upon completion of a test, a written approval of that part of the work will be given to the Contractor. Only after written approval, signed by the Engineer, shall the Contractor apply insulation or paint or allow his work to be furred-in. This written approval, however, does not relieve the Contractor of the responsibilities for any failure during the guarantee period. The expense of all tests shall be borne by the Contractor, along with all temporary equipment, materials, gauges, etc. required for tests.

2. PLUMBING

A. Piping shall be tested before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory.

B. Water piping systems shall be subjected to a hydrostatic test of one hundred fifty pounds. The system shall be proven tight after a twenty-four (24) hour test.

C. The house drain line, interior storm sewers, interior rain water conductors, and all soil, waste and vent piping shall be subjected to a hydrostatic test of not less than a 10-foot head or an air test of not less than 5 lbs. per sq. inch using a mercury column gauge and shall hold for 15 minutes.

D. Exterior sewer lines to the termination point outside the building shall be subject to a ten-foot hydrostatic test or an approved smoke test. These lines shall be subjected to a second test after 2 feet of backfill has been properly installed.

E. After fixtures have been installed, the entire plumbing system, exclusive of the house sewer, shall be subjected to an air pressure test equivalent to one inch water column and proven tight. The Contractor responsible shall furnish and install all of the test tees required, including those for isolating any portion of the system for tests.

F. The Contractor shall perform all additional tests that may be required by the Kentucky Department of Health or other governing agency.

G. Set temperature control on water heaters and adjust tempering valves as required.

H. Any leaks or imperfections found shall be corrected and a new test run until satisfactory results are obtained. The cost of repair or restoration of surfaces damaged by leaks in any system shall be borne by the Contractor.

I. The natural gas piping shall be tested in accordance with requirements and/or recommendations of the local gas company.

J. The domestic hot water recirculation system balancing shall be performed. The system shall be balanced as often as necessary to obtain desired system operation and results.

3. HEATING, VENTILATING AND AIR CONDITIONING

A. All piping shall be tested before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory. Water piping systems shall be subjected to a hydrostatic test of not less than one hundred pounds and shall be proven tight after a twenty-four (24) hour test.

B. All motors, bearings, etc. shall be checked and lubricated as required. All automatic, pressure regulating and control valves shall be adjusted. Excessive noise or vibration shall be eliminated.

C. Thermometers and gauges shall be checked for accuracy. If instruments are proven defective, they shall be replaced.

D. For all balance valves, include pressure drop and balance valve setting in the final balance reports.

E. System balancing, where required, shall be performed only by persons skilled in this work. The system shall be balanced as often as necessary to obtain desired system operation and results.

F. All fan belts shall be adjusted for proper operation of fans. If sheaves are required to obtain the air flows specified, the Contractor shall provide them.

G. Set temperature controls on boilers, etc. as specified.

H. The Contractor shall adjust all pump drives or balancing valves to obtain water flow specified. The Contractor shall also provide and change pump impellers, if required, to obtain flows specified.

I. The Contractor shall perform and be responsible for lubrication of all equipment prior to operation. Equipment damaged by failure to perform proper lubrication shall be repaired at his expense.

J. For the purpose of placing the heating, ventilating and air conditioning system in operation according to design conditions and certifying same, final testing and balancing shall be performed in complete accordance with AABC Standards for Field Measurements and Instrumentation Form No. 81266, Volume One, for air and hydronic systems as published by the Associated Air Balance Council. The Contractor shall procure the services of an AABC or NEBB Certified company, approved by the Engineer, that specializes in and whose business is to balance and test mechanical systems. The Balance Contractor must be independent and may not be a Branch or Company owned by any other Contractor on the project.

K. Instruments used for testing and balancing of air and hydronic systems shall have been calibrated within a period of six months prior to balancing. All final test analysis reports shall include a letter of certification listing instrumentation used and last date of calibration.

L. The temperature controls supplier shall provide thorough training, all required software and cable connections to the test and balance trades for use in balancing the systems.

M. The Contractor must submit any list of interim deficiencies and preliminary balance reports to the Engineer prior to final balance. The Contractor shall make all necessary corrective measures prior to the final balance report submittal.

N. Four (4) copies of the complete test reports shall be submitted to the Consulting Engineer prior to final acceptance of the project.

O. The Contractor shall provide and coordinate his work in the following manner:

(1) Provide sufficient time before final completion date so that tests and balancing can be accomplished.

(2) Provide immediate labor and tools to make corrections when required without undue delay.

(3) The Contractor shall put all heating, ventilating and air conditioning systems and equipment and rangehood system into full operation and shall continue the operation of same during each working day of testing and balancing.

P. Balance all water and air systems. Be sure to include:

(1) Domestic Hot Water Recirculating System.

(2) Water source Heat pump water and air flow. Balance each diffuser associated with the heat pumps to within 10% of design.

(3) Outside air unit (OA-1). Balance the airflow of each supply diffuser or branch duct on the system. Balance the exhaust grilles to within 10% of the design.

Q. Geothermal Balance

(1) Confirm flushing velocities (forward and backward) in geothermal well field.

(2) Confirm pressure drop values for each well field zone.

(3) Set flow rate for each well field zone.

(4) Submit report confirming above geothermal information to the Engineer prior to submission of final balance report.

4. BUILDING AIR TIGHTNESS TEST

A. The fan pressurization test to determine final compliance with the air tightness requirement shall be conducted when all components of the air barrier system have been installed and inspected, and have passed any intermediate testing procedures as detailed in the construction drawings and specifications. The test may be conducted before finishes that are not part of the air barrier system have been installed. For example, if suspended ceiling tile, interior gypsum board, or cladding systems are not part of the air barrier system, the test may be conducted before they are installed.

B. Test Requirements

(1) The air leakage test must be performed in accordance with ASTM E 779 with the following additions and exceptions:

(2) The test consists of measuring the flow rates required to establish a minimum of 12 positive and 12 negative building pressures. The lowest test pressure shall be 0.1 in wg; the highest test pressure shall be 0.3 in wg; and there must be at least 0.1 in wg difference between the lowest and highest test pressures.

(3) The test pressure must be measured in a representative location such that pressures in the extremities of the enclosure can be shown to not exceed 10% of the measured test pressure. At least 12 bias pressure readings must be taken across the envelope and averaged over at least 20 seconds each before and after the flow rate measurements. None of the bias pressure readings must exceed 30% of the minimum test pressure when testing in both directions.

(4) Where it can be shown that it is impossible to test in both directions, then the building may be tested in the positive direction only, provided the bias pressure does not exceed 10% of the minimum test pressure.

(5) The mean value of the air leakage flow rate calculated from measured data at 0.3 in wg must not exceed 0.25 CFM per square foot of envelope area. Measurements must be referenced at standard conditions of 14.696 PSI and 68F.

(6) The test shall be conducted with ventilation fans and exhaust fans turned off and the outdoor air inlets and exhaust outlets sealed (by dampers or masking). The contractor must provide a responsible HVAC technician with the authority to place the HVAC system in the correct mode for the pressure test. The test technician must have unhindered access to mechanical rooms, air handlers, exhaust fans, and outdoor air and exhaust dampers.

(7) The contractor must ensure that all windows in the enclosure are kept closed. Entry and exit through doors in the test enclosure must be prohibited during the test. Data collected while the pressures and flows are affected by a door opening and closing shall be discarded.

(8) The testing agency is required to perform a diagnostic evaluation in accordance with ASTM E 1186, whether the building achieves the air tightness requirement or not. The diagnostic evaluation will assist the contractor and responsible parties in identifying and eliminating air leakage so the building meets the requirement upon retesting. The testing results will also be expressed in terms of the Equivalent Leakage Area (EqLA) at 0.3 in wg. The EqLA is the equivalent area of a flat plate that leaks the same amount as the building envelope at 0.3 in wg.

(9) A report shall be provided to Engineer and Architect after the first Air Tightness Test and the first diagnostic evaluation. After corrective measures are taken by the appropriate subcontractors, a second and final test Air Tightness Test shall be provided by the testing agency. A diagnostic evaluation shall again be provided after the second Air Tightness Test, should the second Air Tightness test reveal the building still does not meet air tightness requirements.

(10) Any subsequent testing and evaluation after the second Air Tightness Test and second diagnostic evaluation shall be considered additional scope, and the cost of which shall be paid by the responsible party.

5. FIRE PROTECTION SYSTEM

A. Test in accord with local Fire Marshal requirements and/or requirements or recommendations of NFPA Regulations.

6. AQUISITION OF DOCUMENTS

The general contractor or construction manager shall furnish one set of all documents, addenda, change orders, shop drawings, etc to the balance contractor for his use.

7. TESTING, ADJUSTING, AND BALANCING TO BE PERFORMED UNDER SEPARATE CONTRACT

A. GENERAL

(1) Related Documents

a. All Divisions 200000 through 250000 specification sections, drawings, and general provisions of the contract apply to work of this section, as do other documents referred to in this section.

(2) Scope of Work

a. The Owner will directly contract with a certified testing, adjusting, and balancing (TAB Agency) to test, adjust, and balance the HVAC systems.

b. This specification section is included herein to assist and inform the Contractor of the standards, requirements and scope of the work to be performed by the Commonwealth's TAB Contractor.

(3) Preparation and Coordination Requirements – General

a. Shop drawings, submittal data, up-to-date revisions, change orders, and other data required for planning, preparation, and execution of the TAB work shall be provided to the TAB Agency no later than 30 days prior to the start of TAB work.

b. System installation and equipment startup shall be complete prior to the TAB Agency's being notified to begin.

c. The building control system shall be complete and operational. The Building Control system contractor shall install all necessary computers and computer programs, and make these operational. Assistance shall be provided as required for reprogramming, coordination, and problem resolution.

d. All test points, balancing devices, identification tags, etc., shall be accessible and clear of insulation and other obstructions that would impede TAB procedures.

e. Qualified installation or startup personnel shall be readily available for the operation and adjustment of the systems. Assistance shall be provided as required for coordination and problem resolution.

(4) Preparation and Coordination Requirements - HVAC Controls

a. Written notice shall be submitted through the General Contractor to the Architect stating that the Control System is operating and controlling the HVAC System.

b. The control subcontractor shall have entered all data needed for the TAB Agency to begin work.

c. The control subcontractor shall be available to correct any problems that the TAB Agency might have with the systems.

d. All costs for additional work by the TAB Agency due to the Contractor's failure to comply with the above shall be paid by the Contractor and any subcontractor(s) for HVAC controls.

(5) Preparation and Coordination Requirements – Mechanical

a. Written notice shall be submitted through the General Contractor to the Architect stating that the HVAC system is operational and ready for the TAB Agency.

b. The mechanical subcontractor shall have proved all units operational and all air outlets in the full open position.

c. The mechanical contractor shall be available to correct any problems that the TAB Agency might have with any equipment or systems.

d. The mechanical contractor shall furnish and install any replacement sheaves, pulleys and drive belts required for flow adjustments, as determined by the TAB Agency. Adjustable sheaves shall be selected so that the final adjustment position is in the middle third of the total adjustment range.

e. All costs for additional work by the TAB Agency due to the Contractor's failure to comply with the above shall be paid by the Contractor and any subcontractor(s) for mechanical work.

(6) Preparation and Coordination Requirements – Ductwork

a. Ductwork air leakage testing shall be performed by the TAB Agency.

b. The ductwork/sheetmetal subcontractor shall promptly correct any related problems discovered by the leakage tests.

c. All costs associated with retesting and/or delays or other problems which impede the TAB Agency from performing such testing shall be paid by the Contractor and any subcontractor(s) for ductwork.

(7) Work by TAB Agency

a. The work included in the remainder of this section consists of furnishing labor, instruments, and tools required in testing, adjusting and balancing the HVAC systems, as described in these specifications or shown on accompanying drawings. Services shall include checking equipment performance, taking the specified measurements, and recording and reporting the results. This work shall be performed by the TAB Agency under direct contract to the Owner. The remainder herein is also for the information of the Contractor and all subcontractors.

b. The TAB agency shall provide lifts, scaffolding, etc. as required to balance devices in areas with high ceilings such as gymnasiums, auditoriums, atriums, cupolas, etc.

c. The items requiring testing, adjusting, and balancing include the following:

Air Systems:

Supply Fan AHU
Exhaust Fans
Zone Branch and Main Ducts
Water Source Heat Pumps
Diffusers, Registers and Grilles
Coils (Air Temperatures)

Hydronic Systems:

Pumps
System Mains and Branches
Coils

(8) Qualifications

a. Agency Qualifications: The TAB Agency shall be a current member of a nationally recognized balance organization (National Organization). This Organization shall provide the Owner with National Guarantee document certifying the work of the TAB Agency. Acceptable organizations are Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB).

1) The selected TAB Agency must provide proof of certification for the total project (air, water, sound, vibration, etc.).

2) The selected TAB Agency shall possess computers, cables, and software needed to operate the building control system. This requires the TAB Agency to be properly licensed and/or trained to run the Control Contractor’s software.

(9) Definitions, References and Standards

a. All work shall be in accordance with the latest edition of the National Standards, as published by the National Organization affiliated with the TAB Agency.

(10) Submittals

a. Qualifications: The TAB Agency shall submit a company resume listing personnel and project experience in air and hydronic system balancing and a copy of the Agency's test and balance engineer (TBE) certificate. Certification in noise, vibration, and air quality shall be submitted as the job requires.

b. Procedures and Agenda: The TAB Agency shall submit the TAB procedures and agenda proposed to be used.

(11) Reports

a. Final TAB Report: The TAB Agency shall submit the final TA report for review by the Engineer. All outlets, devices, HVAC equipment, etc., shall be identified, along with a numbering system corresponding to report unit identification. The TAB Agency shall submit a National Project Performance Guaranty assuring that the project systems were tested, adjusted and balanced in accordance with the project specifications and National Standards.

b. Submit 3 copies of the Final TAB Report.

(12) Deficiencies

a. Any deficiencies in the installation or performance of a system or component observed by the TAB Agency shall be brought to the attention of the appropriate responsible person. Also notify the mechanical project representative from the Division of Engineering.

b. The work necessary to correct items on the deficiency listing shall be performed and verified by the affected contractor before the TAB Agency returns to retest. Unresolved deficiencies shall be noted in the final report.

B. INSTRUMENTATION

All instruments used for measurements shall be accurate and calibrated. Calibration and maintenance of all instruments shall be in accordance with the requirements of the National Standards.

(1) General

a. The specific systems shall be reviewed and inspected for conformance to design documents. Testing, adjusting and balancing on each identified system shall be performed. The accuracy of measurements shall be in accordance with National Standards. Adjustment tolerances shall be + or - 10% unless otherwise stated.

b. Equipment settings, including manual damper quadrant positions, manual valve indicators, fan speed control levers, and similar controls and devices shall be marked to show final settings.

c. All information necessary to complete a proper TAB project and report shall be per National Organization's standards unless otherwise noted. The descriptions for work required, as listed in this section, are guides to the minimum information needed.

(2) Air Systems

a. The TAB Agency shall verify that all ductwork, dampers, grilles, registers, and diffusers have been installed per design and set in the full open position. The TAB Agency shall perform the following TAB procedures in accordance with the National Standards:

For Supply Fans:

1) Fan Speeds - Test and adjust fan RPM to achieve maximum or design CFM. Confirm proper rotation direction.

2) Current and Voltage - Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure fan motor is not in or above the service factor.

3) Pitot-Tube Traverse - Perform a Pitot-tube traverse of main supply and return ducts, as applicable to obtain total CFM.

4) Outside Air - Test and adjust the outside air on applicable equipment using a Pitot-tube traverse. If a traverse is not practical use the mixed/air temperature method if the inside and outside temperature difference is at least 20 degrees Fahrenheit or use the difference between Pitot-tube traverses of the supply and return air ducts.

5) Static Pressure - Test and record system static profile of each supply fan.

For Return Fans:

1) Fan Speeds - Test and adjust fan RPM to achieve maximum or design CFM. Confirm proper rotation direction.

2) Current and Voltage - Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure fan motor is not in or above the service factor.

3) Pitot-Tube Traverse - Perform a Pitot-tube traverse of the main return ducts to obtain total CFM.

4) Static Pressure - Test and record system static profile of each return fan.

For Relief Fans:

1) Fan Speeds - Test and adjust fan RPM to achieve maximum or design CFM. Confirm proper rotation direction.

2) Current and Voltage - Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure fan motor is not in or above the service factor.

3) Static Pressure - Test and record system static profile of each relief fan.

4) Pitot-Tube Traverse - If possible, per system ductwork, perform a traverse to determine relief air CFM.

For Exhaust Fans:

1) Fan Speeds - Test and adjust fan RPM to achieve maximum or design CFM. Confirm proper rotation direction.

2) Current and Voltage - Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure fan motor is not in or above the service factor.

3) Pitot-Tube Traverse - Perform a Pitot-tube traverse of main exhaust ducts to obtain total CFM.

For Zone, Branch and Main Ducts:

1) Adjust ducts to within design CFM requirements. As applicable, at least one zone balancing damper shall be completely open. Multi-diffuser branch ducts shall have at least one outlet or inlet volume damper completely open.

For Diffusers, Registers and Grilles:

1) Tolerances - Test, adjust, and balance each diffuser, grilles, and register to within 10% of design requirements.

2) Adjust all adjustable diffusers to minimize air drafts and eliminate suspended light fixture sway.

3) Adjustable diffusers in spaces with ceilings taller than 9 feet shall be adjusted to eliminate air stratification during heating season.

4) Identification - Identify the type, location, and size of each grille, diffuser, and register. This information shall be recorded on air outlet data sheets.

For Coils:

1) Air Temperature - Once air flows are set to acceptable limits, take wet bulb and dry bulb air temperatures on the entering and leaving side of each cooling coil. Dry-bulb temperature shall be taken on the entering and leaving side of each heating coil.

(3) Hydronic Systems

a. The TAB Agency shall, as applicable, confirm that all hydronic equipment, piping, and coils have been filled and purged; that strainers have been cleaned, and that all balancing valves (except bypass valves) are set full open. The TAB Agency shall perform the following testing and balancing functions in accordance with the National Standards:

For Pumps:

1) Test and adjust chilled water, hot water, and condenser water pumps to achieve maximum or design GPM. Check pumps for proper operation. Confirm proper rotation direction. Pumps shall be free of vibration and cavitation. Record appropriate gauge readings for final TDH and Clock/Off/Dead head calculations.

2) Current and Voltage - Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure pump motor is not in or above the service factor.

For System Mains and Branches:

1) Adjust water flow in pipes to achieve maximum or design GPM.

For Chillers:

1) Verify that chillers have been started by others and are in operation. Test and adjust chiller water flows to achieve maximum or design GPM.

2) Current and Voltage - Test and record motor voltage and amperage, and compare data with the name plate limits to ensure compressor motor is not in or above the service factor.

3) Test and record temperature profiles of chillers.

For Cooling Towers:

1) Verify that cooling towers have been filled and started by others, and are in operation. Confirm proper rotation direction for all motors.

2) Test and adjust water flows to balance tower cells and flows between towers.

3) Test and record temperature profiles for water and air side operation.

For Boilers:

1) Verify that boilers have been filled and started by others, and are in operation.

2) Current and Voltage - As applicable, test and record motor voltage and amperage, and compare data with the nameplate limits to ensure motor is not in or above the service factor.

3) Test and adjust water flow through water boilers.

4) Test and record temperature and pressure profiles of water or steam boilers.

For Coils:

1) Tolerances - Test, adjust, and balance all chilled-water and hot-water coils within 10% of design requirements.

2) Verification - Verify the type, location, final pressure drop and GPM of each coil. This information shall be recorded on coil data sheets.

For Domestic Hot Water System:

1) Balance domestic hot water recirculation system.

For Duct Testing:

1) See Specification Section 231200 for specific requirements.

(4) Other TAB Services

a. Preconstruction Plan Check and Review: The TAB Agency shall review the project documents and contractor submittals for their effect on the TAB process and overall performance of the HVAC system. It shall submit recommendations for enhancements or changes to the system within 30 days of document review.

b. Job Site Inspections: During construction, the TAB Agency shall inspect the installation of pipe systems, sheet metal work, temperature controls, and other component parts of the HVAC systems. Inspections shall

be conducted a minimum of two times. (Typically, these are performed when 60% of the total system is installed and again when 90% of the total system is installed, prior to insulation of the duct and piping). The TAB Agency shall submit a written report of each inspection.

c. Duct Leakage Testing: The installing contractor shall isolate and seal sections of ductwork for testing. The test pressures required and the amount of duct to be tested shall be described by the Engineer in the appropriate duct classification section. All testing shall be based on one test per section only unless otherwise noted.

d. Temperature Testing: To verify system control and operation, a series of three temperature tests shall be taken at approximately two-hour intervals in each separately controlled zone. The resulting temperatures shall not vary more than two degrees Fahrenheit from the thermostat or control setpoint during the tests. Outside temperature and humidity shall also be recorded during the testing periods. (Random zones may be selected by the Engineer if such a test is needed to prove building system.)

e. Kitchen Hood Testing: The TAB Agency shall test and adjust kitchen hood total airflow by duct Pitot-tube traverse or best possible method, if applicable under local code. All sealed of test holes in the exhaust duct to be by others per local code requirements. The TAB Agency shall test and record face velocities in accordance with design requirements. It shall test and adjust make-up airflow (if included) to meet design face velocities and pressurization and to minimize turbulence.

f. Building/Zone Pressurization: The TAB Agency shall test and adjust building/zone pressurization by setting the design flows to meet the required flow direction and pressure differential. For positive pressure areas, it shall set the supply air to design flow, and gradually reduce and exhaust air rate to obtain the required flow or pressure difference. For negative pressure areas, it shall set the supply air to design flow, and gradually increase the exhaust air rate to obtain the required flow or pressure difference.

END OF TESTING AND BALANCING

SECTION 204100 - COMMISSIONING OF MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 General Requirements

2. Division 09160 Commissioning

3. Division 20-25 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CA: Commissioning Authority.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 MECHANICAL SYSTEMS TO BE COMMISSIONED

A. The following systems shall be commissioned:

1. Complete HVAC Systems including all heat pumps and OA unit.
2. Complete HVAC control system including point to point documentation.
3. The domestic hot water system.
4. Building envelope.

1.5 MECHANICAL CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CA.

B. Attend construction phase controls coordination meeting.

C. Attend testing, adjusting, and balancing review and coordination meeting.

D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.6 CA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

1.7 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
6. Test and inspection reports and certificates.
7. Corrective action documents.
8. Verification of testing, adjusting, and balancing reports.

1.8 SUBMITTALS

A. Certificates of readiness.

B. Certificates of completion of installation, prestart, and startup activities.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify in accordance with ASHRAE and ACG Commissioning Guidelines that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CA.

3.2 TESTING AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CA and to the Engineer.

B. Notify the CA at least ten days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CA.

1. The CA will notify testing and balancing Contractor ten days in advance of the date of field verification. Notice will not include data points to be verified.
2. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment, including the geothermal well field, for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CA along with the HVAC&R Contractor testing and balancing Contractor and HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, equipment and submit to the Engineer for review.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CA may direct that set points be altered when simulating conditions is not practical with the approval of the Engineer.

H. The CA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

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

3.4 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. HVAC&R Direct Digital Controls System Testing: Functional Operation requirements are specified in Division 20-25 Sections. Assist the Controls Vendor CA to prepare testing plans for satisfactory compliance.

B. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Division 15 piping Sections. The CA and the HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the Engineer.. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

C. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

D. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

END OF COMMISSIONING OF MECHANICAL

SECTION 210100 - FIRE PROTECTION SYSTEM

1. GENERAL

A. The General Conditions, Instructions to Bidders, Section 200100, 1. A, and other Contract Documents are a part of this specification and shall be binding on the Contractor. It shall be the Contractor's responsibility to apprise himself of all information pertinent to his work prior to submitting his proposal. No adjustments will be made in this Contract which is a result of failure to comply with this requirement.

B. No Contractor, other than those regularly engaged in the installation of approved and franchised automatic sprinkler systems, will be considered or approved for the work under this section of the specifications. Bidders must have had not less than five (5) years experience in the fabrication and erection of such systems: wet, dry and rack storage types, and shall have completed installations similar and equivalent in scope to this system under approval by one or more of the recognized Underwriting Associations in the Insurance Field.

C. Before submitting bid, examine all Mechanical, Architectural, and Structural Drawings, visit the site and become acquainted with all conditions that may, in any way whatsoever, affect the execution of this work. Also, the Contractor shall coordinate with the rating bureau and insuring agency to verify adequacy of water supply for the proposed sprinkler system extension.

D. The Contractor shall take his own measurements and be responsible for exact size and location of all openings required for installation of this work. Figured dimensions where indicated are reasonably accurate and should govern in setting out work. Detailed method of installation is not indicated. Where variations exist between described work and approved practice, the Engineer shall be consulted for directive.

E. It is the intent of the Plans and Specifications to provide a general layout only and locate major equipment, piping, etc. Variations in head locations, pipe routing, etc., may be anticipated by the Contractor and shall be coordinated with all other trades and indicated on the drawings and descriptive literature called for hereinafter. It shall be the express responsibility of the Contractor to provide all required materials and equipment and perform all work required to install a complete and approved installation.

F. All materials and methods shall be in accordance with applicable codes, regulations and/or ordinances and meet approval of local inspection authority and the State Fire Marshal. Also, all work shall comply with the latest editions of the National Board of Fire Underwriters, National Fire Protection Association, OSHA Regulations, the National Building Code, the Life Safety Code, IMC Code and the Southern Building Code (Where applicable). The local insuring agency shall review plans prepared and submitted by the Contractor but shall have no authority to make changes once work has begun.

G. All work performed under this section shall be accomplished in close harmony with all other trades. All work not so coordinated shall be removed and reinstalled at the expense of the Contractor.

H. The Contractor shall submit a proposed layout to the Engineer prior to submittal to the Fire Marshal's Office.

2. SCOPE OF WORK

A. Furnish all material, labor, tools, equipment and supervision required for installation of a complete fire protection and stand pipe system as indicated on the project drawings. Include all necessary piping, sprinkler heads, test connections, valves, drains, cabinets, siamese connections, fire hydrants, fire pump, etc.

B. The Contractor shall provide flushing and sterilization of all water lines in accordance with current Kentucky Plumbing Codes, Rules and Regulations and shall make connection to domestic water mains in accord with current rules and regulations of the State Department of Sanitary Engineering and Division of Water.

C. Provide stand pipes with fire hose cabinets or fire valves as indicated or as required to meet the requirements of NFPA and the local fire authority.

D. Provide sprinklers in attics, overhangs, awnings, cooler/freezers, in accessible spaces and all other areas required by NFPA and the local fire authority.

E. Provide dry pipe systems or freeze proof heads as required to provide continuous coverage without freezing.

3. WATER SUPPLIES AND SYSTEM LAYOUT CRITERIA

A. Where flow and pressure data are available, they are indicated on the project drawings. The Contractor shall independently verify all such information and notify the engineer of any discrepancies discovered prior to beginning the work. Where no flow information is indicted on the project drawings, the Contractor shall obtain it and indicate it on the shop drawing submittal. Piping systems shall be hydraulically sized based on the most conservative flow information obtained. No adjustments in the contract amount will be allowed for failure of the Contractor to obtain adequate flow information.

4. DRAWINGS AND DESCRIPTIVE LITERATURE

A. The Contractor shall prepare and submit to the Engineers, seven (7) copies of detailed drawings indicating his proposed Automatic Sprinkler System. These drawings shall indicate minimally the following components when they are used in the system.

(1) Name and address of Owner, Architect and Engineers.
(2) Make and type of sprinkler heads (Catalog cuts).
(3) Make and type of alarm bell (Catalog cuts).
(4) Make and type of retard chamber (Catalog cuts).
(5) Make and type of dry pipe alarm valve (Catalog cuts).
(6) Make and type of flanged check valve (Catalog cuts).
(7) Make and type of flanged gate valve (Catalog cuts).
(8) Make and type of automatic drains (Catalog cuts).
(9) Make and type of pipe hangers (1 catalog cut of each make and/or type).
(10) Make, type and electrical characteristics of:

a. The pressure sensing switch*.
b. The main gate valve supervisory switch*.
c. The flow switch*.

(11) Make and type of supervised O.S & Y valve.
(12) Make and type of indicating butterfly valve.
(13) Make and type of clean agent fire suppression equipment.
(14) Make and type of fire hose valve cabinets.

Note: All layouts and drawings are to be closely coordinated with the work of all other trades. The Engineers will, upon request, provide a complete set of Architectural, Structural, Mechanical and Electrical Plans and Specifications to aid the Contractor in this work.

*SPECIAL NOTE: 1) The items (indicated by asterisk) must be clearly coordinated with the Fire Alarm System supplier. 2) Supervisory switches located in wet locations (i.e., fire protection vault) shall be provided with NEMA 6 enclosures.

(15) On a set of drawings to the same scale as the drawings accompanying these specifications, indicate:

a. Each head location coordinated with lights, diffusers and other ceiling mounted device.
b. Location of all risers, mains, runout lines, etc.
c. Size of all risers, mains, runout lines, etc.
d. Location and type of pipe hangers.
e. All other information required by the Kentucky Department of Housing, Buildings and Construction.

The Contractor shall submit these drawings to the Engineer through the General Contractor/Construction Manager and Architect where applicable. The Contractor shall submit reviewed drawings to the Kentucky Department of Housing, Buildings and Construction for their review and approval. No work shall be done until drawings are approved by the Kentucky Department of HBC.

5. SYSTEM DRAINAGE

A. The entire Standpipe and Sprinkler System (except that part which is below grade and will not freeze) shall be installed so as to allow 100% drainage.

B. All sprinkler branch piping shall be installed so as to drain back to the main riser.

C. Approved 2" drawoff piping shall be provided on sprinkler risers with discharge piping running to nearest floor drain or open air.

D. Where sprinkler piping is trapped, an approved auxiliary draw-off shall be provided and neatly installed.

E. All draw-offs shall have a metal tag labeled "Sprinkler Drain."

6. INSPECTIONS AND TESTS

A. Furnish all labor, equipment and conduct all required tests in the presence of the Owner and Engineer or designated representative.

B. All piping and devices comprising the fire protection system shall be tested under hydrostatic pressure of not less than 200 PSI and maintained for not less than two (2) hours.

C. Upon completion of his work, the Contractor shall submit a written and signed certificate to the Engineers indicating that he performed the above prescribed tests and rectified all malfunctions arising there from.

7. PERMITS

A. The Contractor shall obtain and pay for all necessary state, municipal, county, city and other permits and fees and pay all State taxes which are applicable.

8. GUARANTEE

A. All workmanship, equipment and material shall be guaranteed in writing against defects from any cause, other than misuse, for a period of one year after date of final acceptance.

9. ACCEPTANCE CERTIFICATE

A. Upon completion, the Contractor shall submit to the Engineers, a properly filled out "Sprinkler Contractor's Certificate Covering Materials and Tests." (4 copies).

10. CLEANING

A. Upon completion of this work all debris, material, and equipment shall be removed from the building and premises; all piping shall be cleaned ready for finish painting. Note: Do not remove rust inhibitive primer specified hereinafter.

11. PAINTING

A. All fire protection piping, fittings, etc., shall have one factory or shop coat of rust inhibitive primer. The Contractor shall thoroughly clean all such items in areas where the piping will be exposed so as to readily receive the finish coat specified in the Architectural Division of Painting. Colors shall be as specified in Identification Section of these specifications.

12. PIPE LAYING

A. Bell holes shall be excavated accurately to size and barrel of pipe shall bear firmly on bottom of trench throughout its length. All foreign matter and dirt shall be removed from the inside of the pipe before it is lowered into its position in the trench, and it shall be kept clean by approved means during and after laying. At times when pipe laying is not in progress, the open ends of pipe shall be closed by approved means, and no trench water shall be permitted to enter the pipe. Cutting of pipe, where necessary, shall be done in a neat and workmanlike manner, without damage to pipe. Refer also to Excavation.

13. EQUIPMENT AND MATERIALS

A. Signs

Appropriate code approved and required signs shall be installed on all control valves, drains, inspector's test, etc., indicating the function, installation, etc. Signs shall be neatly affixed with rust inhibitive screws, rivets or where hung from piping; with stainless steel No. 14 AWG wire.

B. Finish

All exposed materials such as valves, fire department connections, sprinkler heads, fire pump test headers, etc., shall be brass or chrome-plated brass.

C. Check Valves

(1) 2-1/2" and over; listed and approved by UL and FM; marked SV-FM; 175# working pressure; 1 BBM; flanged; equivalent to Mueller, Scott or Lunkenheimer.

(2) 2" and under; 150# working pressure; bronze; screwed; equivalent to Jenkins, Scott or Lunkenheimer.

D. Pipe & Fittings

(1) Nipples and fittings shall be of same material, composition, and weight classification as pipe in which installed.

(2) Up to 2" (Interior) Schedule 40 ASTM A-53 black steel; 125# cast iron screwed fittings or Schedule 10, ASTM A-135 black steel with victaulic or similar type approved fittings.

(3) 2-1/2" and larger (Interior) Schedule 40 black steel with flanged, welded or victaulic (or similar) type approved fittings or Schedule 10, ASTM A-135 black steel with victaulic or similar type approved fittings.

(4) Flexible piping shall be allowed for the 2 feet prior to the sprinkler head where located above a lay-in ceiling provided bracing to support the pipe/head from the ceiling grid is provided.

(5) Dry Pipe System Piping: Same as standard system except Schedule 10 piping is not acceptable.

E. Clamps and Anchors

(1) Furnish and install approved clamps, as required, at all (45 degree) l/8 bends, (90 degree) 1/4 bends and flange and spigot pieces to the straight pipe to insure permanent anchorage of all fire lines. Clamps, clamp rods, nuts, washers, and glands shall be coated with a quick drying coal tar bituminous paint after installation.

F. Hangers

(1) All piping shall be adequately and permanently supported in an approved manner on approved hangers (Submit with drawings).

G. Sleeves and Escutcheon Plates

(1) Furnish and install sleeves for pipes where piping penetrates masonry walls; exterior wall sleeves to be watertight. Fire and smoke stop all penetrations through fire and smoke walls and coordinate with General Contractor for locations.

(2) Furnish and install cast brass chrome plated split ring type escutcheons where piping penetrates walls, ceilings and floors, whether in finished areas or not.

H. Electric Wiring

(1) All electric wiring for the system which may be required shall be installed in accordance with the National Board of Fire Underwriters, and National Electric Code. The cost of this electric wiring shall be included under this Contract. All electrical wiring and conduit installed in fire protection pits shall be sealed watertight.

I. Inspection Test Connections & Pressure Gauges

(1) A 1" inspection test connection as required by the Kentucky Building Code. Discharge shall run to open air.

(2) Control valve for test connection shall be installed not over 7' above the floor.

(3) A pressure gauge at the inspection. Test connection at each location indicated on the Plans. Pressure gauges shall be 2-1/2" diameter and readable from the floor.

J. Gate Valves

(1) 2-1/2" and over; listed and approved by UL and FM; marked SV-FM; 175# working pressure; 1 BBM; OS&Y; flanged; cast iron discs; bronze seat rings; four point wedging mechanism; equivalent to Mueller, Scott or Lunkenheimer.

(2) 2" and under; 150# working pressure; bronze; rising stem; screwed; bronze discs; bronze seat rings; two point wedging mechanism; equivalent to Jenkins, Scott or Lunkenheimer.

K. Sprinkler Head Cabinet

(1) Furnish and install a cabinet, clearly labeled, with four (4) sprinklers of each type complete with required wrenches. Locate as directed by Engineer. Label "Sprinkler Heads."

L. Sprinkler Heads

Gem, Grinnell, Star, Viking, Reliable, Central or approved equivalent as follows:

(1) Where piping is exposed: "Standard up right."

(2) Where piping is concealed above finished ceilings, provide two pieces, semi recessed, chrome plated sprinkler heads with removable escutcheon.

(3) Install sprinkler head guards where heads are subject to physical abuse. Heads located below seven (7) feet above floor, etc.

(4) Sprinkler head degree ratings shall be determined by the area serviced in accord with current Codes and Standard Practices. Indicate degree ratings on submitted Shop Drawings.

(5) The Contractor shall submit to the Engineer for inspection, one (1) sample of each type of sprinkler head, proposed to be used on the project.

(6) Where heads are installed in a tile ceiling, they shall be installed in the middle of the tiles, at half or quarter points along the length of the tiles. Install sprinkler heads at quarter points of center scoured 2' X 4' ceiling tiles.

M. Alarm Bell

(1) Furnish and install an electric alarm bell.

Grinnell, Viking, Mueller or equivalent.

N. Flow Indicator Switches

(1) Furnish and install flow indicator switches as required by NFPA 13. All flow indicator switches shall be UL approved. Coordinate with Fire Alarm System supplier/installer. Provide a set of dry contacts on each flow switch for interface to the Control System if this control point is specified in the Controls Section.

O. Tamper Switches for Water Shut-Off Valves

(1) Furnish and install tamper switches where required by NFPA 13. All tamper switches shall be UL approved. Coordinate with fire alarm system supplier/installer. All tamper switches located in fire protection pits shall be waterproof, capable of operating beneath water similar to Potter PTS Series and be NFPA approved.

P. Fire Valve Cabinets

(1) Manufacturer. The products specified hereunder shall be Crocker or equivalent by Larsen’s Mfg. Co., J.L. Industries, Kidde, or other nationally recognized manufacturer of cabinets conforming closely to specification requirements.

(2) Valve cabinets for recessed installation at all locations where shown shall be similar to Crocker Model No. 2700 with flat trim and clear glazed full glass door. Provide 18 gauge steel tub, 20 gauge steel door, 16 gauge steel frame, and white enamel finish interior with all exposed exterior portions painted with color selected by Architect.

(3) Each cabinet shall be equipped with one 2 ½" (or as required by local authority) Fire Department valve with cap and chain. All connections and threads shall be as required by the local authority.

Q. Fire Hose Valve

(1) Manufacturer. The products specified hereunder shall be Crocker or equivalent by Elkhart, Central Sprinkler, Kidde, or other nationally recognized manufacturer of hose valves conforming closely to specification requirements. Valve shall be with cap and chain. All connections shall be 2 ½" or as required by the local authority.

END OF FIRE PROTECTION

SECTION 220100 - PLUMBING SPECIALTIES

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 specified in this section.

B. The Contractor shall provide all equipment and specialties complete with trim required and connect in a manner conforming to the Kentucky Building Code.

C. The Contractor shall obtain exact centerline rough-in dimensions between partitions, walls, etc. as required for lay-out of his rough-in work. All work shall be roughed-in so that all exposed piping will be straight and true without bends or offsets.

D. Prior to final inspection, test by operation at least twice, all equipment.

E. Prior to final inspection, remove all stick-on labels, dirt, grease, other removable stampings, lettering, etc. from equipment and specialties and thoroughly clean same.

F. All equipment and specialties shall be installed as recommended by the manufacturer in a neat and workmanlike manner. Unacceptable workmanship shall be removed and replaced at the installing Contractor's cost.

2. DRAINAGE SPECIALTIES

A. GENERAL

(1) Provide all drainage specialties indicated, specified and/or required to provide complete and acceptable removal of all storm, sanitary, waste, laboratory waste, etc. from the building and into approved receptors.

(2) Drainage specialties shall be on non-electrolytic conduction to the material to which they are connected.

(3) Drainage specialties shall be installed in a manner so as to insure no leakage of toxic or odorous gases or liquids and shall have traps and/or backflow preventers where required. Nor shall they allow backflow into other or existing systems.

B. CLEANOUTS - INTERIOR (CO)

(1) In addition to cleanouts indicated, provide cleanouts in soil and waste piping and storm drainage at the following minimum locations:

a. At base of each stack.
b. At fifty (50) foot maximum intervals in horizontal lines.
c. At each change of direction of a horizontal line.
d. As required by current KBC.
e. As required to permit rodding of entire system. (If in doubt, contact Engineers.)

(2) Water closets, slop sinks and other fixtures with fixed traps shall not be accepted as cleanouts.

(3) Cleanouts and/or test tees concealed in inaccessible pipe spaces, walls and other locations shall have an eight (8) inch by eight (8) inch (minimum) access panel or cover plates shall be set flush with finished floors and walls and shall be key or screw driver operable.

(4) Access panels for cleanouts shall be of the Zurn, 1460 series or equivalent by Josam or Watts. Where they are not to receive paint, they shall be polished bronze unless otherwise indicated where they are to receive paint or other finishes. They may, at the Contractor's option, be Perma-Coated steel, prepared to receive finish.

(5) Cleanouts and access panels shall be sized so as to permit the entry of a full sized rodding head capable of one hundred percent circumferential coverage of the line served.

(6) Provide a non-hardening mixture of graphite and grease on threads of all screwed cleanouts during installation.

(7) Do not install cleanouts against walls, partitions, etc. where rodding will be difficult or impossible. Extend past the obstruction.

(8) In finished walls, floors, etc., insure that cleanouts are installed flush with finished surfaces and, where required, grout or otherwise finish in a neat and workmanlike manner.

(9) Cleanouts shall be as manufactured by Zurn, Josam, Jay R. Smith, Watts, MIFAB, Ancon or equivalent, similar to the following:

a. Zurn, Z-1440 cleanouts or Z-1445 cleanout tee at base of exposed stack and at change in direction of exposed lines.

b. Zurn, Z-1440 cleanout or Z-1445-1 cleanout tee where stacks are concealed in finished walls

c. Zurn, ZN-1400-T cleanout with square scoriated top in finished concrete and masonry tile floors.

d. Zurn, ZN-1400-Tx cleanout with square recessed top for tile in vinyl and linoleum finished floors.

e. Zurn, ZN-1400-Z cleanout with round recessed top for terrazzo floors.

f. Zurn, Z-1400-HD cleanout with tractor cover for exterior locations. Provide concrete supporting pad crowned to shed water. Refer to drawings for pad size.

g. Mueller, No. D-731 or D-714, Nibco, Flage or equivalent for cleanouts in copper waste with cover plates and/or access panels listed for other cleanouts.

h. Threaded hex head type cleanouts of same materials as pipe for piping 2" and smaller.

i. Zurn, cleanout with round top with adjustable retainer for carpet area. Install flush with carpet.

C. TRAP PRIMERS

Provide trap primers for all floor drains and open receptacle. Acceptable Trap Primer Manufacturers included Zurn, Precision Plumbing Products and Sioux Chief. Trap Primer selection shall be as follows:

(1) Trap Primer Type-1 (TP-1)

Precisions Plumbing Products Prime-Time or equal electronic trap priming manifold, with atmospheric vacuum breaker, pre-set 24 hour clock, manual override switch, 120 volt solenoid valve with 120v/3wire connection. Provide in 12” x 12” x 4” surface mounted metal cabinet. Provide with 10 opening manifold, un-used manifold opening shall be capped. Install united as required by manufacturer.

(2) Trap Primer Type-2 (TP-2)

Precision plumbing products Prime-Rite or equal trap primer shall be installed on a cold water line, with distribution unit(s) to serve 1 to 8 drains. Install per manufacturer's recommendations.

(3) Trap Primer Type-3 (TP-3)

Zurn Z-1022 or equal trap primer shall be installed in cold water supply line of nearest plumbing fixture. One trap primer per floor drain, one trap primer per fixture. Pipe to waste inlet per manufacturer's recommendations.

D. ROOF DRAINS

(1) Each drain shall be provided complete with a three (3) foot by three (3) foot, four (4) pound sheet lead flashing and clamping collar. Roof drains shall be installed in strict accordance with the drain manufacturers and roofing manufacturer's instructions. Provide all accessories required for a complete installation.

(2) RD-1, Zurn, Z-100 15", or equivalent, diameter roof drain, dura-coated cast iron body with combination membrane flashing clamp/gravel guard and low silhouette cast iron dome. Provide with any accessories needed for installation in roof specified by Architect and as recommended by the roofing manufacturer.

(3) RD-2 (Overflow Roof Drain with external water dam) Zurn, Z-100-89 , or equivalent, 15" diameter roof drain, dura-coated cast iron body with 2" high combination membrane flashing clamp/gravel guard and low silhouette cast iron dome. Provide with any accessories for installation in roof specified by the Architect and as recommended by the roofing manufacturer.

3. WATER SUPPLY SPECIALTIES

A. GENERAL

(1) Provide all water supply specialties indicated, specified and/or required for the complete installation. Install in a neat and workmanlike manner in accordance with the manufacturer's recommendations and the KBC.

(2) Where required by the KBC, install code approved vacuum breakers in each water supply specialty.

B. FREEZEPROOF WALL HYDRANTS (FPWH)

(1) Provide code approved wall hydrants at each location indicated in a neat and workmanlike manner. Affix tight to walls and insure that the feed piping is on the heated side of the building insulation blanket.

(2) Where hydrants are of handwheel type, remove handwheels and turn over to owners in an envelope labeled "Wall Hydrants" exterior upon completion of the project.

(3) Where hydrants have key operators, turn over at least two (2) keys in an envelope labeled "Wall Hydrants" to owners upon completion of the project.

(4) Where hydrants have lockable boxes, turn over at least two (2) keys in an envelope labeled "Wall Hydrants, Exterior" to owners upon completion of project.

(5) Mount all wall hydrants at least twenty (20) inches above finished exterior grade. Where this is not possible or practical, contact Engineers.

(6) Wall hydrants shall be as follows or equivalent:

a. Zurn 1300 or equivalent, 3/4", encased, flush, non-freeze wall hydrant with key lock and combination backflow preventer/vacuum breaker.

C. HOSE BIBBS (HB)

(1) Provide code approved hose bibbs with vacuum breakers and male threaded spouts at each location indicated and as follows:

(2) Do not install hose bibbs spaces which do not have existing planned or installed floor drains even if sill cocks are indicated for these areas.

(3) Hose bibbs shall be mounted at eighteen (18) inches above finished floor served.

(4) The hose bibb shall be Woodford or equivalent similar to the following:

a. Woodford Model 24 with loose key handle polished chrome finish, brass construction.

D. BOILER DRAINS (BD)

Install 3/4 inch bronze body boiler drains, similar and equivalent to Nibco, No. 72 or 73, as indicated and at the following locations:

(1) At the low point of the plumbing system.

(2) On boiler low point.

(3) In each hot water heater and/or storage tank.

(4) At the low point of each hydronic system.

(5) On the water refrigeration machine (100 percent drainage).

(6) On each water storage tank.

(7) At each pump suction.

(8) At the low point of each isolatable section of any system carrying water.

NOTE: Install a code approved vacuum breaker where installation on to domestic water system.

E. WATER HAMMER ARRESTORS (WHA): Provide water hammer arrestors at each location indicated and/or as required to eliminate hydrostatic on the domestic water system. Provide at least one water hammer arrestor at all quick acting valve locations including:

Automatic Clothes Dryers – Type “A”
Commercial Dishwashers – Type “B”
Mop Basins (downstream of check valve) – Type “A”
Flush valve fixtures - Type “B” (Each toilet room with 1-3 flush valve fixtures shall have its own Type “B” water hammer arrestor.)

(1) Multiple Fixtures – Branch Line Less Than 20' Long: The preferred location for a Zurn Shoktrol is at the end of the branch line between the last two fixtures when the branch lines do not exceed 20' in length, from the start of the horizontal branch line to the last fixture supply on this line.

(2) Multiple Fixtures – Branch Line More Than 20' Long: On branch lines over 20' in length, use two Shoktrols whose capacities total the requirement of the branch. Locate one unit between the last and next to last fixture and the other unit approximately midway between the fixtures.

(3) Water hammer arrestors shall be Zurn, Z-1700, Shoktrol, Smith, Josam, Wade, or equivalent. Water hammer arrestors shall be stainless steel, bellows type. Field fabricated capped cylinders shall not be acceptable.

(4) Note: Provide insulation unions where arrestors are of dissimilar material from the piping served (unless piping is non-conducting, such as ABS or PVC).

MARK	MANUFACTURER & MODEL	SIZE	P.D.I. SIZE
TYPE "A"	ZURN, Z-1700 # 100	1-11	A
TYPE "B"	ZURN, Z-1700 # 200	12-32	B
TYPE "C"	ZURN, Z-1700 # 300	33-60	C
TYPE "D"	ZURN, Z-1700 # 400	61-113	D

F. PRESSURE REDUCING VALVES (PRV)

Install at each location indicated and/or as required to reduce domestic building water service to a maximum of eighty (80) PSIG code approved pressure reducing stations with by-pass. Install in a manner indicated or as required. Provide unions and stops for removal of station. PRV shall be adjustable from thirty (30) percent above or below reduced pressure. Where this cannot be attained with single stage, provide multiphased reduction.

G. REDUCED PRESSURE BACKFLOW PREVENTERS (RPBP)

Watts #909 or equivalent reduced pressure backflow preventer. Provide with gate valves for isolation, strainer and air gap fitting. RPBP shall be UL listed.

H. DOUBLE CHECK VALVE ASSEMBLY

Watts #709, Watts #757, or equivalent double check valve assembly. Provide with strainer and gate valves for isolation. Assembly shall be UL listed.

4. GENERAL SPECIALTIES

A. VACUUM BREAKERS AND BACK FLOW PREVENTERS

Where required by the KBC, whether indicated or not, provide approved vacuum breakers or backflow preventers at the following locations.

(1) Where domestic water system connects to fire protection system.

(2) Where domestic water system connects to hydronic system.

(3) At any hose (threaded) tap on the domestic water system.

B. ROOF FLASHINGS

All plumbing vents or other plumbing passing thru the roof shall be flashed as approved by the KBC and as recommended by the roofing manufacturer and/or Contractor.

C. GAS PRESSURE REGULATORS

Provide gas pressure regulators for all gas fired equipment that requires a lower pressure than what is delivered to the appliance. Regulators shall be installed in accordance with the requirements of NFPA 54 and/or International Fuel Gas Code, whichever is more stringent.

END OF PLUMBING SPECIALTIES

SECTION 220200 - PLUMBING FIXTURES, FITTINGS AND TRIM

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 in this section.

B. The Contractor shall provide all fixtures complete with trim required and connect in a manner conforming to the State Plumbing Code.

C. The Contractor shall obtain exact centerline rough-in dimensions between partitions, walls, etc. as required for lay-out of his rough-in work. All work shall be roughed-in so that all exposed piping will be straight and true without bends or offsets.

D. All exposed piping or in casework below sinks, stops, traps, tailpieces, etc., shall be code approved chrome plated brass unless otherwise indicated or specified. Water supplies shall connect through walls with stops and chrome plated escutcheons with set screws.

E. All fittings, fixtures and trim shall be new unless otherwise indicated or specified. They shall also be of equivalent quality, dimensions, material, etc. as those specified.

F. Handicapped fixtures shall be mounted as recommended by the KBC and ADA.

G. All fixtures shall be mounted as recommended by the manufacturer. Fixtures shall be rigidly mounted to walls and floors. Pay particular attention to flush valves and bracket concealed portion to building structure during rough-in. Loose, shaky flush valves, lavatories, etc. shall not be acceptable.

H. Prior to final inspection open all faucets and allow to run for fifteen (15) minutes, then remove all faucet aerators and thoroughly clean until smooth flow is obtained.

I. Prior to final inspection, test by operation at least twice:

(1) (Where applicable) adequate flow of hot and/or cold water at;

a. All Faucets
b. Flush Valves
c. Hose Bibbs
d. Sill Cocks
e. All Other Valved Hot and/or Cold Water Openings In the Plumbing System

(2) All toilet seats

J. Prior to final inspection, remove all stick-on labels, dirt, grease, other removable stampings, lettering, etc. from plumbing fixtures and thoroughly clean same.

K. All sink and lavatory traps shall have screw in plugs in the bottom for ease of cleaning and have mechanical fittings for ease of removal.

L. All fixtures shall be set level and true and shall be grouted into finished walls, floors, etc. in a neat and workmanlike manner with an approved waterproof non-yellowing grout for such service.

M. Special Note for Handicap Grab Rails: Coordinate top of shower valves, flush valves, flush tank, etc., with location of grab rails as shown on the architectural plans. The Contractor shall install all items to allow for installation, removal and service without removal of the grab bar.

N. All exposed drain pipes and domestic water piping under handicap accessible sinks and lavatories shall be insulated in accordance with ADA requirements and shall have a vinyl plastic covering over all insulation.

O. The Contractor shall obtain a copy of the casework shop drawings and confirm sinks, faucets, gas turrets, etc., will fit in the space provided. Additionally, in ADA applications with handicap sink base cabinets, the Contractor shall limit the total distance from the bottom of the sink to the bottom of the P-trap and coordinate waste pipe rough-in height to ensure the proper installation of the handicap sink base cabinet front closure panel. The Contractor shall not order sinks until he confirms no conflicts occur and shall adjust sink sizes if required. If the Contractor orders sinks, faucets, etc., that do not fit in the casework supplied, he shall replace them at no additional cost.

P. All lavatories, sinks, etc. shall be supplied with center rear drain outlets where necessary to avoid conflict with casework, handicapped kneeboards, etc. If the Contractor orders sinks that do not fit in the casework supplied, he shall replace them at no additional cost.

Q. All single supply faucets shall be provided with mechanical mixing valves unless otherwise noted. Mechanical mixing valves shall have hot and cold water inlet connections, common outlet, in-line check valves, and adjustable temperature setting. Mixing valves shall be Moen model 104424 or equal. Provide one mixing valve per single supply faucet unless otherwise noted. Contractor shall provide all required connections and set mixing valve to required temperature.

2. FIXTURES AND TRIM

Available Manufacturers: Subject to compliance with requirements of manufacturers offering plumbing fixtures and trim. Plumbing fixtures and trim, which may be incorporated in the work include, but are not limited to, the following:

A. Plumbing Fixtures - Water Closet, Lavatory, and Urinal

American Standard, U.S. Plumbing Products
Eljer Plumbingware Div., Wallace-Murray Corp.
Kohler Co.
Crane Plumbing
Toto
Zurn Co.
Sloan Fixtures

B. Plumbing Trim

American Standard, U.S. Plumbing Products
Chicago Faucet Co.
Kohler Co.
Delta Co.
T&S Brass & Bronze Work Co.
Zurn Co.
Just Co.
Speakman Co.
Moen Commercial

C. Flush Valves

Delany Co.
Sloan Valve Co.
Zurn Co.

D. Fixture Seats

Bemis Mfg. Co.
Church Seat Co.
Olsonite Corp., Olsonite Seats

E. Water Coolers

Elkay Mfg. Co.
Halsey Taylor Div., King-Sealey Thermos Co.
Haws Drinking Faucet Co.
Western Drinking Fountains, Div. of Sunroc Corp.
Oasis Co.
Acorn AQUA

* Acceptable wall hung water coolers shall be equal to Oasis P8AM, Elkay EZS8 or Halsey Taylor HAC8FS. All other wall hung water coolers shall be subject to review of the Engineer.

F. Service Sinks and Mop Basins

American Standard, U.S. Plumbing Products
Eljer Plumbingware Div., Wallace-Murray Corp.
Fiat Products
Kohler Co.
Stern-Williams Co., Inc.
Florestone

G. Stainless Steel Sink

Elkay Mfg. Co.
Just Mfg. Co.
Moen, Div. of Stanadyne/Western
Sterling Co.

H. Fixture Carriers

Josam Mfg. Co.
Jay R. Smith
Tyler Pipe
Zurn Industries
Watts
Guardian Co.

I. P-Trap Insulation Kit (Trap Wrap)

Truebro
Brocar
Plumberex

Note: Kitchen, Special Equipment, Etc.

Contractor to provide final plumbing connections to all of the equipment furnished by Owner including, but not limited to: chrome supplies, stops, continuous drains, drain tailpiece, Kentucky Code "P" traps and escutcheons.

3. FIXTURE SELECTION

A. Refer to drawings for fixture schedule.

END OF PLUMBING FIXTURES

SECTION 220300 - PLUMBING EQUIPMENT

1. GENERAL

   A. All plumbing equipment shall comply with the latest provisions of KBC.

2. WATER HEATER

   A. Reheem HE, A.O. Smith or equivalent electric water heater; Refer to drawings for size and electrical requirement; copper sheathed tin coated elements (75 watt/sq. in. maximum density); glasslined tank; foam insulation; magnesium anode rod; automatic over-heat control; enamelled steel jacket; (2) elements wired for non-simultaneous operation; upper and lower thermostat; 240/1/60; with ASME temperature and pressure relief valve; set temperature at 105°F.

3. EXPANSION TANK (DOMESTIC WATER)

   A. Amtrol Therm-X-Trol expansion tank, precharged air chamber, stainless steel connection and heavy duty butyl diaphragm. Refer to plans for model number and size.

4. RECIRCULATING DOMESTIC HOT WATER PUMPS

   A. Thrush, Armstrong, Bell and Gossett or approved equivalent all bronze in-line centrifugal circulating pump with mechanical seals, drip proof motor and all required overloads, starters and disconnects.

END OF PLUMBING EQUIPMENT

SECTION 230100 - PUMPS

1. GENERAL

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

B. All required motor starters shall be furnished with the respective pump.

C. Electric motors shall be furnished with the pumps and shall be of the size and type scheduled or otherwise specified. All motors shall be UL labeled and shall comply with applicable NEMA standard.

D. Shop drawings shall be submitted as required by Section 200300 and shall include complete pump specifications, installation and start-up instructions, current and accurate pump performance curves with the selection points clearly indicated, maintenance data and spare parts lists.

E. Pumps shall be factory tested, cleaned and painted prior to shipment. Size, type, capacity and electrical characteristics are listed in the pump schedule.

F. Insofar as possible, all pumps shall be by the same manufacturer.

G. Pump shall have data plate indicating horsepower, voltage, phase, ampacity, pressure head, and flow rate.

H. Special notes for pumps controlled by variable frequency drives:

(1) Supplier shall provide the largest non-overloading impeller size for the specified pump motor horsepower, regardless of the specified pump head given on the pump schedule(s).

(2) Pumps 5 HP to 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. Ground motor frame per manufacturer’s instructions. Install kit in strict accordance with manufacturer’s instructions.

(3) The contractor shall include in their Submittal the variable speed performance for each pump that shall be operated with a variable frequency drive.

2. MATERIAL

A. BASE MOUNTED PUMPS

(1) Type: Horizontal, base mounted, end suction, single stage, flexible coupled, 175 PSI working pressure.

(2) Pump Body: Cast iron, flanged gauge and drain tappings, bronze fitted.

(3) Shaft: Stainless steel. Refer to special notes for pumps controlled by VFD’s above for shaft grounding kit specification.

(4) Bearing: Re-lubricatable ball bearing.

(5) Seal: Mechanical, carbon ring with ceramic seal.

(6) Motor: open, drip proof, re-lubricatable ball bearing. Minimum efficiency per NEMA Premium Induction Motor Efficiency.

(7) Impeller: Enclosed, balanced.

(8) Base: Structural steel.

(9) Coupling: Flexible with coupling guard.

(10) Manufacturers: Subject to compliance with the specified and scheduled requirements. Pumps by the following manufacturers will be considered:

Amtrol/Thrush
Armstrong/Aurora
Bell and Gossett
Federal Pump
Patterson
Sigmund
Worthington Pump
Weinman
Taco
FloFab

(11) SELECTIONS:
Refer to the schedule on the plans for base-mounted pump selections.

END OF PUMPS

SECTION 230200 - HVAC EQUIPMENT AND HYDRONIC SPECIALTIES

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. The Contractor shall provide in complete working order the following heating, ventilation and air conditioning equipment located as indicated and installed, connected and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

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

D. 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 heat pumps, chillers, VFDs, air handling units, etc.

E. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90 and/or International Energy Conservation Code 2006, whichever is more stringent.

F. 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.

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

(1) Review the Controls Section of these Specifications (if applicable) to determine controls to be furnished by the equipment manufacturer, if any. The Contractor shall provide all controls with equipment unless specifically listed otherwise.

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

(3) Insure 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.

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

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

(6) Provide factory start-up on site by a factory representative (not a third party contractor) for all HVAC equipment, including pumps, VFDS, boilers, chillers, cooling towers, heat pumps, rooftop units, etc. Submit factory start-up reports to the Engineer.

(7) 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 and provided on DVD to the Owner with the Operation and Maintenance Manuals.

(8) Review the Section on Motor Starters and Electrical Requirements for Mechanical Equipment.

(9) Requirements for motors controlled by variable frequency drives:

a. All motors shall be inverter duty rated.

b. Motors 5 HP to 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. Ground motor frame per manufacturer's instructions. Install kit in strict accordance with manufacturer's instructions.

(10) All condensate producing equipment shall be provided with a condensate trap as recommended by the equipment manufacturer and a condensate overflow switch where applicable such as heat pumps.

(11) Provide low ambient and all required controls and accessories on all HVAC equipment to ensure they can provide cooling during the winter season.

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

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

2. EQUIPMENT

A. OUTSIDE AIR UNIT OA-1

1) Quality Assurance

a. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with current ARI 410 Standard.
b. Certify aid-handling units in accordance with ARI 430.
c. ISO 9001 Certification.

2) Regulatory Requirements

a. Unit shall be manufactured to conform to UL 1995 Standard and shall be listed by either UL/CUL or ETL. Units shall be provided with listing agency label affixed to unit. In the event the unit is not UL/CUL or ETL approved, the contractor shall, at his/her expense provide for a field inspection by a UL/CUL or ETL representative to verify conformance. If necessary, contractor shall perform modifications to the unit to comply with UL/CUL or ETL as directed by the representative, at no additional expense to the owner.

b. Certify air-handling units in accordance with ARI 430. If air-handling units are not certified in accordance with ARI 430, contractor shall be responsible for expenses associated with testing of units after installation to verify performance of fan(s). Any costs incurred to adjust fans to meet scheduled capacities shall be the sole responsibility of the contractor.

c. Certify air-handling coils in accordance with ARI 410. If air-handling coils are not certified n accordance with ARI 410, contractor shall be responsible for expenses associated with testing of coils after installation

to verify performance of coil(s). Any costs incurred to adjust coils to meet scheduled capacities shall be the sole responsibility of the contractor.

3) Start-Up and Operating Requirements

a. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation. Provide temporary filters at all duct openings during start-up.

4) Warranty

a. The equipment manufacturer shall provide, at no additional cost, a parts and labor warranty that covers a period of one-year from substantial completion. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

5) Acceptable Manufacturers

a. Basis of design manufacturer is JCI. Approved equals are Trane, York, and McQuay. Other manufacturers must obtain pre-approval in writing from consulting engineer prior to bid day. Alternates must comply with all performance and features as called for in this specification.

b. Manufacturer must clearly define any exceptions made to Plans and Specifications. Any deviations in layout or arrangement shall be submitted to consulting engineer prior to bid date for consideration. Acceptance of deviation(s) from specifications shall be in the form of written approval from the consulting engineer. Contractor is responsible for expenses that occur due to exceptions made as a result of a substitution.

6) General

a. Unit layout and configuration shall be defined in project plans and schedule.

b. Provide unit mounting legs to support all sections of unit and raise unit for proper trapping. Contractor will be responsible for providing a housekeeping pad. Unit mounting devices not constructed of galvanized steel shall be chemically cleaned and coated with both a rust-inhibiting primer and finished coat of rust-inhibiting enamel.

7) Unit Casing

a. Unit shall be constructed of a complete structural frame with removable panels. Unit manufacturer shall ship separate segments so unit can be broken down for ease of installation in tight spaces. The entire air handler shall be constructed of galvanized steel. Casing finished to meet ASTMB 117 250-hour salt-spray test. The removal of side panels shall not affect the structural integrity of the unit. All removable panels shall be gasketed to minimize air leakage. All doors shall have gasketing around full perimeter to prevent air leakage. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.

b. Construct casing sections capable of operating from -4"wg to +6"wg.

c. Access panels and/or access doors shall be provided on both sides of the unit in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance. If panels are not removable, then manufacturer shall provide access sections with doors between all internal components to ensure access and cleanability of the air handler.

d. Access doors shall be double wall construction to prevent damage to insulation during routine maintenance.

e. Access panels and doors shall be hinged and fully removable without the use of specialized tools to allow complete access of all interior surfaces.

f. Door hardware shall be surface mounted to minimize penetrations in the door casing that could lead to air leakage paths.

g. All joints between exterior panels and structural frames, as well as joints between module frames, shall be properly sealed and gasketed to provide an air seal.

h. Insulation – High density Foam Insulated Panels. Insulation shall be encased in double-wall casing between exterior and solid interior panel such that no insulation can erode to the air stream. Insulation shall be 2 inch thick and have a minimum R-Value of 13 and shall be UL listed. The installation shall comply with NFPA-90A and B requirements.

8) Fans

a. Provide fans of type and class as specified on the schedule. Fan shafts shall be solid, coated with a rust-inhibiting coating, and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. All fans shall be statically and dynamically tested by the manufacturer for vibration and alignment as an assembly at the operating RPM to meet design specifications. Fans controlled by variable frequency drives shall be statically and dynamically tested for vibration and alignment at speeds between 25% and 100% of design RPM. If fans are not factory-tested for vibration and alignment, the contractor shall be responsible for cost and labor associated with field balancing an dcertified vibration performance. Fan wheels shall be keyed to fan shafts to prevent slipping.

b. Provide grease lubricated ball bearings selected for L-50 200,000-hour average life per ANSI/FBMA 9. Greasable bearings shall have lubrication lines extended to the drive side of the unit. Lubrication lines shall be a clear, high-pressure, polymer to aid in visual inspection. Extend both grease lubrication lines to drive side of unit and rigidly attach to drive side bearing support with zerk fittings. If extended lubrication lines are not provided, manufacturer shall provide permanently lubricated bearing with engineering calculations for proof of bearing life.

c. Fans shall be mounted on isolation bases. Internally- mounted motor shall be on the same isolation base. Fan and motor shall be internally isolated with spring isolators. Flexible canvas ducts shall be installed between fan and unit casing to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A and UL 181 requirements. If fans and motors are not internally isolated, then the entire unit shall be externally isolated from the building, including supply and return duct work, piping, and electrical connections. External isolation shall be furnished by the contractor in order to avoid transmission of noise and vibration through the ductwork and building structure.

d. Fan modules shall have a minimum of one access door located on the drive side of the unit to allow inspection and maintenance of the fan, motor, and drive components. Construct door(s) per Section (10) paragraphs D,E,F.

e. Belts shall be enclosed as required by OSHA standard 29 CFR 1910 to protect worker from accidental contact with the belts and sheaves.

I. MOTORS AND DRIVES

1. All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change. Fan sections without factory-installed motors shall have motors field installed by the contractor. The contractor

shall be responsible for all costs associated with installation of motor and drive, alignment of sheaves and belts, run testing of the motor, and balancing of the assembly.

2. Fan Motors shall be heavy duty, open drip-proof (ODP) high efficiency, electrical voltage per drawings.

3. Motors shall be selected to operate continuously at 104 F (40 C) ambient without tripping of overloads. Motors shall have a +/- 10 percent voltage utilization range to protect against voltage variation. Motors shall be in compliance with EPACT when applicable.

4. V-Belt Drive shall be constant pitch rated at 1.5 times the motor nameplate.

5. Manufacturer shall provide for each fan a nameplate with the following information to assist air balance contractor in start up and service personnel in maintenance:

   a. Fan and motor sheave part number
   b. Fan and motor bushing part number
   c. Number of belts and belt part numbers
   d. Fan design RPM and motor HP
   e. Belt tension and deflection
   f. Center distance between shafts

(9) Coils

a. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drainpan under the coil.

b. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.

c. Construct cooling coil casings of stainless steel and heating coil casings of galvanized steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.

d. All coils shall be completely cleaned prior to installation into the air-handling unit. Complete fin bundle in direction of airflow shall be degreased and steam cleaned to remove any lubricants used in the manufacturing of the fins, or dirt that may have accumulated, in order to minimize the chance for water carryover.

e. On stacked cooling coils, intermediate drain pans shall be installed between the coils. Intermediate drain pans shall have drop tubes to guide condensate to the main drain pan, thus preventing flooding of lower coils that would result in moisture carryover.

f. Hydronic Coils

   1. Supply and return header connections shall be clearly labeled on outside of units such that direction of coil water-flow is counter to direction of unit airflow.

   2. Coils shall be proof tested to 300 psig and leak tested to 200 psig air pressure under water.

   3. Headers shall be constructed of round copper pipe or cast iron.

   4. Coil tubes shall be seamless copper and have a minimum outer diameter of 1/2-inch. The tube wall

thickness shall be no less than 0.024-inches. Fins shall be aluminum with a minimum thickness of 0.0075-inches.

10) Base-Level Drain Pans

a. Insulation shall be encased between exterior and interior walls. Units with cooling coils shall have stainless steel drain pans under complete cooling coil section that extend beyond the air-leaving side of the coil to ensure capture of all condensate in section. Cooling coil drain pans shall be sloped in 2 planes, pitched toward drain connections to ensure complete condensate drainage when unit is installed level and trapped per manufacturer's requirements. See section 2.05, paragraph E for specifications on intermediate drain pans between cooling coils.

b. Units with heating coils shall have a drain pan under complete heating coil section sloped in 2 planes and pitched toward drain connections to ensure proper drainage during cleaning and to capture water in the event of a coil failure.

c. All drain pan connections supplied by unit manufacturer including piping and piping connections extending from drain pans shall be constructed of stainless steel. The contractor is responsible to ensure the unit is installed level, trapped in accordance with the manufacturer's requirements, and visually inspected to ensure proper drainage of condensate.

d. Flat drain pans shall be acceptable in sections that may have incidental, but not continuous contact with moisture. Flat drain pans shall be accessible for cleaning.

11) Filter

a. Provide factory-fabricated two-stage filter sections of the same construction and finish as unit casings. Filter section shall have filter guides and access door(s) extending the full height of the casing to facilitate filter removal. Provide filter block-offs as required to prevent air bypass around filters.

b. Filter type, efficiency, and arrangement shall be provided as defined in project plans and schedule. Filters shall be removable from one side of filter section(s).

c. Manufacturer shall provide one set of startup filters and an additional 1 set of operational filters.

12) Dampers

a. All dampers shall be internally mounted. Dampers shall be premium ultra low leak and located as scheduled. Dampers shall be Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 5 CFM/square foot at one-inch water gauge and 9 CFM/square foot at 4 inches water gauge. All leakage testing and pressure ratings shall be based on AMCA Publication 500. Manufacturer shall submit brand and model of damper(s) being furnished.

13) Access Sections

a. Access for inspection and cleaning of the unit drain pan, coils and fan sections shall be provided. The unit shall be installed for proper access. Procedure for proper access, inspection and cleaning of the unit shall be included in the maintenance manual. Access section shall have double wall, hinged, removable access doors on one side of sections. Access selections immediately downstream of cooling coil sections shall have a sloped stainless steel drain pan constructed.

14) Internal Face and Bypass Section

a. Provide an internal face and bypass section as shown on the drawings. Units provided with coil immediately downstream of bypassed coil shall be provided with space equivalent to bypassed coil height or greater to insure full face activation of downstream coil.

15) Energy Wheel Section

a. The air-handling unit shall have a total energy wheel sized per the ventilation requirement as defined on the schedule. The energy wheel shall be an integral part of the air-handling unit. Unit shall be installed as a complete system with no additional outside air unit, or other field assembled and ducted energy recovery device. Manufacturer shall include performance information in the submittal that meets or exceeds scheduled wheel performance.

b. Energy wheel shall be sized to handle 100% of the supply and exhaust airflow.

c. The air-handling unit shall be certified by ARI to contain a rotary energy recovery wheel that is ARI 1060 certified. The air-handling unit nameplate shall bear the ARI 1060 certification label. Performance characteristics of the energy shall be provided as defined by ARI 1060. The energy wheel shall be an enthalpy wheel capable of sensible and latent heat transfer. Sensible, latent and total net effectiveness of the wheel performance shall meet or exceed performance as defined on schedule. The calculated total net effectiveness of the recovery device shall not be less than 70 percent when the specified ventilation flow rate equals the exhaust flow rate. Wheel face velocity and pressure drop shall not exceed performance as defined on schedule. The energy recovery cassette shall be an Underwriters Laboratories (UL) Recognized Component certified for mechanical, electrical, and fire safety in accordance with UL Standard 1812.

d. Total energy wheel casing shall be constructed like all other casing sections.

e. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor, and drive belts. The total energy recovery wheel shall incorporate a desiccant aperture. The rim shall be continuous rolled stainless steel to form an even concentric circle to prevent leakage around the rim and to minimize wear of components. All diameter and perimeter seals shall be provided as part of the cassette assembly. Perimeter seals shall be self-adjusting; diameter seals shall be adjustable. Seals shall be factory set. Wheel bearings shall be permanently sealed and lubricated and have a minimum L-10 life of 400,000 hours.

f. The wheel drive motor shall be provided, mounted in the cassette frame and supplied with a connector for field service. The wheel drive motor shall be thermally protected and UL Component Recognized. On units that require drive belt tensioners for the wheel belt/motor assembly, the wheel manufacturer shall provide at no additional charge to the customer a visual inspection every four months, and adjustment if necessary, of the recommended belt tension during the unit warranty period. The wheel drive motor shall be no greater than 0.33 hp and shall be the same voltage as the airhandler fan motors.

g. **Energy recovery media for wheels larger than 25 inches in diameter shall be provided in the form of removable segments.** The segments shall be removable without the use of tools to facilitate maintenance and cleaning as required. Coated segments shall be washable using standard detergent or alkaline-based coil cleaners. The desiccant shall not dissolve in the presence of water or high humidity.

h. Access doors shall be provided on all air entering and air leaving sides of wheel to allow for wheel maintenance, belt or motor removal. Access doors shall be constructed per Section (10) paragraphs D,E,F.

i. A factory mounted combination motor starter / disconnect switch with Hand-Off-Auto switch shall be pre-wired to the energy wheel motor.

B. 2 STAGE WATER SOURCE HEAT PUMPS

1) All equipment shall be ARI Certified per ARI/ISO/ASHRAE/ANSI Standard 13256-1 for Group Loop Rating. All units shall be UL Listed for product safety. All units shall have ARI13256-1 and UL labels. Units shall be designed to operate throughout the range of entering fluid temperature of 25ºF to 110ºF.

   a) Acceptable Manufacturers are ClimateMaster, Water Furnace, Mammoth, JCI, FHP, Trane or approved equivalent.

   b) To be considered equivalent, a manufacturer must submit a calculated system EER and be no less than 95% of the basis of design System EER. Satisfying this requirement does not alleviate the manufacturer from complying with all other specified requirements and performance data. To calculate the System EER, utilize the following equation with each size heat pump on the project included:

   System EER= ((Quantity of Smallest capacity HP x Scheduled EER)+….+(Quantity of Largest capacity HP x Scheduled EER))/Total Number of WSHP's.

2) BASIC CONSTRUCTION:

   a. Units shall have the air flow arrangement as shown on the plans. The heat pumps shall be fabricated from heavy gauge galvalume sheet metal coated with lacquer acrylic. All interior surfaces shall be lined with ½ inch, 1-1/2 lb. acoustic type glass fiber insulation. All fiberglass insulation shall be coated and shall meet NFPA 90A. Units shall have a factory installed filter bracket for use with standard 1-inch filters. Supply and return water connections shall be copper FPT fittings and shall be securely mounted flush to the cabinet allowing for connection to a flexible hose without the use of a back-up wrench. All units shall have a stainless steel drain pan.

   b. FAN AND MOTOR ASSEMBLY:

3) All units shall have a direct-drive centrifugal fan. The fan motor shall be variable speed, permanently lubricated, ECM type with thermal overload protection. The fan motor shall be isolated from the fan housing by torsionally flexible isolation. The fan motor shall vary the speed of the fan to maintain a constant airflow quantity. External static pressure rating of the unit shall be based on a wet coil.

   a. REFRIGERANT CIRCUIT:

4) Units shall have a sealed, R-410A, refrigerant circuit including a two-stage hermetic scroll compressor, thermal expansion valve, finned tube refrigerant-to-air heat exchanger, a reversing valve, a coaxial (tube-in-tube) refrigerant-to-water heat exchanger, and safety controls including a high pressure switch and a low pressure switch. The reversing valve shall be a four-way solenoid activated on a call for cooling, which fails to the heating position. Access fittings shall be factory installed on high and low pressure refrigerant lines to facilitate field service. Activation of any safety device shall prevent compressor operation via a lockout circuit. The lockout circuit shall allow reset at the thermostat or at the disconnect switch or through the DDC. Hermetic scroll compressors with internal overload protection shall be mounted on rubber isolators and be located in an insulated compartment to minimize sound transmission.

5) The two stage hermetic scroll compressor shall be activated via a 2-stage control system. Stage one shall activate the part load capacity of the compressor for operation at approximately 70% of full load capacity. The ECM fan motor shall automatically reduce the fan speed to maintain a constant airflow quantity at approximately 70% of the full load air quantity. Stage two shall activate the full load capacity of the compressor and the ECM fan motor.

   a. ELECTRICAL:

6) A control box shall be located within the unit and shall contain a printed circuit UPM control board, 50VA transformer, controls for compressor, reversing valve, condensate safety sensor and fan motor. Each unit shall

have a terminal block for low voltage field wiring connections. Unit controls shall be 24 volts and shall provide heating or cooling as required by the wall thermostat.

7) The unit-mounted UPM control system shall have the following features:

1) Anti-short cycle time delay on compressor operation.
2) Random start on power up mode.
3) High and low voltage interruption protection.
4) 90-second bypass timer for the low pressure switch.
5) Shutdown on high or low refrigerant pressure switch, freezestat or condensate sensor.
6) Alarm output which closed for remote fault indication.
7) Reset of a unit safety switch at the wall thermostat or at the main power disconnect.
8) Automatic intelligent reset. Unit shall automatically reset the unit one time after a safety shut down.
9) Ability to defeat time delays for servicing.
10) A LED to indicate safety alarms. The LED shall annunciate the following alarms: high refrigerant pressure, low refrigerant pressure, low water temperature, or a high level of condensate in the drain pan.

8) PIPING:

a. Each unit shall supply, return water and condensate drain connections shall be copper or brass female pipe thread fittings and mounted flush to cabinet exterior.

C. WATER TO WATER HEAT PUMP

(1) GENERAL

a. Units shall be Underwriter Laboratories (UL) listed for safety on all models. Each unit shall be run tested at the factory. Each unit shall be pallet mounted and stretch wrapped. The units shall be warranted by the manufacturer against defects in materials and workmanship for a period of one year on all parts, and 5 years on the compressor. The units shall be manufactured in an ISO 9001:2000 certified facility. The units shall be designed to operate with entering fluid temperatures between 20° F (-7° C) and 120° F (49° C) as manufactured by JCI. Other acceptable manufacturers are McQuay, Trane, Florida Heat Pump, and Water Furnace.

(2) CASING & CABINET

a. The cabinet shall be fabricated from heavy-gauge galvanized steel and shall be supported by a full angle iron frame. The interior shall be insulated with ½" (12.7mm) thick, multi density, coated, glass fiber. All units shall allow front service access to replace the compressor and/or electrical components without unit removal.

(3) REFRIGERATION CIRCUITS

a. All units shall contain a sealed refrigerant circuit including hermetic scroll compressor(s), bidirectional thermal expansion valve metering device(s), coaxial style fluid-to refrigerant heat exchangers, refrigerant reversing valve(s) and service ports. Compressor shall be high efficiency, designed for heat pump duty with refrigerant R-410A, and mounted on rubber vibration isolators. Compressor motors shall be equipped with overload protection. Refrigerant reversing valves shall be pilot operated sliding piston type with replaceable encapsulated magnetic coils energized only during the chiller cycle. The water-to-refrigerant heat exchanger shall be coaxial or brazed plate design with a designed refrigerant working pressure of 600 PSIG (4100 kPa) and a designed water side working pressure of no less than 400 PSIG (2750 kPa). All heat exchangers for domestic water heating shall be double wall.

(4) ELECTRICAL

a. Controls and safety devices will be factory wired and mounted within the unit. Controls shall include compressor contactors, 24V transformer, reversing valve coils and a solid state lock-out control circuit (UPM). The UPM controller shall include the following features:

1. Anti-short cycle time delay, random start, interstage delay, brown out/surge/power interruption protection, 120 second low pressure switch bypass timer, shutdown on high or low refrigerant pressure safety switch inputs, shutdown for the optional freezestat, 24 VAC alarm output for remote fault indication, unit reset at thermostat or disconnect, ability to defeat time delays for servicing, time delay between stages and automatic intelligent reset.

2. The UPM shall automatically reset after a safety shut down and restart the unit, if the cause of the shut down no longer exists, after the anti-short cycle and random start timers expire.

3. Should a fault re-occur within 60 minutes after reset, then a permanent lockout will occur.

b. A light emitting diode (LED) shall annunciate the following alarms for each refrigerant circuit: high refrigerant pressure, low refrigerant pressure and low water temperature (when equipped with the optional low water temperature sensor). The LED will display each fault condition as soon as the fault occurs. If a permanent lockout occurs, then the fault LED will display the type of fault until the unit is reset. Safety devices include a low pressure cutout set at 20 PSIG (140 kPa) for loss of charge protection (a freezestat used for loss of charge protection is not acceptable) and a high pressure cutout control set at 600 PSIG (4100 kPa). An energy management relay to allow unit control by an external source shall be factory installed.

(5) PIPING

a. Water piping connections shall be female pipe thread with a single set of source and load connections per unit.

A. Hose Kits

(1) **HOSE KIT SIZES SHALL BE AS SCHEDULED ON THE DRAWINGS.**

a. Provide a factory-assembled, one piece hose kit/piping package for supply and return connections for each heat pump.

b. Contractor shall provide and install Hays Hose Kit Piping Packages or Nexus Hose Kit Piping packages with integral automatic balance valve. Each kit shall be sized for 2.0 to 7.0 feet per second. Valves may be mounted in any altitude and do not require straight sections of pipe either upstream or down stream for proper operation. Griswold is not an acceptable manufacturer.

c. Each return side hose kit/piping package shall include the following:

1) Single piece Y - valve body for sizes ½" – 1-1/2", shall be constructed of hot forged brass with threaded inlets and outlets. 2" – 3" shall be constructed of bronze. 4" and larger shall be constructed of carbon steel with flanged inlets and outlets. All valve bodies are suitable for a minimum of 400 PSIG working pressure.

2) Automatic flow control valves shall be factory set to rated flow and shall automatically control the flow to within 10% of the rated value subject to the operating parameters of; 2 to 80 PSID, fluid freezing to 225° F, 2.0 to 7.0 FPS.

3) Valve internal control mechanism shall be of a quiet, clog resistant design with reverse flow capabilities and consist of precision orifice that is field changeable within the listed flow rate.

4) Single pressure/temperature test ports for verifying the pressure differential and system temperature, full flow design ball valve with blow out proof stems for shut off.

5) Manufacturer shall provide certified independent laboratory tests verifying accuracy of performance.

6) All valves shall be labeled with controlled flow direction, flow rate, PSID control range, manufacturer and model number, unit tagging.

d. Each supply side hose kit/piping package shall include the following:

1) Single piece Y - valve body for sizes ½" – 1-1/2", shall be constructed of hot forged brass with threaded inlets and outlets. 2-3" shall be constructed of bronze. 4" and larger shall be constructed of carbon steel with flanged inlets and outlets. All valve bodies are suitable for a minimum of 400 PSIG working pressure.

2) Single pressure/temperature test ports for verifying the pressure differential and system temperature, full flow design ball valve with blow out stems for shut off.

3) Strainer shall be Y-type configuration furnished with hose connector blow down valve. Strainer screen shall be stainless steel mesh and easily accessible for cleaning without disconnecting hoses.

4) All valves shall be labeled with flow direction, manufacturer and model number, unit tagging.

e. Stainless Steel Braided Supply and Return Hoses: All hoses shall be equipped with end connections at terminal unit. All end connections shall be either permanently crimped swivel ends or butt welded to carbon steel end fittings to meet stated pressure ratings. Operational temperature shall be rated from fluid freezing to 200 degrees F. Minimum burst pressure shall be four times the working pressure. Furnish with field flushing connection fitting. ½" to 1-1/4" shall be reinforced, fire retardant EPDM rubber, bonded to the inside wall of braiding. 1 ½" and larger shall be a corrugated type 321 stainless steel tube.

f. Flushing Bypass: Provide with means at each heat pump to flush system completely while allowing no fluid flow through heat pump. Also see "Start-up and Flushing" instructions in this section.

g. Condensate Hose Kits: Contractors Option: Manufactured ¾" tubing x 54" long clear flexible plastic hose, with molded P-trap, fittings, couplings and clamps. All condensate drains larger than ¾" shall be field fabricated by contractor to allow for flexible movement. All sizes shall match sizes indicated on drawings.

h. Warranty: Automatic Flow Control Valves containing orifice and diaphragm shall be warranted for the life of the HVAC system in which it was originally installed. Manufacturer shall warrant all other components, for no less than five (5) years from date of purchase. Manufacturer shall warrant steel braided hose for no less than three (3) years from date of substantial completion.

B. HEAT PUMP AIR FILTER SYSTEM FOR VERTICAL HEAT PUMP UNITS

(1) GENERAL: The Contractor shall completely assemble each system for each heat pump and install in heat pumps ready to use.

Heat pumps 5 tons and smaller require one 24" X 24" air filter system (one 24 x 24 filter).

Heat pumps 6 tons through 10 tons require one 48" x 24" air filter system (two 24 x 24 filters).

These dimensions are typical unless noted otherwise on the drawings.

(2) Side Access Filter Housing:

Airguard single stage flat bank side access filter housing (Model FB).
Accommodate required quantity of 24" x 24" x 2" deep flat filters.
Factory assembled.
One door.
16 gauge aluminized steel.
See plans for sizes and quantities per unit.

(3) Filter Media:

AAF, 2" thick pleated, MERV 7 filters.

C. Ventilating Fans

(1) Ventilating fans shall be of the type, capacity, size, etc. here-in-after scheduled. Catalog numbers are listed as design criteria only. Alternate selections will be accepted provided quality, function, etc. are equivalent. All fans shall be UL listed, complete with all required disconnects and starters and shall be AMCA rated and certified. Model numbers listed are Greenheck, acceptable alternates are Penn, Carnes, Acme, Shipman, Jenn-Aire and Loren-Cook. The Architect shall select the color for all exposed fans.

(2) Selection

Refer to the schedule on the plans.

D. Combination Variable Frequency Drive / Disconnect (Vfd) For Motors 50 Hp And Less

(1) Manufacturers

a. Danfoss Graham VLT 6000 Series, Reliance, Yaskawa, Emerson, ABB, or approved equal.

(2) General

a. Furnish complete variable frequency VFDs 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 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.

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, kWhr, 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 (^{0}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 voltage (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.

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

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

(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: undervoltage, 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.

b. 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

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.

L. Hydronic Specialties

(1) Manufacturers

Subject to compliance with the specified and scheduled requirements the following manufacturers will be considered, but not limited to:

Hoffman
Amtrol/Thrush
Armstrong/Aurora
Bell & Gossett
Patterson
Taco
Wheatley

(2) Air Release Tank

The air release tank shall be of the in-the-pipe-line type with flanged tangential openings for inlet and outlet connections. The inside shall be specifically designed to create a low velocity vortex for the separation of free air from the water stream. The tank shell shall be rated at 125 PSI working pressure and shall be constructed with the ASME code for unfired pressure vessels and shall be so certified and stamped. The tank shall be equipped with a bottom drain connection and expansion tank/vent connection. Tank shall be line sized. Tank shall not have a strainer.

(3) Expansion Tank

The tank shall be constructed in accordance with the ASME Code for unfired pressure vessels and shall be suitable for 125 PSI water working pressure and 340ºF maximum water temperature. The tank shall be a pre-charged, heavy duty butyl rubber diaphragm-type pressure vessel complete with standard tire charging valve. Refer to the plans for mounting orientation. Capacities shall be as scheduled on the drawings.

(4) Suction Diffusers

Provide at the inlet of each base mounted pump, a suction diffuser as manufactured by Bell and Gossett, Victaulic, Thrush, or approved equivalent. Each suction diffuser shall be equipped with a disposable fine mesh start-up strainer and an adjustable support foot to carry weight of inlet piping. Victaulic Series 731 G, W731G, Bell and Gossett Suction Diffuser, or equal.

(5) Triple Duty Valves

Provide at the discharge of each base mounted pump and where shown on the plans, a triple duty valve as manufactured by Bell & Gossett, Thrush or Engineer approved equivalent. Each valve shall perform check, shut-off and throttling functions and shall be line sized.

Alternatively, in lieu of a triple duty valve, a Victaulic grooved end "Tri-Service" valve assembly may be used in applicable piping systems. The assembly shall consist of a Victaulic Vic-300 MasterSeal™ butterfly valve with memory stop feature for shut-off and balancing, and a 779 Venturi-Check for backflow prevention and flow measurement.

(6) Flexible Connections

Provide at the inlet and discharge side of each base mounted pump, at each connection to major equipment requiring vibration isolation and where shown on plans, a flexible connector, Metraflex Metrasphere or Engineer approved equal. Flexible connectors shall be of the flexible neoprene and nylon or EPDM and suitable for 225 PSI working pressure and 230°F temperature. Couplings shall be installed per the manufacturer's recommendations, in close proximity to the source of the vibration.

Alternatively, in lieu of a flexible connector, three (3) Victaulic Style 77 flexible couplings may be used on suction side and discharge side of base mounted pumps (six Victaulic flexible couplings per pump).

(7) Pressure Reducing Valve

Provide at the point of connection of the domestic water line to the hydronic system and where shown on the plans, a pressure reducing valve by Thrush, Bell and Gossett, or Engineer approved equivalent. Such pressure reducing shall be provided with an inlet strainer and shall be set to maintain a pressure of 4 PSI in excess of that at the highest point in the hydronic system. Each pressure reducing valves shall be line sized.

(8) Vacuum Breaker

Provide, where shown on the plans, a vacuum breaker as manufactured by Huffman, Jackson or Engineer approved equivalent.

(9) Manual Air Vents

Provide, where shown on the plans, at each rise in piping and where required a manual air vent.

(10) Automatic Air Vents

Provide, where shown on the plans, automatic air vents.

(11) Expansion Loops

Expansion loops shall be Metaflex Metra loops or Engineer approved equivalent. Install with pipe guides and anchors as recommended by the manufacturer in all piping runs 75 feet long or greater and also where indicated on the plans.

Alternatively, in water piping systems, use adequate numbers of Victaulic Style 77 flexible couplings in header piping to accommodate thermal growth and contraction, and as required for the elimination of expansion loops. (In accordance with Victaulic recommendations and as approved by the Engineer). Where expansion loops are required in Victaulic piping systems, use Victaulic flexible couplings on the loop(s).

2. FACTORY START-UP REPORTS

A. Provide factory start-up on site by a factory representative (not a third party contractor) for all HVAC equipment, including pumps, VFD's, boilers, chillers, cooling towers, heat pumps, rooftop units, 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.

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

(1) Water Source Heat Pumps

a. High voltage power supply is correct and accordance with the unit nameplate.
b. The phasing of the unit is correct per the compressor rotation.
c. The field wiring and circuit protection is the correct size.
d. The low voltage control circuit wiring is correct per the unit wiring diagram.
e. The piping system is clean and complete.
f. Verify water flow is established and circulating through all units.
g. The condensate line is properly sized, run, trapped and pitched.
h. The indoor blower turns freely without rubbing.

Start-up checklist and log: Upon unit start-up, the following items shall be checked and logged for each water source heat pump. Note, the items listed below must be verified/checked before the system is put into full operation:

i. Entering fluid temperature (heat and cool mode)
j. Leaving fluid temperature (heat and cool mode)
k. Temperature differential (heat and cool mode)
l. Return air temperature (heat and cool mode)
m. Supply air temperature (heat and cool mode)
n. Water coil heat exchanger (water pressure "in" – psig) (heat and cool mode)
o. Water coil heat exchanger (water pressure "out" – psig) (heat and cool mode)
p. Pressure differential (psig) (heat and cool mode)
q. Compressor amps
r. Compressor volts
s. Compressor discharge line temperature (after 10 minutes)
t. Refrigerant charge (oz.)
u. Test drain pan operation
v. Check and note strainer condition.
w. Check and note filter condition.

(2) Air Handling Units/Energy Recovery Units

a. Fan rotation
b. Recovery wheel rotation
c. Confirm all wiring connections are correct
d. Confirm all field wiring is correct
e. Adjust belt tensions and alignments
f. Confirm pipe connections are correct
g. Confirm sequence of operation is correct
h. Confirm damper operation

(3) Base-Mounted Pumps

a. With power off, note the following:
   1) pump properly secured, level, and grouted
   2) pipe installed so as not to transmit stress to pump
   3) coupler between pump and water shaft aligned
   4) pump and motor lubricated
b. With power on, note the following:
   1) impeller rotation
   2) Actual amps/volts vs. nameplate amps/volts.
   3) Inlet and outlet pressure

(4) Ventilating/Exhaust Fans

a. Fan rotation direction
b. Motor current draw

3. WATER TREATMENT

A. SCOPE

Provide a one-year water treatment program for the Geothermal/Heat Pump water loop systems, including the OA-1 hydronic loop. The one-year period shall start from the date of substantial completion. The program shall minimize corrosion, scaling, and prevent biological fouling of the piping system.

B. QUALIFICATIONS

Chemicals, service, and equipment shall be supplied by a single water treatment company for undivided responsibility. The water treatment chemical and service supplier shall be a recognized specialist, active in the field of commercial/industrial water treatment for at least 5 years, whose major business is in the field of industrial water treatment. The water treatment company shall have regional water analysis laboratories, service department, and full time representatives located within the trading area of the job site or facility.

Water treatment company shall be Bluegrass Kesco, Nalco, American Water Treatment, or approved equal.

C. SERVICE

Provide quarterly field service and Owner consultation. System water or fluid shall be tested for proper chemical parameters, clarity, and biological activity. If needed, provide chemical addition. Provide any laboratory and technical assistance required to achieve a successful program.

D. CHEMICALS

Provide one year's supply of the recommended chemical for scale and corrosion protection of the closed loop recirculating system. If needed, provide separate chemical to control microbiological growth in the system. Formulations shall not contain any ingredients which are harmful to system materials of construction.

E. EQUIPMENT

(1) Bypass Feeder

Provide one 5 gallon bypass chemical feeder for each system. Neptune DBF-5HP or approved equivalent.

(2) HPS Loop Filter LF-1

Harmsco HIF or WB series fluid filter. Refer to schedule on the drawings for selection. Provide with a total of three sets of filter cartridges.

F. REPORTS

A summary of water or fluid quality and treatment shall be provided in writing to the Owner and Engineer after each quarterly site visit. Results of quarterly biological activity tests shall also be provided to the Owner and Engineer.

4. HEATING/COOLING SYSTEM CLEANING

A. GENERAL

The heating/cooling system for this contract is a hydronic heat pump system and there are several precautions which must be observed during its installation. The Contractor is advised to read all of the manufacturer's instructions prior to commencing the installation.

B. SYSTEM START-UP

The Contractor shall include as a part of his work a factory system fill and start-up by an authorized Factory Representative of the unit manufacturer.

C. CLEANING AND FLUSHING HYDRONIC HEAT PUMP PIPING SYSTEMS

(1) During construction, extreme care shall be exercised to prevent all dirt and other foreign matter from entering the pipe or other parts of the system. Pipe stored on the project shall have the open ends capped and equipment shall have all openings fully protected. Before erection, each piece of pipe, fitting or valve shall be visually examined and all dirt removed.

(2) After the system is complete it shall be thoroughly cleaned before placing in operation to rid the system of dirt, biological contamination, piping compound, loose mill scale, oil and any and all other material foreign to the water.

(3) Before chemical cleaning and sterilization of the entire system, the loop field shall be flushed and purged until free of dirt, debris, and air. During the chemical cleaning and sterilization process the supply and return run-outs shall be temporarily connected together at each heat pump location.

(4) After purging of the field loop the Contractor shall add an approved system cleaning solution at the recommended concentration to the entire system. Circulate the system with cleaner for the time recommended by the chemical manufacturer. After prescribed circulation time, flush the system until cleaner is removed.

(5) After chemical cleaning, the entire system shall be sterilized. Introduce a solution of sodium hypochlorite to achieve a chlorine residual of 25 to 50 ppm. Maintain this chlorine level for 12 to 24 hours. Flush out system until chlorine residual in system equals that of the makeup water.

(6) After the system has been completely cleaned and sterilized as specified herein, the individual heat pumps shall be connected permanently to the supply and return runouts and the system filled for operation under normal closed loop conditions. Within 48 hours of the completion of the sterilization implement a water treatment program to passivate all metal surfaces.

END OF HVAC

SECTION 231100 - REGISTERS, GRILLES, DIFFUSERS & LOUVERS

1. REGISTERS, GRILLES AND DIFFUSERS

A. GENERAL

Alternate R, G & D selections, other than manufacturers and models listed below, will be accepted, provided quality, function and characteristics are equivalent. Acceptable alternates are Price,Titus, Metalaire, Carnes, Anemostat, Kruegar, and Tuttle & Bailey. Shop drawings shall identify and list all characteristics of each device exactly as scheduled herein. Finishes shall be selected by the Architect. If Architect elects not to select color, all colors shall be off-white. Factory color samples shall be submitted with shop drawings.

B. SELECTION

Refer to the Selections Scheduled on the Drawings.

3. LOUVERS

A. GENERAL

Alternate louver selections, other than manufacturer and model listed below, will be accepted, provided quality, function and characteristics are equivalent. Acceptable alternates are Ruskin, Air Balance, Airline, Airstream, Louvers and Dampers and Penn. Shop drawings shall identify and list all characteristics of each device exactly as scheduled herein. Finishes shall be selected by the Architect unless scheduled otherwise.

B. LINTELS

Provide lintels above all louvers as required. Refer to the lintel schedule in Specification Section 201100.

C. SELECTION

Refer to the Selections Scheduled on the Drawings.

END OF REGISTERS, GRILLES, DIFFUSERS

SECTION 231200 - SHEET METAL AND FLEXIBLE DUCT

GENERAL

The Contractor's attention is directed to the General and Special Conditions, General Requirements-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.

This branch of the work includes all materials, labor and accessories for the fabrication and installation of all sheet metal work as shown on the drawings and/or as specified herein. Where construction methods for various items are not indicated on the drawings or specified herein, all such work shall be fabricated and installed in accordance with the recommended methods outlined in the latest edition of SMACNA's HVAC Duct Construction Standards, Metal and Flexible, and its subsequent addenda. HVAC duct systems shall be fabricated and installed in accordance with the SMACNA duct construction standards (SMACNA-HVAC) including Appendix B of the Seismic Restraint Manual Guidelines for Mechanical Systems. These references and plate numbers shall be used by the Engineer for required sheet metal thicknesses and final acceptance of methods of fabrication, hanging, accessories, etc. All equipment furnished by manufacturers shall be installed in strict accord with their recommended methods.

A. It is the responsibility of each Product Manufacturer listed to confirm their product meets the requirements of the "Buy American Clause" included elsewhere in this Specification Manual. Effort has been made to identify appropriate products, however, the listing of a Manufacturer or Product above does NOT excuse the Product Manufacturer from reviewing the "Buy American Clause" and confirming their compliance before submitting their Product for bid / use on this Project.

PRESSURE VENTS

Provide a pressure relief vent in the supply air ductwork at each air handling unit. It shall be located between the fan outlet and the first manual or automatic (i.e., fire, fire smoke, or any motorized) damper or closure device. It shall be sized to relieve the duct air pressure below the rated pressure construction of the ductwork and above the working pressure of the fan. Provide a vacuum relief vent in the return and/or outside air ductwork at each air handling unit. It shall be located between the air handling unit casing and the first manual or automatic damper or closure device. It shall be sized to relieve the duct vacuum below the rated construction of the ductwork and above the working negative pressure of the fan. Automatic fan shutdown upon damper closure shall not be an acceptable protection for either overpressure or vacuum conditions. All duct relief dampers shall be of the automatic resetting type unless otherwise noted.

FILTER RACKS

If separate filter grilles are specified for an HVAC unit the Contractors shall remove any unit mounted filters and blank off the unused filter access opening with sheet metal and seal air tight. Refer to the HVAC Equipment specification on filter racks required on vertical heat pumps.

WALL PENETRATIONS

Where ducts penetrate interior or exterior walls, the walls shall be sealed air tight. Refer to the sleeving, cutting, patching and repairing section of the specifications for additional requirements.

PROTECTION DURING CONSTRUCTION

All ductwork openings shall be covered during construction to prohibit dust and dirt from entering the installed ductwork, air handling unit, terminal devices, etc. Provide temporary filters on all return grilles and duct openings if the units are running prior to the building being satisfactorily cleaned. The Contractor shall pay for duct cleaning if

precautionary measures are not taken. On all PVC coated exhaust ductwork, the Contractor shall follow SMACNA Advanced Cleanliness guidelines.

LOW VELOCITY DUCTWORK

General (Low Velocity)

All ductwork requiring insulation located in areas without ceilings, such as the Corridors, shall include double wall construction with a paint grip finish. Refer to Architectural Plans for coordination. This includes low velocity supply heat pumps. Exhaust and return duct in these areas shall also be prepared for painting.

Double turning vanes shall be installed in all square turns and in any other locations indicated.

Provide "spin-in" type fittings for all round ducts serving supply air diffusers where the duct branches off the rectangular duct main. The spin-in fitting shall not penetrate farther than 40% into the duct width.

Cross-break all ducts where any duct section dimension or length is 18" or larger.

Air volume dampers shall be installed in each duct branch takeoffs and/or where indicated, whichever is more stringent. All such dampers shall be accessible without damage to finishes or insulation and shall be provided where required for proper system balance.

Splitter dampers shall be provided in all rectangular supply air duct tees. Damper blade operator shall extend a minimum two inches thru the insulation.

Unless otherwise dimensioned on the drawings, all diffusers, registers and grilles shall be located aesthetically and symmetrically with respect to lighting, ceiling patterns, doors, masonry bond, etc.

Ducts shall be hung by angles, rods, 18 ga. minimum straps, trapezes, etc., in accordance with SMACNA's recommended practices. There shall be no less than one set of hangers for each section of ductwork. Where ductwork contains filter sections, coils, fans or other equipment or items, such equipment or items shall be hung independently of ductwork with rods or angles. Do not suspend ducts from perlins or other weak structural members where no additional weight may be applied. If in doubt, consult the structural engineer.

Provide approved flexible connectors at inlet and outlet of each item of heating and cooling equipment whether indicated or not. Install so as to facilitate removal of equipment as well as for vibration and noise control.

All ductwork connections, fittings, joints, etc., shall be sealed. Seal with "Duct Seal 321". Apply per manufacturer's recommendations.

Duct dimensions indicated are required inside clear dimensions. Plan duct layouts for adequate insulation and fitting clearance.

All angular turns shall be made with the radius of the center line of the duct equivalent to 1.5 times the width of the duct.

Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed at the inlet and discharge of all centrifugal fans, coils, VAV boxes, fan sections of air handling units, at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panel at each fire damper located and sized so as to allow hand reset of each fire dampers. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. All access doors shall be 16"x16" or as high as ductwork permits and 16" in length.

The Contractor who installs the sheet metal shall furnish to the Air Balancing Contractor, a qualified person to assist in testing and balancing the system.

Locate all supply, return and exhaust diffusers and grilles in the locations shown on the architectural reflected ceiling plan.

All fans and other vibrating equipment shall be suspended by independent vibration isolators.

Materials (Low Velocity)

Ductwork, plenums and other appurtenances shall be constructed of the following:

Steel sheets, zinc coated, Federal Specification 00-S-775, Type I, Class E & ASTM A93-59T with G-90 zinc coating or aluminum alloy sheets 3003, Federal Specification AA-A-359, Temper H-14.

Exposed ductwork in finished spaces such as gymnasiums, etc., shall be dual wall ductwork with a perforated liner. Refer to the High Velocity Duct Section for construction.

Ductwork, plenums and other appurtenances shall be constructed of the materials of the minimum weights or gauges as required by the IMC and SMACNA HVAC Duct Construction Standards - Metal and Flexible, or as follows whichever is more stringent.

	ROUND DUCT	RECTANGULAR DUCT	
DIA., INCHES	GAUGE	WIDTH, INCHES	GAUGE
3 TO 12	26	UP TO 12	26
12 TO 18	24	13 TO 30	24
19 TO 28	22	31 TO 54	22
29 TO 36	20	55 TO 84	20
37 TO 52	18	85 AND ABOVE	18

Flexible ductwork which is uninsulated shall be corrugated aluminum. Use flexible ductwork only where indicated. No sections shall be greater than five feet in length. Ductwork shall be UL rated and in accordance with IMC.

Insulated Flexible Duct (Use Only Where Indicated)

Owens/Corning or equivalent, one (1) inch thick fiberglass insulation; flexible liner; with aluminum pigment vinyl vapor barrier facing. Insulated flexible duct shall meet Fire Hazards Standards of NFPA 90A and IMC, flame spread not to exceed 25, smoke develop and fuel contributed not to exceed 50 when tested in accordance with ASTM-E84. "K" factor shall not exceed .26 at 75°F mean temperature, tested in

accordance with ASTM C177.71. Flexible duct may be used only for runouts and no sections shall be more than four feet in length.

Flexible duct shall not be used in areas where there is no ceiling.

Flexible duct shall be supported by at least one hanger.

The total offset in flexible duct shall not exceed 90 degrees.

PVC Coated galvanized ductwork- **ALL EXHAUST DUCT**

All exhaust ductwork shown on the plans shall be low velocity 4 milx 4mil PVC Coated galvanized duct. Ductwork shall meet all SMACNA requirements for 6" pressure class ductwork. The duct shall be transported, stored, and installed in accordance with SMACNA Advanced Cleanliness standards. Any scratches or imperfections observed in the PVC coating shall be repaired per the manufacturers recommended procedure or removed from the jobsite. No flexible duct shall be allowed on Exhaust systems.

Miscellaneous (Low Velocity)

Flexible Connectors: Duro-Dyne, Ventfabrics, Inc., U.S. Rubber or equivalent; conforming to NFPA Pamphlet No. 90-A; neoprene coated glass fabric; 20 oz. for low velocity ducts secured with snap lock.

Turning Vanes: Barber-Colman, Titus, Waterloo, or equivalent; fabricated as recommended by SMACNA: noiseless when in place without mounting projections in ducts. All turning vanes shall be double blade type.

Air Extractors: Metalaire Model 102-1 Carnes, Titus, Barb-Air or approved equivalent. Provide with operating hardware by Ventfabrics, Inc. Operator shall extend two inches from duct to allow for external insulation, where required. Regulator shall seal operator shaft air tight. Install hardware as recommended by manufacturer.

Splitter Damper: Splitter damper shall be constructed of 16 gauge galvanized steel. Provide with operating hardware by Ventfabrics, Inc. to include damper blade bracket, ball joint bracket and operator shaft. Operator shall extend two inches from duct to allow for external insulation, where required. Regulator shall seal operator shaft air tight. Install hardware as recommended by manufacturer.

Access Doors; In Ductwork: In ducts where indicated or where required for serving equipment, fabricated according to SMACNA recommendations and be equivalent to those manufactured by Air Balance, Vent Products or other approved equivalent. Provide a hinged access door in duct adjacent to all fire, smoke and control dampers for the purpose of determining position. Access doors shall also be provided on each side of duct coils (water, electric, steam, etc.), and downstream side of VAV boxes and CAV boxes. Access doors for rectangular ducts shall be 16"x16" where possible. Otherwise install as large an access door as height permits by 16" in length.

Access Doors; In Ceilings or Walls: Titus, Krueger, Milcor or approved equivalent with key locks.

In mechanical, electrical or service spaces. 14 gauge aluminum brushed satin finish, 1" border.

In finished areas.
14 gauge primed steel with 1" border. To accept the architectural finishes specified for the space.

Provide where required to access equipment, dampers, valves, filters, etc.

Volume Dampers (Rectangular): Ruskin, Model MD35 or Empco, Air Balance; Louvers and Dampers, Titus, Carnes, Cesco/Advanced Air, Creative Metals, United Air volume dampers. Frames shall be 4" x 1 "x 16 gauge

galvanized steel. Blades shall be 16 gauge galvanized steel, maximum of 6" wide. Maximum single section size shall be 48" wide and 72" high. Provide with Ventfabrics 1" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.

Volume Dampers (Round): Ruskin, Model MDRS25 or, Empco, Air Balance; Louvers and Dampers, Titus, Carnes, Cesco/Advanced Air, Creative Metals, United Air Round Damper. Dampers shall be butterfly type consisting of circular blade mounted to axle. Frames shall be 20 gauge steel, 7" long. Damper blades shall be 20 gauge galvanized steel. Axle shall be 3/8" diameter steel. Provide with Ventfabrics 1" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.

Fire Dampers: Fire dampers shall comply with IMC and shall be constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have a 1-1/2 or 3 hour fire protection rating as required by fire wall. Damper shall have a 165°F fusible link, and shall include a UL label in accordance with established UL labeling procedures. Fire damper shall be equipped for vertical or horizontal installation as required by the location shown. Fire dampers shall be installed in wall and floor openings utilizing 16 gauge minimum steel sleeves, angles, other materials, practices required to provide an installation equipment to that utilized by the manufacturer when dampers were tested at UL. Installation shall be in accordance with the damper manufacturer's instructions. Fire dampers in duct systems that are not equipped with any type of fire or smoke shutdown shall be Dynamic type. Fire dampers in duct systems that will shut down during a fire or smoke emergency shall be Static type. Provide velocity level and pressure level as required for application (if in doubt, contact Engineer). Fire dampers shall be Ruskin Type IBD for 1-1/2 hour rating or Ruskin Type IBD 23 for a 3 hour rating. Other acceptable manufacturers are Air Balance, Prefco, United Air, Creative Metals, National Controlled Air or Safe Air. Provide an access door for fire damper reset at all fire damper locations.

HIGH VELOCITY DUCTWORK

Application (High Velocity)

All Variable Air Volume system supply ductwork between the air handling unit and all Variable Air Volume terminals or Lab Air Control Valves shall be high velocity ductwork unless noted otherwise.

General (High Velocity)

Provide flexible connectors at inlet and outlet of air handling equipment to accommodate a minimum of three times the operating pressure of the system.

Duct dimensions indicated are required inside clear dimensions.

All ductwork connections, fittings, joints, etc., shall be sealed. Seal with Hardcast "DT" tape and Hardcast "RTA-50" adhesive installed in strict accordance with manufacturers recommendations.

Ductwork shall be installed per SMACNA Medium or High Pressure Manual, whichever is applicable. (Latest Edition shall apply.)

All hanger straps shall be 18 ga. minimum with reinforcement angles installed in strict accordance with SMACNA. Flat oval ducts shall be installed with 2"x2"x1/4" angles on top and bottom ducts 18" wide and larger. Use 1"x1"x3/16" angles on ducts under 18" wide.

Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA or the duct manufacturer, and/or as indicated. Test openings shall be placed at the discharge of all air handling units and at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panels at each fire damper located and sized so as to allow hand reset of each fire damper. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. Where access doors are installed in insulated ductwork, the access door shall be the insulated type.

Materials (High Velocity Single Wall)

All round and oval high velocity ductwork shall be United McGill "Uni-Seal" or "Uni-Weld" ductwork or Semco, Dixie, Eastern Sheet Metal approved equivalent as required by pressure rating of the system.

Ductwork shall be spiral, lock-seam type and be constructed of galvanized steel. Any ductwork exposed to view shall have paint grip finish for painting by Contractor. Ductwork shall be constructed of the following minimum gauges:

DIAMETER (Or Equivalent Round Diameter For Oval Ducts)	METAL THICKNESS
3-14 Inches	26 Ga.
15-26 Inches	24 Ga.
27-36 Inches	22 Ga.
37-50 Inches	20 Ga.
52-60 Inches	18 Ga.

All duct fittings shall be fabricated by duct manufacturer. Duct fittings shall be minimum 20 gauge. All fittings shall be a minimum of one gauge heavier than the pipe size.

Miscellaneous (High Velocity)

Flexible Connectors: Duro-Dyne, Ventfabrics, U.S. Rubber or equivalent; conforming to NFPA Pamphlet No. 90-A or IMC, whichever is more stringent; neoprene coated glass fabric; 30 oz. for high velocity ducts secured with bolted angles.

Fire Dampers: Fire dampers shall comply with IMC and be constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have a 1, 2 or 3 hour fire protection rating as required by fire wall. Damper shall have a 165°F. fusible link, and shall include a UL label in accordance with established UL labeling procedures. Fire damper shall be equipped for vertical or horizontal installation as required by the location shown. Fire dampers in duct systems that are not equipped with any type of fire or smoke shutdown shall be Dynamic type. Fire dampers in duct systems that will shut down during a fire or smoke emergency shall be Static type. Provide velocity level and pressure level as required for application (if in doubt, contact Engineer). Fire dampers shall be installed in wall and floor openings utilizing 16 ga. steel sleeves, angles, other materials, and practices required to provide an installation equivalent to that utilized by the manufacturer when dampers were tested at UL. Installation shall be in accordance with the damper manufacturer's instructions. Fire dampers shall be Ruskin Type IBD2, Style C, for a 12 hour rating or Ruskin IBD 23 for a 3 hour rating. Other acceptable manufactures are Air Balance, Prefco, Creative Metals, National Controlled Air or Safe Air. Provide an access door for fire damper reset at all fire damper locations.

Access Doors; In Ceilings and Walls: Titus, Krueger, Milcor or approved equivalent; 14 gauge aluminum brushed satin finish; 1" border; all doors are to be furnished and installed by the Mechanical Contractor. Provide with required to access air distribution equipment, dampers, etc., unless specified in architectural portion of the specifications.

Access Doors; In Ductwork: All access doors in round or oval high velocity ductwork shall be screw and gasketed type. Screws shall be maximum 4 inches on centers. Access door sizes shall be as follows:

DUCT DIAMETER	OPENING SIZE
3-4 inches	4" x 10"
5-6 inches	6" x 10"
7-24 inches	10" x 16"
26-36 inches	16" x 16"
Over 36 inches	16" x 22"

Air Leakage Testing of the Ductwork Systems

It is the intent of this section to insure the ductwork installed has minimal air leakage.

Air leakage testing shall be accomplished by an AABC or NEBB certified company. Refer to the Test & Balance specifications.

The duct systems which will require testing are as follows:

All high velocity supply air duct systems

All exhaust air duct systems.

Do not insulate the supply air systems prior to testing.

The maximum allowable supply air leakage rate is 2.5% of the systems design CFM when the ductwork is pressurized to 2.5” WG (Therefore, if a supply air system is tested, and the supply air fan rated capacity is

10,000 CFM, the allowable leakage is 250 CFM.) The maximum allowable return air and exhaust air leakage rate is 2.5% of the system design when the ductwork is pressurized to 1.50"WG.

The entire supply air ductwork system shall be tested with some exceptions. On VAV systems, the high velocity ductwork upstream of the VAV boxes or Lab air control valve shall only be tested. Cap the duct at the inlet to the VAV box. Ductwork associated with Heat Pumps is not required to be tested.

All exhaust air sheet metal ductwork associated with the system shall be tested. Cap the main duct prior to the central equipment fan connection. Also cap the branch ducts at the diffusers, including the round branch air volume with sheet metal caps. Seal caps well to damper to avoid air loss at this location. This air loss, from the caps, is included in the noted leakage rate.

The noted allowable leakage rate is the total allowable. It shall include leakage associated with the following:

All ductwork as described in above paragraphs.

Access doors

Volume dampers

Relief air doors

End caps used to seal ducts

If any duct system fails a test, the contractor shall reseal the system. It shall then be retested until the duct system meets the leakage allowment at no additional cost to the owner.

Carefully select the ductwork construction requirements and the type of duct sealant to be used as required to meet the leakage allowances. The sheet metal duct pressure classification is a minimum only. The contractor shall select the appropriate sheet metal pressure classification, duct sealant class and duct sealant materials to meet the project air leakage allowances.

A duct pre-installation conference shall be held prior to the installation of the ductwork. Present should be the owner's representative, engineer, Test & Balance Contractor, General Contractor, Mechanical Contractor, Sheet Metal Contractor, Insulation Contractor and the manufacturer's representative of the duct sealant to be used. At this meeting, the contractor shall advise all of the duct materials and sealant materials to be used to meet the air leakage allowances.

Whenever the systems are being leak tested by the Test & Balance Contractor, a representative from the Mechanical Contractor shall be present to assist.

END OF SHEET METAL AND FLEXIBLE DUCT

SECTION 250100 - MOTOR STARTERS AND OTHER ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

1. MOTOR STARTERS-GENERAL

A. Where motor starters are required for mechanical equipment they are to be the responsibility of the Contractor furnishing the equipment as outlined herein.

B. Motor starters shall be furnished by the Equipment Supplier with his equipment. Coordinate all requirements for starters with equipment suppliers and other trades.

C. Motor starters shall be NEMA style. I.E.C.-style starters are not to be provided. Their sizing and installation shall be coordinated with the equipment manufacturer's requirements and in accordance with the National Electrical Code.

D. Unless otherwise noted, provide combination starter/disconnects for all equipment requiring a starter.

2. ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

A. All mechanical equipment shall be provided for single point electrical connection unless specifically noted to the contrary. Refer to schedules and other sections of these specifications for further requirements. It is the responsibility of the Contractor to coordinate the electrical characteristics of all equipment with the electrical provisions indicated on the Contract Documents. The Contractor shall notify the Engineer in writing ten calendar days prior to bid of any discrepancy so a written clarification by Addendum may be made. If such notice is not given, the Contractor shall be responsible for any and all costs or delays associated with any changes required. Specification of equipment characteristics made during review of shop drawings shall not relieve the Contractor of this responsibility.

B. The equipment manufacturer shall provide internally mounted fuses with his equipment, as required, to comply with the U.L. listing on the equipment name plate. (i.e., hermetically sealed compressors or equipment with name plate data that recommends or requires fuse protection.) See also, National Electrical Code, Article 440, and other applicable sections of the N.E.C.

C. It is the Contractor's responsibility to furnish and install fusible or non-fusible disconnect switches or circuit breakers for disconnecting means as required by the Code for all electrically powered equipment. All power wiring from source, thru disconnecting means and motor starters to motor terminals or equipment junction box is to be furnished and installed by the Contractor. Each separate contractor engaged for the project shall coordinate with all other trades to ensure all necessary equipment and labor is included for fully functioning mechanical systems, installed per code requirements. Unless otherwise notes, provide combination starter/disconnects for all equipment requiring a starter.

D. Final electrical connection of equipment shall be verified for proper voltage requirements in conjunction with the motor nameplate patch and actual wiring configuration. Any costs associated with damage to appliances motors, equipment, etc., connected to incorrect supply voltage shall be borne by the Contractor.

E. Refrigeration condensing units with internal compressors shall be furnished with integral starter. The Contractor is to furnish and install a fusible disconnecting mains with fuses sized to motor nameplate requirements. Coordinate wiring, mounting and style of disconnect switch at unit in field.

F. All interlock or other control wiring, unless specifically noted otherwise, is the responsibility of the Contractor.

G. All equipment shall be suitably enclosed. All enclosures for equipment shall be rated and approved for the environment in which it operates. (i.e., NEMA 1, NEMA 3R, NEMA 7, NEMA 12, etc.) Verify the requirement with the installation condition if not indicated on the plans.

H. Observe the following standards for manufacturers of equipment and selection of components.

(1) Starters, control devices and assemblies: NEMA, U.L. - (I.E.C. style not acceptable)

(2) Enclosures for electrical equipment: NEMA, U.L.

(3) Enclosed switches: NEMA, U.L.

(4) All electrical work, generally: National Electrical Code

(5) All electrical work in industrial occupancies: J.I.C. standards

(6) All electrical components and materials: U.L. listing required.

I. Where required, the Contractor is to provide mounting rails or channels to install starters with code-required clearances. Framing shall be solidly anchored by welding expansion shields in masonry or other approved anchorage. Frames are to be constructed of steel angles or pre-manufactured channel systems such as Unistrut, Kindorf or B-Line Company. Framing material shall be pre-finished with corrosion-resistant material or painted with two coats corrosion-resistant oil-based enamel.

3. REQUIREMENTS FOR MECHANICAL EQUIPMENT, 1/2 H.P OR LESS

A. This section describes requirements for small mechanical equipment such as (but not limited to) package terminal heating/cooling units, (water source heat pumps, etc.) VAV boxes, unit heaters, vertical and horizontal unit ventilators, exhaust fans, in-line fans, fan coil units, cabinet heaters and the like.

B. Small equipment with motor(s) of 1/2 H.P., single phase or less are generally not required to be furnished with NEMA-style starter(s), unless otherwise noted.

C. For such equipment, provide integral contactor or horsepower-rated relay where controlled by thermostat or other type of switch. Contactors or relays shall be as recommended by the manufacturer of the equipment, suitable for the service duty.

D. Provide transformer within unit as required to derive low voltage A.C. for thermostat control or derive from temperature controls panel, if available.

E. Provide internal fusing for unit motor and other loads in fuse block or in-line fuseholder. See also Article 2-B, this Section.

F. Where externally-mounted disconnecting means is required and would be impractical, unsightly or inappropriate in the judgment of the Engineer, disconnects shall be located within the unit. These disconnects may be fusible H.P.-rated snap switches or manual starters with overload elements, as required. Locate this and other electrical equipment within enclosure where easily accessible behind access panel or door on unit, and as acceptable to the electrical inspector or local authority having jurisdiction. Refer to mechanical equipment schedules for further information.

G. Where fractional horsepower duplex pumps such as water circulators, sump pumps, etc. are provided, they shall be provided with alternators, cordsets, etc., as required for a complete installation.

4. REQUIREMENTS FOR MECHANICAL EQUIPMENT, 3/4 H.P. OR LARGER

A. This section describes requirements for mechanical equipment such as (but not limited to) exhaust fans, larger air handling units, cooling tower fans, water source heat pumps, chilled or hot water pumps, D.X. roof-top units, air compressors and the like.

B. Provide premium efficiency motors.

C. Equipment provided with motor(s) of 3/4 H.P. and larger, single or three-phase are required to be furnished with starters suitable for the load(s) specified. It is recommended that starters be furnished integrally with or mounted on equipment for field wiring by the Contractor. Where starters are furnished separate from equipment, furnish templates or rough-in diagrams to the appropriate contractor for his use in installation.

D. All starters shall be size 0 minimum. They shall be constructed and tested in accord with latest edition of NEMA standards. All starters shall be across-the-line magnetic type, unless indicated otherwise. On motors of 20 H.P. or greater rating, the supplier shall provide starters capable of limiting inrush currents. These shall be of the wye-delta, reduced voltage open-transition type, or electronic controlled, as required. Do not utilize closed transition starters unless specifically indicated.

E. Magnetic starters shall be furnished with the following characteristics and accessories as a minimum. See other sections of these specifications and mechanical schedules for further requirements.

(1) Contacts shall be silver-alloy, double-break type. Contacts shall be replaceable without removal of wiring or removal of starter from enclosure. Number of contacts shall be as required for service indicated. Contacts shall be gravity dropout type, positive operation.

(2) Coil voltage shall be 120 volts, A.C., 60 HZ or less, as required to suit control systems available voltages. Coils shall be of molded construction, rated for continuous duty. Provide coil clearing contact as required.

(3) Provide control transformer of adequate K.V.A. as required on all starters with line-to-line voltages higher than 120 volts A.C. Provide fuse block and slow-blow fuse to protect control transformer per NEMA, N.E.C. and U.L.

(4) Provide hand-off-auto selector switch in face of starter, wired into hand and off switch positions. Auto position (if needed) to be field wired as indicated on plans or schedules for automatic control. Provide a green run pilot light.

(5) Provide NEMA Class 20 resettable overload relays, accurately sized to the motor nameplate rating of the motor served and the temperature differential between motor and controller. Overloads shall be easily replaceable, and resettable without opening enclosure, via a push button or similar means. Class 10 or Class 30 overloads may be used, depending on the type of anticipated service.

(6) Provide at least one N.O. and one N.C. auxiliary contact (field-convertible to opposite operation) with each starter. Refer to mechanical details or schedules for additional requirements, if any. All starters shall have space for two additional single-pole contacts.

(7) All starters shall be thru-wiring type.

(8) Provide phase failure sensing relay to open starter coil circuit (on loss of one or more phases) on all three-phase starters controlling motors of 15 H.P. or larger.

(9) Provide power factor correction capacitors on motors of 15 H.P. or larger where predicted power factor based on manufacturer's data will fall below 0.90%. Capacitors shall be of the unit-cell type, in single enclosure with discharge resistors and tank overpressure circuit interrupter for safety.

5. REQUIREMENTS FOR WIRING

A. All wiring, including controls, interlock, miscellaneous power, sensors, thermostats, etc., shall be installed in metallic raceway systems that are in compliance with all Division 26 requirements of these Specifications, unless specifically noted otherwise. Open cabling systems will only be permitted where specifically permitted within the Division 26 Specifications and if less than 50 volts A.C. peak-to-peak or 50 volts maximum D.C.

B. Where open cabling is permitted, it shall be installed with proper support as specified in the Division 26 Specifications.

C. Where open cabling is permitted, and installed in environmental air plenum (return, relief, supply, etc.), the materials installed shall be in compliance with N.E.C. Articles 700, 725, 770 (for fiber optic), 780 and 800.

D. Where open cabling is permitted, it shall only be installed open in accessible spaces. Where concealed in walls, it shall be routed through raceways to outlet box(es) for the terminal device.

6. INVERTER DUTY MOTORS

A. Motors which are controlled by variable frequency drive shall be:

(1) NEMA MG-1 Part 31 rated for Inverter Duty.

(2) Furnished with shaft grounding kit for all motors:

a. 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.

b. Motors Pumps greater than 100 HP to 1000 HP in size shall be furnished with shaft grounding kit, Aegis SGR Bearing Protection Ring or equal. Provide shaft grounding ring on drive end and non-drive end of motor per manufacturer's instructions. Additionally provide insulated bearing journals to further reduce risk of current dissipation through bearings. Ground motor frame per manufacturer's instructions. Install kit in strict accordance with manufacturer's instructions.

END OF MOTORS STARTERS

SECTION 250200 - CONTROLS – DIRECT DIGITAL

1. GENERAL

A. The Contractor shall furnish all labor, materials, equipment and services required to provide a complete Web based temperature control system as specified and as shown on the plans.

B. Prior to the installation of or payment for any work, the Contractor shall prepare submittals which shall be reviewed by the Architect and Engineer. These submittals shall include a complete control diagram and sequence of operation of the entire system, plus engineering data on all devices used.

C. The Contractor shall be a licensed installer of HVAC temperature controls by a national temperature controls manufacturer. The Owner currently has a Trane building automation system. The contractor shall provide either a Trane system or provide a new building management system that is accessible through a desktop icon on the same PC as the existing Trane system. Acceptable manufacturers are Siemens, Johnson, Andover, TAC, or Automated Logic. Trane controls shall be bid as an Alternate Bid. The installer shall have 5 years experience and installed a minimum of 8 systems of similar size. Their offices shall be within 150 miles of the project site.

D. The system herein specified shall be free from defects in workmanship and material under normal use and service if, within twelve (12) months from the date of acceptance by the Engineer, any of the equipment herein described is proved to be defective in workmanship or material, it will be adjusted, repaired, or replaced free of charge by the Contractor.

E. All equipment, unless specified to the contrary, shall be fully proportioning and adjustable. The Control System shall consist of all room thermostats, air stream thermostats, valves, damper operators, relays, freeze protection equipment, dampers, panels, and other accessory equipment not provided with the equipment to fill the intent of the specifications and drawings.

F. All units, controls, equipment, heat pumps, etc., and controls shall reset automatically when power is restored after an outage.

G. All control wiring concealed in walls and exposed in mechanical rooms, closets, etc., shall be in conduit. Provide plenum rated wiring where cable is concealed above ceilings. Do not paint wiring. The Contractor is responsible for protecting wiring from paint. Any painted cabling shall be replaced.

H. All dampers shall be capable of operating properly with the system pressures encountered. This shall include modulating and shut-off functions.

I. The Contractor shall also refer to the mechanical maintenance, HVAC equipment, and all other sections of the specifications for additional control requirements.

J. Provide smoke detectors and shut down control for all air handling units and combined air systems as required by the KBC and IMC Section 606.

K. All DDC controllers or control modules shall have covers to protect the circuit boards. All wiring shall be anchored securely within 6" of the controller.

L. Provide all control dampers, etc. not supplied with the equipment or required to accomplish the sequences specified.

M. The Contractor shall provide all refrigeration control and interlock wiring as recommended by the equipment manufacturer.

N. Wiring and required conduit in connection with the control system(s), including power wiring of any voltage, shall be installed by the Contractor. The Contractor may, at his option, engage the Electrical Contractor to accomplish this work. It is emphasized however, that the Contractor is finally responsible for all such work.

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

P. The electrical work required for the installation of the control system(s), shall be provided by the Contractor in accordance with all National and Local Electrical Codes. All wiring shall be concealed except in Mechanical Rooms. All electrical work specified under this division of the specifications shall also comply with Division 16 of these specifications.

Q. All exterior electrical work, equipment, etc. shall be waterproofed.

R. Controls system and all related components shall comply with ASHRAE Standard 135 (BACnet protocol).

2. OWNER'S TRAINING

A. The Contractor shall provide full instructions to designated personnel in the operation, maintenance, and programming of the system. The training shall be specifically oriented to the system and interfacing equipment installed. Eight hours of Owner Training shall be provided at substantial completion, again after 6 months (four hours) and (four hours) again 1 year after substantial completion. The Owner Training shall include an overview of the entire HVAC system operation, temperature sensor setpoint manipulation, critical alarm training and graphics display overview. Subcontractors shall be present during Owner training sessions.

B. The Contractor shall provide a Sign-in Sheet and Meeting Minutes of the training. The Contractor shall also video tape the initial training sessions. Complete Operations and Maintenance Manuals shall be reviewed by the Contractor during training.

3. CONTROL SYSTEM CHECKOUT AND TESTING – BY CONTROLS CONTRACTOR PRIOR TO DEMONSTRATION AND ACCEPTANCE

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.

(1) Calibrate and prepare for service each instrument, control, and accessory equipment furnished under Section 250200.
(2) Verify that control wiring is properly connected and free of shorts and ground faults.
(3) Enable control systems and verify each input device's calibration. Calibrate each device according to manufacturer's recommendations.
(4) Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
(5) 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.
(6) 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.
(7) 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.
(8) Alarms and Interlocks.
    a. Check each alarm with an appropriate signal at a value that will trip the alarm.

b. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
c. Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

4. 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. Submission of log is required before Demonstration and Acceptance may begin.

(1) Engineer will be present to observe and review system demonstration. Schedule with Engineer at least 14 days before system demonstration begins. Systems balancing shall be complete prior to demonstration, coordinate scheduling with TAB agency accordingly.
(2) Demonstrate actual field operation of each sequence of operation as specified in these specifications. Provide at least two persons for one day each (16 man hours) 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. Specified on site time does NOT include time necessary to correct deficiencies.
(3) Demonstrate complete operation of operator interface.
(4) Demonstrate all alarms, including external alarms to Owner selected pagers, phones, e-mail accounts, etc. Also demonstrate fire alarm system interface.
(5) 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.
(6) Provide all required tools to perform system demonstration and point calibration (drills, duct plugs, thermometers, hygrometers, hand-held carbon dioxide sensors, aerosol test smoke, 2-way radios, water probes, DP sensors for water and air, etc.)

B. Acceptance.

(1) After tests described in this specification are performed to the satisfaction of both Engineer and Owner, Engineer will accept control system. 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.
(2) 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 and Engineer.

5. EQUIPMENT

A. CONTROL PANEL(S)

(1) Each system shall be provided with a local panel for mounting of all relays, switches, controllers, and thermometers associated with that system. Where one cabinet will not accommodate all the equipment necessary for one system, a second cabinet shall be mounted and bolted adjacent to it. Cabinets shall be provided with a 2/3's door. All devices shall be provided with lamacoid plastic nameplates for identification.

B. THERMOSTATS

(1) General

a. All thermostats shall have a "warmer-cooler" knob. This control shall allow the space occupants to reset the temperature up or down a predetermined amount. This amount, or no amount at all, shall be settable thru the BAS.

b. The thermostat shall have an unoccupied override button and an integral communications port.

c. The thermostat shall have no integral thermometer.

d. All thermostats provided for the project shall be similar in size and appearance.

e. Provide tamper-proof guards for all wall mounted thermostats selected by Owner.

f. All thermostats shall be mounted on a plastic base or other insulating material to prevent wall coupling effect.

g. Thermostats shall be mounted with the top at a maximum of 48" A.F.F. and shall be mounted to comply with A.D.A.

h. Thermostats shall provide temperature deadband of 5˚ F as required by IECC 2003.

i. Public areas such as corridors shall include a temperature sensor with no temperature setpoint adjustable through the BMS.

C. DAMPERS

(1) Several louvers of practical widths shall be provided for larger dampers. Modulating dampers shall have opposed blades. Dampers shall have edge and end seals. Dampers shall be Ruskin CD-60 or better. Maximum leakage rate shall be 2 CFM per square foot at 1" W.G. pressure differential for dampers greater than 12" wide. Leak rate for dampers 12" and less shall be 3 CFM per square foot. NOTE: Do not mount outside air dampers so close to water coils, piping, etc., that freeze-up may occur due to a leaky damper.

D. RELAYS AND SWITCHES

(1) Relays and switches shall be of the positive and gradual acting type and shall be furnished and installed as required for the successful operation of the system. All switches shall have suitable indicating plates.

E. VALVES

(1) All valves shall be of the fully modulating and silent type unless otherwise specified. They shall provide accurate control of the heating or cooling medium under all load conditions. All valves 2-inches or smaller shall have brass or bronze bodies with screwed ends. Valves 2-1/2 inches and larger shall have iron bodies, brass or bronze trimming with flange ends. Valves shall be normally open or normally closed as required. Valves shall be installed with the stem in the upright position or as recommended by the valve manufacturer.

6. DESCRIPTION

A. General: The control system shall be as indicated on the drawings and described in the specifications.

B. Direct Digital Control (DDC) technology shall be used to provide the functions necessary for control of mechanical systems on this project.

C. The control system shall accommodate simultaneous multiple user operation. Access to the control system data should be limited only by operator password. Multiple users shall have access to all valid system data. An operator shall be able to log onto any workstation on the control system and have access to all appropriate data.

D. The control system shall be designed such that each mechanical system will be able to operate under stand-alone control. As such, in the event of a network communication failure, or the loss of any other controller, the control system shall continue to independently operate under control.

E. Communication between the control panels and all workstations shall be over a high-speed network. All nodes on this network shall be peers. The operator shall not have to know the panel identifier or location to view or control an object. Application Specific Controllers shall be constantly scanned by the network controllers to update point information and alarm information.

F. The documentation is schematic in nature. The Contractor shall provide hardware and software necessary to implement the functions and sequences shown.

1. WEB BROWSER CLIENTS

(1) The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™, Firefox™, or Safari™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.

(2) The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the FMCS, shall not be acceptable.

(3) The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

(4) The Web browser client shall support at a minimum, the following functions:

a. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.

b. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.

c. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.

d. Storage of the graphical screens shall be in the Network Area Controller (NAC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.

e. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.

f. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

1) Modify common application objects, such as schedules, calendars, and set points in a graphical manner.

(a) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.

(b) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.

2) Commands to start and stop binary objects shall be done by selecting the appropriate command from the pop-up menu. No entry of text shall be required.

3) View logs and charts.

4) View and acknowledge alarms.

5) Setup and execute SQL queries on log and archive information.

(5) The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.

(6) Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

2. ONSITE RESPONSIBILITY

A. Project Management Services: The building automation contractor shall have a project manager assigned to this project and shall attend all pre-construction and construction progress meetings. The project manager shall supervise the installation of the complete temperature control system and shall be available to the mechanical contractor to answer any questions related to the installation and operation of the water source heat pumps, 100% outside air units with energy recovery, and temperature control system.

3. QUALITY ASSURANCE

A. System Installer Qualifications

1. The Installer shall have an established working relationship with the Control System Manufacturer of not less than six years.

2. The Installer shall have successfully completed Control System Manufacturer's classes on the control system. The Installer shall present for review the certification of completed training, including the hours of instruction and course outlines upon request.

3. The installer shall have an office within 150 miles of the project site and provide 24-hour response in the event of a customer call.

4. The list of acceptable manufacturers applies to operator workstation software, controller software, the custom application programming language, Building Controllers, Custom Application Controllers, and Application Specific Controllers. All other products specified herein (i.e., sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

B. Codes and Standards: Meet requirements of all applicable standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section.

1. Underwriters Laboratories: Products shall be UL-916-PAZX listed.

2. National Electrical Code -- NFPA 70.

3. Federal Communications Commission -- Part J.

4. ASHRAE/ANSI 135-1995 (BACnet)

5. EIA 901.2 (LonTalk)

C. All products used in this installation shall be new, currently under manufacture, and shall be applied in similar installations for a minimum of 5-years. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner's representative in writing prior to bid date. Spare parts shall be available for at least 5 years after completion of this contract.

4. SYSTEM PERFORMANCE

A. Performance Standards. The system shall conform to the following:

1. Graphic Display. The system shall display a graphic with a minimum of 20 dynamic points. All current data shall be displayed within 20 seconds of the request.

2. Graphic Refresh. The system shall update all dynamic points with current data within 30 seconds.

3. Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be 10 seconds. Analog objects shall start to adjust within 10 seconds.

4. Object Scan. All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or workstation will be current, within the prior 60 seconds.

5. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 45 seconds.

6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.

7. Performance. Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every 5 seconds. The controller shall scan and update the process value and output generated by this calculation at this same frequency.

8. Multiple Alarm Annunciation. All workstations on the network shall receive alarms within 5 seconds of each other.

9. Reporting Accuracy. Table 1 lists minimum acceptable reporting accuracies for all values reported by the specified system.

Table I -- Reporting Accuracy

Measured Variable	**Reported Accuracy**
Space temperature	±0.5°C [±1°F]
Ducted air	±1.0°C [±2°F]
Outside air	±1.0°C [±2°F]
Water temperature	±0.5°C [±1°F]
Delta-T	±0.15°C[±0.25°F]
Relative humidity	±5% RH
Water flow	±5% of full scale
Air flow (terminal)	±10% of reading *Note 1
Air flow (measuring stations)	±5% of reading
Air pressure (ducts)	±25 Pa [±0.1 "W.G.]
Air pressure (space)	±3 Pa [±0.01 "W.G.]
Water pressure	±2% of full scale *Note 2
Electrical Power	5% of reading *Note 3
Carbon Monoxide (CO)	± 50 PPM

Carbon Dioxide (CO_2)	± 50 PPM

Note 1: (10%-100% of scale) (cannot read accurately below 10%)
Note 2: for both absolute and differential pressure
Note 3: * not including utility supplied meters

5. SUBMITTALS

Contractor shall provide shop drawings and manufacturers' standard specification data sheets on all hardware and software to be provided. No work may begin on any segment of this project until the Engineer and Owner have reviewed submittals for conformity with the plan and specifications. Twelve (12) copies are required. All shop drawings shall be provided to the Owner electronically as .dwg or .dxf file formats.

Quantities of items submitted shall be reviewed by the Engineer and Owner. Such review shall not relieve the contractor from furnishing quantities required for completion.

Provide the Engineer and Owner, any additional information or data that is deemed necessary to determine compliance with these specifications or which is deemed valuable in documenting the system to be installed.

Submit the following within 60 days of contract award:

1. A complete bill of materials of equipment to be used indicating quantity, manufacturer and model number.
2. A schedule of all control valves including the valve size, model number (including pattern and connections), flow, CV, pressure rating, and location.
3. A schedule of all control dampers. This shall include the damper size, pressure drop, manufacturer and model number.
4. Provide manufacturers cut sheets for major system components. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is being submitted to cover. Include:

    a) Building Controllers
    b) Custom Application Controllers
    c) Application Specific Controllers
    d) Operator Interface Computer
    e) Portable Operator Workstation
    f) Auxiliary Control Devices
    g) Proposed control system riser diagram showing system configuration, device locations, addresses, and cabling.
    h) Detailed termination drawings showing all required field and factory terminations. Terminal numbers shall be clearly labeled.
    i) Points list showing all system objects, and the proposed English language object names.
    j) Sequence of operations for each system under control. This sequence shall be specific for the use of the Control System being provided for this project.
    k) Provide a BACnet Product Implementation Conformance Statement (PICS) for each BACnet device type in the submittal.
    l) Color prints of proposed graphics with a list of points for display.

Project Record Documents: Upon completion of installation submit twelve (12) copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and include:

1. Project Record Drawings - These shall be as-built versions of the submittal shop drawings. One set of electronic media including CAD .DWG or .DXF drawing files shall also be provided.

2. Testing and Commissioning Reports and Checklists.

3. Operating and Maintenance (O & M) Manual - These shall be as built versions of the submittal product data. In addition to that required for the submittals, the O & M manual shall include:

    a) Names, address and 24-hour telephone numbers of Contractors installing equipment, and the control systems and service representative of each.
    b) Operators Manual with procedures of operating the control systems including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.
    c) Programming Manual with a description of the programming language including syntax, statement descriptions including algorithms and calculations used, point database creation and modification, program creation and modification, and use of the editor.
    d) Engineering, Installation and Maintenance Manual(s) that explains how to design and install new points, panels, and other hardware; preventative maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.
    e) A listing and documentation of all custom software created using the programming language including the point database. One set of magnetic media containing files of the software and database shall also be provided.
    f) One set of electronic media containing files of all color-graphic screens created for the project.
    g) A list of recommended spare parts with part numbers and supplier.
    h) Complete original issue documentation, installation, and maintenance information for all third party hardware provided including computer equipment and sensors.
    i) Complete original issue media for all software provided including operating systems, programming language, operator workstation software, and graphics software.
    j) Licenses, Guarantee, and Warrantee documents for all equipment and systems.
    k) Recommended preventive maintenance procedures for all system components including a schedule of tasks (inspection, cleaning, calibration, etc.) time between tasks, and task descriptions.

Training Manuals: The Contractor shall provide a course outline and training manuals for all training classes at least six weeks prior to the first class. The Owner reserves the right to modify any or all of the training course outline and training materials. Review and approval by Owner and Engineer and shall be completed at least 3 weeks prior to first class.

6. WARRANTY

A. Warrant all work as follows:

1. Labor & materials for control system specified shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. Control System failures during the warranty period shall be adjusted, repaired, or replaced at no charge or reduction in service to the Owner. The Contractor shall respond to the Owner's request for warranty service within 24 hours during customary business hours.

2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of warranty.

3. Operator workstation software, project specific software, graphics, database, and firmware updates shall be provided to the Owner at no charge during the warranty period. Written authorization by Owner must, however, be granted prior to the installation of such changes.

4. The system provider shall provide a web-accessible Users Network to give the Owner access to question/answer forum, graphics library, user tips, upgrades, and training schedules.

7. OWNERSHIP OF PROPRIETARY MATERIAL

A. All project developed hardware and software shall become the property of the Owner. These include but are not limited to:
   1. Project graphic images,
   2. Record drawings,
   3. Project database,
   4. Job-specific application programming code,
   5. All documentation.

8. OPERATOR INTERFACES

A. Graphical User Interface Computer

1. Contractor shall supply a Portable Operator Terminal, all necessary software, and interfaces to provide for the uploading/downloading of controller databases and programs, monitoring of all network variable types, including display of all bound SNVTs, monitoring and overrides of all controller physical input/output points, and editing of controller resident time schedules.

2. Provide laptop personal computer including software configuration tools that shall be capable of accessing all system data. This device may be connected to any point on the system network or may be connected directly to any controller for programming, set-up, and troubleshooting.

3. The Portable Operator's Terminal shall be a laptop including all software and hardware required. The laptop shall contain a minimum:

   a. Intel Core i7 Processor 2.8 GHz minimum, 6 MB cache minimum
   b. 8.0 GB DDR3 Memory
   c. 1TB Hard Drive, 7200 RPM
   d. CD-RW/DVD
   e. Windows Operating System (Version 8 or newer)
   f. 15" minimum color display with minimum 1920 x 1200 resolution
   g. AMD Radeon HD 7730M 2GB
   h. Wireless LAN Card
   i. (2) USB Ports

B. Workstation information access shall use the BACnet Protocol. Communication shall use Annex J of ASHRAE Standard 135-95. Local connections of the workstation shall be on ISO 8802-3 (Ethernet). Remote communications shall use either the BACnet Point to Point Physical/Data Link Layer Protocol or IP over Point to point (PTP).

9. SYSTEM SOFTWARE

1. Operating System. Furnish a commercially available, concurrent multi-tasking operating system. The operating system shall also support the use of other common software applications that operate under DOS or Microsoft Windows. The operating system shall be Windows XP Professional.

2. System Graphics. The Operator Workstation software shall be graphically oriented. The system shall allow display of up to 10 graphic screens at once for comparison and monitoring of system status. Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while on line. An operator with the proper password level shall be able to add, delete, or change dynamic points on a graphic. Dynamic points shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation of equipment. Graphics shall be capable of launching other PC applications.

a) Custom Graphics. Custom graphic files shall be created with the use of commonly available graphics packages such as PC Paint. The graphics generation package shall create and modify graphics that are saved in industry standard formats such as PCX, BMP, GIF and JPEG. The graphics generation package shall also provide the capability of capturing or converting graphics from other programs such as Designer, or AutoCAD.

b) Graphics Library. Furnish a complete library of standard HVAC equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library shall also include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.

c) Engineering Units. Allow for selection of the desired engineering units (i.e. Inch pound or SI) in the system. Unit selection shall be able to be customized by locality to select the desired units for each measurement. Engineering units on this project shall be: Standard Inch Pound.

10. SYSTEM APPLICATIONS:

Each workstation shall provide operator interface and off-line storage of system information. Provide the following applications at each workstation.

1. Automatic System Database Save and Restore. Each workstation shall store on the hard disk a copy of the current database of each building controller. This database shall be updated whenever a change is made in any panel in the system. The storage of this data shall be automatic and not require operator intervention. In the event of a database loss in a building management panel, the first workstation to detect the loss shall automatically restore the database for that panel.

2. Manual Database Save and Restore. A system operator with the proper password clearance shall be able to archive the database from any system panel and store on magnetic media. The operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.

3. System Configuration. The workstation software shall provide a graphical method of configuring the system. The user with proper security shall be able to add new devices, and assign modems to devices. This shall allow for future system changes or additions.

4. On-Line Help and Training. Provide a context sensitive, on line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. Provide an interactive tutorial CD, which will act as on-line training/help for the systems operator.

5. Security. Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operator's access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto logoff time shall be set per operator password. All system security data shall be stored in an encrypted format.

6. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

7. Alarm Processing. Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system.

   a) Alarm Reactions. The operator shall be able to determine what actions, if any, are to be taken, by object (or point), during an alarm. Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations, texting, forwarding to an e-mail address, providing audible annunciation or displaying specific system graphics. Each of these actions shall be configurable by workstation and time of day. An object in alarm that has not been acknowledged within an operator specified time period shall be re-routed to an alternate operator specified alarm receipt device.

   b) Binary Alarms. Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to disable alarming when the associated equipment is turned off or is being serviced.

   c) Analog Alarms. Each analog object shall have both high and low alarm limits and warning limits. Alarming must be able to be automatically and manually disabled.

8. Trend Logs. The operator shall be able to define a custom trend log for any data in the system. This definition shall include interval, start-time, and stop-time. Trend intervals of 1, 5, 15, 30, and 60 minutes as well as once a shift (8 hours), once a day, once a week, and once a month shall be selectable. All trends shall start based on the hour. Each trend shall accommodate up to 64 system objects. The system operator with proper password shall be able to determine how many samples are stored in each trend. Trend data shall be sampled and stored on the Building Controller panel and be archived. Trend data shall be able to be viewed and printed from the operator interface software. Trends must be viewable in a text-based format or graphically. They shall also be storable in a tab delimited ASCII format for use by other industry standard word processing and spreadsheet packages.

9. Dynamic Graphical Charting. The operator shall be able to select system values to be charted in real time. Up to three values at one time can be selected for each chart. The type of chart (bar, line, 3-D, etc.) shall be selectable.

10. Alarm and Event Log. The operator shall be able to view all logged system alarms and events from any location in the system. The operator shall be able to sort and filter alarms. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms. All that have not been cleared by the operator shall be archived to the hard disk on the workstation.

11. Object and Property Status and Control. Provide a method for the operator with proper password protection to view, and edit if applicable, the status of any object and property in the system. These statuses shall be available by menu, on graphics, or through custom programs.

12. Clock Synchronization. The real time clocks in all building control panels and workstations shall be synchronized on command of an operator. The system shall also be able to automatically synchronize all system clocks; daily from any operator designated device in the system. The system shall automatically adjust for daylight savings and standard time if applicable.

13. Reports and Logs. Provide a reporting package that allows the operator to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date. Report data shall be archived on the hard disk for historical reporting. Provide the ability for the operator to obtain real time logs of designated lists of objects. Reports and logs shall be stored on the PC hard disk in a format that is readily accessible by other standard software applications including spreadsheets and word processing. Reports

and logs shall be readily printed to the system printer. The operator shall be able to designate reports that shall be printed or stored to disk at selectable intervals.

a) Custom Reports: Provide the capability for the operator to easily define any system data into a daily, weekly, monthly, or annual report. These reports shall be time and date stamped and shall contain a report title and the name of the facility.

b) Standard Reports. The following standard system reports shall be provided for this project. These reports shall be readily customized to the project by the owner.

i. Electrical Meter Report: Provide a monthly report showing the daily electrical consumption and peak electrical demand for each building meter. Provide an annual (12 month) summary report showing the monthly electrical consumption and peak demand for each meter.

ii. Gas Meter Report: Provide a monthly report showing the daily natural gas consumption for each meter. Provide an annual (12 month) report that shows the monthly consumption for each meter.

iii. Weather Data Report: Provide a monthly report showing the daily minimum, maximum and average outdoor air temperature and the number of heating and cooling degree days for each day. Provide an annual (12 month) report showing the minimum, maximum and average outdoor air temperature for the month and the number of heating and cooling degree days for the month.

iv. Tenant Override Reports: Provide a monthly report showing the daily total time in hours that each tenant has requested after hours HVAC and lighting services. Provide an annual summary report that shows the override usage on a monthly basis.

B. Workstation Applications Editors. Each PC workstation shall support full screen editing of all system applications. Provide editors for each application at the PC workstation. The applications shall be downloaded and executed at the appropriate controller panels.

1. Controller. Provide a full screen editor for each type controller and application, that shall allow the operator with proper password to view and change the configuration, name, control parameters, and system set-points.

2. Air System Equipment Coordination. Provide a full screen editor that allows equipment to be grouped for proper operation as specified in the sequence of operations. This shall include the coordination of VAV boxes with their associated Air Handling Equipment.

3. Custom Application Programming. Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded. The programming language shall have the following features:

a) The language shall be English language oriented and be based on the syntax of programming languages such as BASIC. It shall allow for free form or fill in the blank programming. Alternatively, the programming language can be graphically-based using function blocks as long as blocks are available that directly provide the functions listed below, and that custom or compound function blocks can be created.

b) A full screen character editor/programming environment shall be provided. The editor shall be cursor/mouse-driven and allow the user to insert, add, modify, and delete code from the custom programming. It shall also incorporate word processing features such as cut/paste and find/replace.

c) The programming language shall allow independently executing program modules to be developed. Each module shall be able to independently enable and disable other modules.

d) The editor/programming environment shall have a debugging/simulation capability that allows the user to step through the program and to observe any intermediate values and or results. The debugger shall also provide error messages for syntax and execution errors.

e) The programming language shall support conditional statements (IF/THEN/ELSE/ELSE-IF) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

f) The programming language shall support floating point arithmetic using the following operators: +, -, /, x, square root, and xy. The following mathematical functions shall also be provided: natural log, log, absolute value, and minimum/maximum value from a list of values.

g) The programming language shall have pre-defined variables that represent clock time, day of the week, and date. Variables that provide interval timing shall also be available. The language shall allow for computations using these values.

h) The programming language shall have ability to pre-defined variables representing the status and results of the System Software, and shall be able to enable, disable, and change the values of BACnet objects in the system.

11. SYSTEM SOFTWARE

A. Furnish the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the operator workstation.

B. System Security

1. User access shall be secured using individual security passwords and user names.

2. Passwords shall restrict the user to only the objects, applications, and system functions as assigned by the system manager.

3. User logon/logoff attempts shall be recorded.

4. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.

C. Scheduling. Provide the capability to schedule each object or group of objects in the system. Each of these schedules shall include the capability for start, stop, optimal start, optimal stop, and night economizer actions. Each schedule may consist of up to [10] events. When a group of objects are scheduled together, provide the capability to define advances and delays for each member. Each schedule shall consist of the following:

1. Weekly Schedule. Provide separate schedules for each day of the week.

2. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. This exception schedule shall override the standard schedule for that day. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed it will be discarded and replaced by the standard schedule for that day of the week.

3. Holiday Schedules. Provide the capability for the operator to define up to [99] special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.

4. Optimal Start/Stop. The scheduling application outlined above shall support an optimal start/stop algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to

occupancy to achieve the desired space temperature at the specified occupancy time. The algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less then and greater than 24 hours. Provide the ability to modify the start/stop algorithm based on outdoor air temperature. Provide an early start limit in minutes to prevent the system from starting before an operator determined time limit.

D. Remote Communications. The system shall have the ability to email or text alarm message. The system shall use a priority array to determine which alarms to send out and to whom.

12. BUILDING CONTROLLERS

A. General. Provide Building Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.

1. The Building Automation System shall be composed of one or more independent, stand-alone, microprocessor based Building Controllers to manage the global strategies described in System software section.

2. The Building Controller shall have sufficient memory to support its operating system, database, and programming requirements.

3. The controller shall provide a communications port for connection of the Portable Operators Terminal.

4. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.

5. Controllers that perform scheduling shall have a real time clock.

6. Data shall be shared between networked Building Controllers.

7. The Building Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:

a) Assume a predetermined failure mode.
b) Generate an alarm notification.

8. BACnet. The Building Controller shall use the Read (Initiate) and Write (Execute) Services as defined in these BIBBS:

DS-RP-A,B
DS-RPM-A,B
DS-WP-A,B
DS-WPM-B

B. Communications. Each Building Controller shall reside on the Enterprise wide network, which is same high-speed network as the workstations. The Enterprise wide network will be provided by the owner and supports the Internet Protocol (IP). Local connections of the Building Controller shall be on ISO 8802-3 (Ethernet). Communications shall use Annex J of ASHRAE Standard 135-95. Each Building Controller shall also perform routing to a network of Custom Application and Application Specific Controllers. Each Building Controller shall perform communications to a network of Custom Application and Application Specific Controllers using LonTalk FTT-10 and LonMark profiles or BACnet.

C. Environment. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure, and shall be rated for operation at 0 C to 50 C [32 F to 120 F].

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

E. Memory. The Building Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

F. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shut-down below 80% nominal voltage

13. CUSTOM APPLICATION CONTROLLERS

A. General. Provide Custom Application Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.

1. The Building Automation System shall be composed of one or more independent, stand-alone, microprocessor based Building Controllers to manage the local strategies described in System software section.

2. The Controller shall have sufficient memory to support its operating system, database, and programming requirements.

3. Controllers that perform scheduling shall have a real time clock.

4. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.

5. The Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:

a) Assume a predetermined failure mode.
b) Generate an alarm notification.

6. Custom application controllers shall communicate using LonTalk. Controllers shall use FTT-10 transceivers. All communications shall be with the use of LonMark-approved SNVTs.

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

1. Controller used in conditioned ambient shall be mounted in NEMA 1 type enclosures, and shall be rated for operation at 0 C to 50 C [32 F to 120 F].

2. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40 C to 70 C [-40 F to 158 F].

C. A local operator interface shall be provided at building locations where specified in the sequence of operations or point list. The operator interface shall be provided for interrogating and editing data. A system security password shall be available to prevent unauthorized use of the keypad and display.

D. Serviceability. Provide diagnostic LEDs for power, communications, and processor. All low voltage wiring connections shall be made such that the controller electronics can be removed and/or replaced without disconnection of field termination wiring.

E. Memory. The Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

F. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

14. APPLICATION SPECIFIC CONTROLLERS

A. General. Application specific controllers (ASC) are microprocessor-based DDC controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. They are not fully user programmable, but are customized for operation within the confines of the equipment they are designed to serve.

1. Each ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.

2. Each ASC will contain sufficient I/O capacity to control the target system.

B. Environment. The hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40 C to 65 C [-40 F to 150 F].

2. Controller used in conditioned ambient shall be mounted in NEMA 1 type rated enclosures. Controllers located where not to be disturbed by building activity (such as above ceiling grid), may be provided with plenum-rated enclosures and non-enclosed wiring connections for plenum cabling. All controllers shall be rated for operation at 0 C to 50 C [32 F to 120 F].

C. Serviceability. Provide diagnostic LEDs for power and communications. All wiring connections shall be clearly labeled and made to be field removable.

D. Memory. The Application Specific Controller shall maintain all BIOS and programming information in the event of a power loss for at least 90 days.

E. Immunity to Power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%.

F. Transformer. Power supply for the ASC must be rated at minimum of 125% of ASC power consumption, and shall be fused or current limiting type.

G. Application Specific Controllers shall communicate using LonTalk. Controllers shall use FTT-10 transceivers. All communications shall follow LonMark profiles. ASCs which do not have a profile that applies must comply with LonMark standards, utilize SNVTs for all listed points, and be provided with a XIF file for self-documentation.

15. COMMUNICATIONS

A. This project shall comprise a network utilizing BACnet for communications between Building Controllers and PC Workstations. LonTalk or BACnet subnetworks shall be used for communications between Building Controllers, Custom Application Controllers and Application Specific Controllers.

B. Each BACnet device shall operate on the BACnet physical/data link protocols specified for that device as defined earlier in this section.

C. The owner will provide all communication media, connectors, repeaters, hubs, and routers necessary for the inter-network. A 10BaseT jack will be provided adjacent to each Building Control Panel and PC Workstation for connection to this network.

D. All Building Controllers shall have a communications port for connections with the operator interfaces. This may be either an RS-232 port for Point to Point connection or a network interface node for connection to the Ethernet. Building controllers shall also have a LonTalk communications port which supports FTT-10.

E. Communications services over the internetwork shall result in operator interface and value passing that is transparent to the internetwork architecture as follows:

1. Connection of an operator interface device to any one controller on the internetwork will allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the internetwork.

2. All database values (i.e., points, software variable, custom program variables) of any one controller shall be readable by any other controller on the internetwork. This value passing shall be automatically performed by a controller when a reference to a point name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communications services to perform internetwork value passing.

F. The time clocks in all controllers shall be automatically synchronized daily.

16. INPUT/OUTPUT INTERFACE

A. Hard-wired inputs and outputs may tie into the system through Building, Custom, or Application Specific Controllers.

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

C. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 ma to be compatible with commonly available control devices.

D. Pulse accumulation input points. This type of point shall conform to all the requirements of Binary Input points, and also accept up to 2 pulses per second for pulse accumulation, and shall be protected against effects of contact bounce and noise.

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

F. Binary outputs shall provide for on/off operation, or a pulsed low voltage signal for pulse width modulation control. Binary outputs on custom and building controllers shall have 3-position (on/off/auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.

G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0-10 Vdc or a 4-20 ma signal as required to provide proper control of the output device. Analog outputs on building or custom programmable controllers shall have status lights, a 2-position (auto/manual) switch, and manually adjustable potentiometer for manual override.

17. AUXILIARY CONTROL DEVICES

A. Motorized dampers, unless otherwise specified elsewhere, shall be as follows:

1. Damper frames shall be 16 gauge galvanized sheet metal or 1/8" extruded aluminum with reinforced corner bracing.

2. Damper blades shall not exceed 8" in width or 48" in length. Blades are to be suitable for medium velocity performance (2,000 fpm). Blades shall be not less than 16 gauge.

3. Damper shaft bearings shall be as recommended by manufacturer for application.

4. All blade edges and top and bottom of the frame shall be provided with compressible seals. Side seals shall be compressible stainless steel. The blade seals shall provide for a maximum leakage rate of 10 CFM per square foot at 2.5" w.c. differential pressure.

5. All leakage testing and pressure ratings will be based on AMCA Publication 500.

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

B. Control dampers shall be parallel or opposed blade types as scheduled on drawings.

C. Electronic damper/valve actuators.

1. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.

2. Where shown, for power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing.

3. All rotary spring return actuators shall be capable of both clockwise or counter clockwise spring return operation. Linear actuators shall spring return to the retracted position.

4. Proportional actuators shall accept a 0-10 VDC or 0-20 ma control signal and provide a 2-10 VDC or 4-20 ma operating range.

5. All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 8 W for DC applications. Actuators operating on 120 VAC or 230 VAC shall not required more than 11 VA.

6. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.

7. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation

8. Actuators shall be provided with a conduit fitting and a minimum 1m electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.

9. Actuators shall be Underwriters Laboratories Standard 873 listed.

10. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.

D. Control Valves

1. Control valves shall be two-way or three-way type for two-position or modulating service as scheduled or shown.

2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

a) Water Valves:
   i. Two-way: 150% of total system (pump) head.
   ii. Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.
b) Steam Valves: 150% of operating (inlet) pressure.

3. Water Valves:

   a) Body and trim style and materials shall be per manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.

   b) Sizing Criteria:
      i. Two-position service: Line size.
      ii. Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or [5] psi, whichever is greater.
      iii. Three-way Modulating Service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), [5] psi maximum.
      iv. Valves 1/2" through 2" shall be bronze body or cast brass ANSI Class 250, spring loaded, Teflon packing, quick opening for two-position service. Two-way valves to have replaceable composition disc, or stainless steel ball.
      v. 2-1/2" valves and larger shall be cast iron ANSI Class 125 with guided plug and Teflon packing.

   c) Water valves shall fail normally open or closed as scheduled on plans or as follows:
      i. Heating coils in air handlers - normally open.
      ii. Chilled water control valves - normally closed.
      iii. Other applications - as scheduled or as required by sequence of operation.

   d) Zone valves shall be sized to meet the control application and they shall maintain their last position in the event of a power failure.

E. TEMPERATURE SENSORS

1. Temperature sensors shall be Resistance Temperature Device (RTD) or Thermistor.

2. Duct sensors shall be rigid or averaging as shown. Averaging sensors shall be a minimum of 1.5m [5 feet] in length.

3. Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed.

4. Space temperature sensors in all classrooms and administration offices shall be surface mounted and equipped with a warmer-cooler knob or slide, override switch, digital room temperature display, and communication port.

5. Space temperature sensors in the cafeteria, gymnasium, library, multipurpose room, corridors, lobby, and entryways, shall sense the room temperature through a flush mounted, flat, stainless steel, cover plate with the manufacture’s logo. A communication port shall be concealed under the cover plate for service. The sensors in these locations shall not be equipped with a warmer-cooler knob or slide, override switch, or digital room temperature display. The override switches for each of these sensors shall be centrally located in one location as shown on the plans with permanent labels indicating the override zone served.

6. Provide matched temperature sensors for differential temperature measurement. Differential accuracy shall be within 0.1 C [0.2 F].

F. HUMIDITY SENSORS

1. Duct and room sensors shall have a sensing range of 20% to 80% with accuracy of ±5% R.H.

2. Duct sensors shall be provided with a sampling chamber.

3. Outdoor air humidity sensors shall have a sensing range of 20% to 95% R.H. It shall be suitable for ambient conditions of -40 C to 75 C [-40 F to 170 F].

4. Humidity sensor's drift shall not exceed 1% of full scale per year.

G. STATIC PRESSURE SENSORS

1. Sensor shall have linear output signal. Zero and span shall be field-adjustable.

2. Sensor sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.

3. Water pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Sensor shall be complete with 4-20 ma output, required mounting brackets, and block and bleed valves. Mount in location accessible for service.

4. Water differential pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (DP) and maximum static pressure shall be 3,000 psi. Transmitter shall be complete with 4-20 ma output, required mounting brackets, and five-valve manifold. Mount in a location accessible for service.

H. LOW LIMIT THERMOSTATS

1. Safety low limit thermostats shall be vapor pressure type with an element 6m [20 ft] minimum length. Element shall respond to the lowest temperature sensed by any one foot section.

2. Low limit shall be manual reset only.

I. FLOW SWITCHES

1. Flow-proving switches shall be either paddle or differential pressure type, as shown.

2. Paddle type switches (water service only) shall be UL listed, SPDT snap-acting with pilot duty rating (125 VA minimum). Adjustable sensitivity with NEMA 1 Type enclosure unless otherwise specified:

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

4. Current sensing relays may be used for flow sensing or terminal devices.

J. RELAYS

1. Control relays shall be UL listed plug-in type with dust cover. Contact rating, configuration, and coil voltage suitable for application.

2. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable plus or minus 200% (minimum) from set-point shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 Type enclosure when not installed in local control panel.

K. TRANSFORMERS and POWER SUPPLIES

1. Control transformers shall be UL listed, Class 2 current-limiting type, or shall be furnished with over-current protection in both primary and secondary circuits for Class 2 service.

2. Unit output shall match the required output current and voltage requirements. Current output shall allow for a 50% safety factor. Output ripple shall be 3.0 mV maximum Peak-to-Peak. Regulation shall be 0.10% line and load combined, with 50 microsecond response time for 50% load changes. Unit shall have built-in over-voltage protection.

3. Unit shall operate between 0 C and 50 C.

4. Unit shall be UL recognized.

L. CURRENT SWITCHES

1. Current-operated switches shall be self-powered, solid state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

M. LOCAL CONTROL PANELS

1. All indoor control cabinets shall be fully enclosed NEMA 1 Type construction with [hinged door], key-lock latch, and removable sub-panels. A single key shall be common to all field panels and sub-panels.

2. Interconnections between internal and face-mounted devices pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control termination's for field connection shall be individually identified per control drawings.

3. Provide on/off power switch with over-current protection and main air gauge for control power sources to each local panel.

18. EXAMINATION

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

B. The contractor shall inspect the site to verify that equipment is installable as shown, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

19. GENERAL WORKMANSHIP

A. Install equipment, piping, wiring/conduit parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

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

C. Install all equipment in readily accessible location as defined by chapter 1 article 100 part A of the NEC. Control panels shall be attached to structural walls unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service.

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

20. WIRING

A. All control and interlock wiring shall comply with the national and local electrical codes and Division 16 of these specifications. Where the requirements of this section differ with those in Division 16, the requirements of this section shall take precedence. Also refer to section 4 of this Specification section.

B. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

C. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

D. Maximum allowable voltage for control wiring shall be 120V. If only higher voltages are available, the Control System Contractor shall provide step down transformers.

E. All wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.

F. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with other sections of this specification and local codes.

G. Size of conduit and size and type of wire shall be the design responsibility of the Control System Contractor, in keeping with the manufacturer's recommendation and NEC.

H. Control and status relays are to be located in designated enclosures only. These relays may also be located within packaged equipment control panel enclosures. These relays shall not be located within Class 1 starter enclosures.

I. Follow manufacturer's installation recommendations for all communication and network cabling. Network or communication cabling shall be run separately from other wiring.

J. Adhere to Division 26 requirements for installation of raceway.

K. This Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

L. Flexible metal conduits and liquidtight, flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquidtight, flexible metal conduits shall be used.

M. New thermostats, sensors, etc. installed on existing wall shall be installed with concealed wiring.

21. FIBER OPTIC CABLE SYSTEM

A. All cabling shall be installed in a neat and workmanlike manner. Minimum cable and unjacketed fibber bend radii as specified by cable manufacturer shall be maintained.

B. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post installation residual cable tension shall be within cable manufacture's specifications.

C. Fiber optic cabinets, hardware, and cable entering the cabinet shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii as specified by cable manufacturer shall be maintained.

22. INSTALLATION OF SENSORS

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

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

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

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

E. Install duct static pressure tap with tube end facing directly down-stream of air flow.

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

G. All pipe mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat conducting fluid in thermal wells.

H. Wiring for space sensors shall be concealed in building walls. EMT conduit is acceptable within mechanical and service rooms.

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

23. FLOW SWITCH INSTALLATION

A. Install using a thread-o-let in steel pipe. In copper pipe use C x C x F Tee, no pipe extensions or substitutions allowed.

B. Mount a minimum of 5 pipe diameters upstream and 5 pipe diameters downstream or 2 feet whichever is greater, from fittings and other obstructions.

C. Install in accordance with manufacturers' instructions.

D. Assure correct flow direction and alignment.

E. Mount in horizontal piping - flow switch on top of the pipe.

24. ACTUATORS

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

B. To compress seals when spring return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.

C. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

D. Valves - Actuators shall be mounted on valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following manufacturer's recommendations.

25. WARNING LABELS

A. Affix plastic labels on each starter and equipment automatically controlled through the Control System. Label shall indicate the following:

C A U T I O N
This equipment is operating under automatic control and may start at any time without warning.

26. IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2" of termination with a cable identifier and other descriptive information.

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

C. Identify control panels with minimum 1-cm letters on laminated plastic nameplates.

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

27. CONTROLLERS

A. Provide a separate Controller for each major piece of HVAC equipment. Points used for control loop reset such as outside air or space temperature are exempt from this requirement.

B. Building level Controllers shall be BACnet/IP. Local controllers for equipment may be BACnet/mstp or LON.

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

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

28. PROGRAMMING

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

B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index.

C. Software Programming

1. Provide programming for the system as per specifications and adhere to the strategy algorithms provided. All other system programming necessary for the operation of the system but not specified in this document shall also be provided by the Control System Contractor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operations.

D. Operators' Interface

1. Standard Graphics. Provide graphics for each major piece of equipment and floor plan in the building. These standard graphics shall show all points dynamically as specified in the points list.
2. The controls contractor shall provide all the labor necessary to install, initialize, start-up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface database, and any third party software installation and integration required for successful operation of the operator interface.

3. As part of this execution phase, the controls contractor will perform a complete test of the operator interface. Test duration shall be a minimum of 8 hours on-site. Tests shall be made in the presence of the Owner or Owner's representative.

E. Demonstration: A complete demonstration and readout of the capabilities of the monitoring and control system shall be performed. The contractor shall dedicate a minimum of 16 hours on-site with the Owner and his representatives for a complete functional demonstration of all the system requirements. This demonstration constitutes a joint acceptance inspection, and permits acceptance of the delivered system for on-line operation.

29. CLEANING

A. This contractor shall clean up all debris resulting from his or her activities daily. The contractor shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the Construction Manager or General Contractor.

B. At the completion of work in any area, the Contractor shall clean all of his/her work, equipment, etc., making it free from dust, dirt and debris, etc.

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

30. PROTECTION

A. The Contractor shall protect all work and material from damage by his/her work or workers, and shall be liable for all damage thus caused.

B. The Contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The Contractor shall protect his/her work against theft or damage, and shall carefully store material and equipment received on site that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

31. FIELD QUALITY CONTROL

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

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship. All visible piping and or wiring runs shall be installed parallel to building lines and properly supported.

C. Contractor shall arrange for field inspections by local and/or state authorities having jurisdiction over the work.

7. SEQUENCE OF CONTROL

A. Setpoints- These values shall be the default setpoint prior to Owner adjustment.

(1) Occupied
   a. Cooling 72 deg F
   b. Heating 68 deg F

(2) Unoccupied
   a. Cooling 78
   b. Heating 58

C. <u>HEAT PUMP WATER LOOP CONTROL</u>

(1) The Heat Pump Water Loop System consists of P-1A and 1B:

(2) The condenser water distribution for the building is accomplished by Pumps P-1A and P-1B. Each pump is selected for 100% of the maximum flow rate. The pumps are to be variable flow and a variable speed pump controller unit is provided by the variable frequency drive. Two differential pressure sensors are located in the specifications, to control the pump speed. This contractor shall provide all control wiring necessary for proper system operation.

(3) The pump controller shall continuously survey the two differential pressure sensors. If the pump controller senses that any differential pressure is below the pressure setpoint, the speed of the controlled pump increases. If the pump controller senses that all differential pressure sensors are above the pressure setpoint, the speed of the controlled pump decreases. If a second pump requires starting to maintain the system pressures, the controller will activate it.

(4) During unoccupied hours, if no heat pumps are calling for cooling then the pumps shall be off. At least five zones must exceed by 2 deg F (adj) the Unoccupied setpoint to activate pumps or a single zone by 7 deg F.

D. OUTSIDE AIR HANDLING UNITS (OA-1)

(1) In the unoccupied mode:

a. The supply fan and exhaust shall be off,
b. The energy recovery wheel shall be off,
c. The outside air damper and exhaust air damper shall be fully closed,

(2) When placed into the occupied mode, the following shall occur in sequential order after operation of the Hydronic Water-to-Water Heat Exchanger System has been proved:

a. The energy recovery wheel shall start and operation shall be proved via current switch.

b. The outside air damper and exhaust air damper shall fully open and be proved via current switch.

c. The supply fan and exhaust fan shall start and operation shall be proved via current switches.

d. The system shall not start if any one component does not prove operation, including the Hydronic Water-to-Water Heat Exchanger System.

(3) In the occupied mode, the face and bypass dampers shall modulate to maintain discharge air temperature (adj.) based upon the following schedule:

Discharge Air Temperature	Mode of Operation
Varies (adj.)	Cooling Mode
Varies	Economizer Mode
68 deg F (adj.)	Heating Mode

(4) The modulating 3-way control valve at the 2-pipe coil for the OA system shall be heating ounly.

(5) If the outside air temperature is between 55 deg F (adj) and 75 deg F (adj), then the energy recovery wheel shall be off. If the temperature leaving the energy recovery wheel drops is 50 F or below, the WWHP shall be activated to discharge 68 F LAT.

(6) A manual reset low limit installed downstream of the chilled/hot water coil shall stop the operation of the system if the discharge temperature falls below 38 deg F.

(7) The fans shall both be controlled by a VFD. The supply fan shall be modulated to maintain pressure in the ductwork. Provide a duct mounted pressure sensor. The exhaust fan shall be controlled to maintain a cfm offset between the outside air and building exhaust. Refer to the equipment schedule for offset.

(8) A smoke detector shall be located in each air stream. If smoke is detected, then the system shall shutoff and an audio/visual alarm shall activate. Upon correction of the problem, the system shall be reset and shall return to normal operation. Coordinate with Fire Alarm System.

E. HYDRONIC WATER-TO-WATER HEAT EXCHANGER SYSTEM (WWHP-1/P-2A/P-2B)

(1) The hydronic water-to-water heat exchanger system shall consist of the following pieces of equipment:

WWHP-1
P-2A & P-2B

(2) In the unoccupied mode:

All WWHP's shall be off,
P-2A and P-2B shall be off.

(3) When placed into the occupied mode, the following shall occur in sequential order prior to starting air handling systems:

a. Pumps (P-2A or P-2B) shall start and operation shall be proved via differential pressure switch. Additionally, pumps P-2A & 2B shall operate in a lead lag sequence. In the event that the lead pumps fails, the lag pump shall automatically start. Once the lag pump has automatically starts, the water-to-water heat exchanger system shall reset and resume operation. After the lead pump failure has been corrected, the lead pump shall automatically restart and the water-to-water heat exchanger system shall resume normal operation.

b. WWHP units shall start and operation shall be proved via leaving water temperature. The control system shall rotate compressor staging on a regular basis.

c. The system shall not start if any one component does not prove operation.

(4) The water-to-water heat exchangers shall be placed into cooling or heating mode based on the following outdoor air temperature schedule:

OA Temp	Mode of operation
68F and above	Cooling
55F and below	Heating

(5) Individual WWHP's shall start and operate based on return water temperatures according to the following schedule (When the outside air temperature is between 55F & 68F the water to water heat pumps and all associated pumps shall be off):

a. WWHP – Compressor stages 1 & 2 (lead/lag)

b. The WWHP's shall stage the compressors as necessary to maintain the 55 deg F discharge temperature off the coil in cooling and the 95 deg F discharge temperature in heating.

There shall be a 5 minute adjustable time delay before an additional compressor can be staged on or off.

Additionally, the water-to-water heat exchangers shall have the ability to sequence the start order (lead/lag) of the compressors. The water-to-water system also supplies water to ceiling fan coil units. If the water temperature setpoint cannot be maintained with all compressors operating, then the fan coil units shall be disabled and placed into the unoccupied mode.

F. GEOTHERMAL HEAT PUMPS

(1) The space thermostat shall be a non-DDC, field-installed, remote-mounted. Provide all required control wiring between thermostat and heat pump unit. Refer to drawings for locations of thermostats and temperature sensors.

(2) The heat pump zone controller shall be placed each heat pump unit into occupied/unoccupied mode based upon the schedule at the Global Control Panel.

(3) During the occupied mode, the heat pump shall cycle as required to satisfy space thermostat/sensor setpoint. The unit shall automatically changeover from heating to cooling.

(4) During the unoccupied mode, the heat pump shall not operate unless the space temperature falls to 60 degrees F. (adj.) or rises above 85 degrees F (adj.).

(5) Each heat pump shall be furnished with a hose kit with a three-wire, two-way, two position control valve. The TCC shall install a wire actuator. Upon call for heating/cooling, the valve shall drive open prior to fan and compressor operation. When space temperature is satisfied, fan and compressor shall turn off and the control valve shall drive closed.

(6) In rooms with two heat pumps, a single thermostat shall control both units in a master-slave arrangement.

(7) The occupied/unoccupied signal shall be sent to a relay provided on each heat pump. The relay is provided with the heat pump.

(8) In the event Pump #P-1A or P-1B fails, all heat pump units shall de-activate.

(9) All heat pumps of 2000 CFM or greater are required to have smoke safeties as required by Codes. If smoke is detected, the supply fan shall deactivate and an audio/visual alarm shall activate, upon correction of the problem, the system shall here set and unit shall return to normal operation.

END OF CONTROLS