100% BID SET
PROJECT MANUAL
VOLUME 2
for the

THIRD FLOOR RENOVATION OF BLDG 29 LABORATORIES AT NEW IBERIA RESEARCH CENTER

NIH GRANT NO.: 1C06OD034041

4401 WEST ADMIRAL DOYLE DRIVE, NEW IBERIA, LA 70560

Owner:

NEW IBERIA RESEARCH CENTER / FACILITY MANAGEMENT, ADMINISTRATION & FINANCE
UNIVERSITY OF LOUISIANA, LAFAYETTE
PARKER HALL
LAFAYETTE, LA 70503

DIRECTOR OF FACILITY MANAGEMENT
SCOTT HEBERT

GRANTS AWARD MANAGER
PHILLIP J. DUPLECHIN, P.E.

Prepared by:

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Lafayette, LA 70503
Tel: 337.207.3761

STRUCTURAL CONSULTANT
FOX-NESBIT ENGINEERING, LLC
600 Jefferson Street, Suite 301-6
Lafayette, LA 70501
Tel: 337.347.6511

MEP CONSULTANT
ADG ENGINEERING
3909 W. Congress Street, Suite 201
Lafayette, LA 70506
Tel: 337.234.5710

ARCHITECT'S PROJECT
No.: 2025.040

APRIL 14, 2026

SECTION 000101
PROJECT TITLE PAGE

PROJECT MANUAL

FOR

NIH GRANT NUMBER: 1C06OD034041
ARCHITECT'S PROJECT NUMBER: 2025.040

THIRD FLOOR RENOVATION OF BLDG 29 LABORATORIES AT
NEW IBERIA RESEACH CENTER / UNIVERSITY OF LOUISIANA, LAFAYETTE

4401 WEST ADMIRAL DOYLE DRIVE
NEW IBERIA , LOUISIANA 70506

DATE: 10 MARCH 2026

PREPARED BY:

CHASE MARSHALL ARCHITECTS

SECTION 000103
PROJECT DIRECTORY

PART 1 GENERAL

OWNER:

A. Name: UNIVERSITY OF LOUISIANA AT LAFAYETTE / FACILITY MANAGEMENT
   1. Address Line 1: Parker Hall, Room 203.
   2. Address Line 2: 310 East Lewis Street.
   3. City: LAFAYETTE.
   4. State: LOUISIANA.
   5. Zip Code: 70503.

Name: THIRD FLOOR RENOVATION OF BLDG 29 LABORATORIES AT NEW IBERIA RESEARCH CENTER / UNIVERSITY OF LOUISIANA, LAFAYETTE.
- Address Line 1: 4401 WEST ADMIRAL DOYLE DRIVE.
- City: NEW IBERIA.
- State: LOUISIANA.
- Zip Code: 70560.

DESIGN TEAM:

Architect: Design Professional of Record. All correspondence from the Contractor regarding construction documents authored by Architect's consultants will be through this party, unless alternate arrangements are mutually agreed upon at preconstruction meeting.
- Company Name: CHASE MARSHALL ARCHITECTS.
  - Address Line 1: 7222 SPRUCE STREET.
  - City: NEW ORLEANS.
  - State: LOUISIANA.
  - Zip Code: 70118.
  - Telephone: 504.208.2676.
- Primary Contact:
  - Title: PROJECT MANAGER.
  - Name: NICK MARSHALL.
  - Email: nick.marshall@chasemarshall.com.

Civil Engineering Consultant:
- Company Name: LCR AND COMPANY.
  - Address Line 1: 318 BELLE GROVE BLVD..
  - City: LAFAYETTE.
  - State: LOUISIANA.
  - Zip Code: 70503.
  - Telephone: 337.207.3761.

Structural Engineering Consultant:
- Company Name: FOX-NESBIT ENGINEERING, LLC.
  - Address Line 1: 600 JEFFERSON STREET, SUITE 301-6.
  - City: LAFAYETTE.
  - State: LOUISIANA.
  - Zip Code: 70501.
  - Telephone: 337.347.6511.

Mechanical, Electrical, and Plumbing Engineering Consultant:
- Company Name: ADG ENGINEERING.
  - Address Line 1: 3909 WEST CONGRESS STREET, SUITE 201.
  - City: LAFAYETTE.
  - State: LOUISIANA.
  - Zip Code: 70506.
  - Telephone: 337.234.5710.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION - NOT USED

END OF SECTION

SECTION 000107
SEALS PAGE

PROJECT NAME: **THIRD FLOOR RENOVATION OF BLDG 29 LABORATORIES AT NEW IBERIA RESEARCH CENTER**

4401 WEST ADMIRAL DOYLE DRIVE
NEW IBERIA, LOUISIANA 70560

DATE: **MARCH 10, 2026**

ARCHITECTURAL SPECIFICATIONS: THE FOLLOWING SPECIFICATION SECTIONS WERE PREPARED BY ME OR UNDER MY DIRECT PERSONAL SUPERVISION:

03/10/2026

CHASE MARSHALL ARCHITECTS

024100 DEMOLITION
030505 UNDERSLAB VAPOR BARRIER
055000 METAL FABRICATIONS
055133 METAL LADDERS
055213 PIPE AND TUBE RAILINGS
057300 DECORATIVE METAL RAILINGS
061000 ROUGH CARPENTRY
071613 POLYMER MODIFIED CEMENT WATERPROOFING
071616 CRYSTALLINE WATERPROOFING
072100 THERMAL INSULATION

END OF ARCHITECTURAL

CIVIL SPECIFICATIONS: THE FOLLOWING SPECIFICATION SECTIONS WERE PREPARED BY ME OR UNDER MY DIRECT PERSONAL SUPERVISION:

CONSULTANT HAS ELECTED TO STAMP, SIGN, AND DATE EACH INDIVIDUAL SECTION.

LCR & COMPANY, L.L.C.

END OF CIVIL

STRUCTURAL SPECIFICATIONS: THE FOLLOWING SPECIFICATION SECTIONS WERE PREPARED BY ME OR UNDER MY DIRECT PERSONAL SUPERVISION:

CONSULTANT HAS ELECTED TO STAMP, SIGN, AND DATE EACH INDIVIDUAL SECTION.

FOX-NESBIT ENGINEERING, LLC

030500 CRYSTALLINE CONCRETE WATERPROOFING ADDITIVE
033000 CAST-IN-PLACE CONCRETE
051200 STRUCTURAL STEEL FRAMING
053100 STEEL DECKING
054000 COLD-FORMED METAL FRAMING
312000 EARTH MOVING
316329 DRILLED CONCRETE PIERS AND SHAFTS

END OF STRUCTURAL

PLUMBING, MECHANICAL, AND ELECTRICAL SPECIFICATIONS: THE FOLLOWING SPECIFICATION SECTIONS WERE PREPARED BY ME OR UNDER MY DIRECT PERSONAL SUPERVISION:

CONSULTANT HAS ELECTED TO STAMP, SIGN, AND DATE EACH INDIVIDUAL SECTION.

ADG ENGINEERING

019113	**GENERAL COMMISSIONING REQUIREMENTS**
220000	**PLUMBING GENERAL PROVISIONS**
220500	**COMMON WORK RESULTS FOR PLUMBING**
220519	**PLUMBING PIPING**
220700	**PLUMBING INSULATION**
220800	**COMMISSIONING OF PLUMBING SYSTEM**
221400	**DRAINAGE AND VENT SYSTEMS**
223310	**DOMESTIC HOT WATER HEATERS**
224000	**PLUMBING FIXTURES AND FIXTURE CARRIERS**
224000	**PLUMBING FIXTURES**
230010	**MECHANICAL GENERAL PROVISIONS**
230020	**BASIC MECHANICAL REQUIREMENTS**
230510	**ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT**
230513	**ELECTRIC MOTORS**
230514	**MOTOR STARTERS**
230515	**VARIABLE FREQUENCY DRIVES**
230519	**METERS AND GAUGES**
230523	**HVAC VALVES**
230529	**HANGERS AND SUPPORTS**
230548	**VIBRATION ISOLATION**
230553	**MECHANICAL IDENTIFICATION**
230593	**TESTING, ADJUSTING, AND BALANCING**
230620	**HYDRONIC SPECIALTIES**
230713	**MECHANICAL INS**

END OF PLUMBING, MECHANICAL, AND ELECTRICAL

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END OF SECTION

STATE OF LOUISIANA
R. CRAIG CAMPBELL, II
License No. 29380
3/10/26
PROFESSIONAL
ENGINEER

SECTION 220000
PLUMBING GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. Furnish all labor and material necessary to provide and install the complete plumbing portion of this Contract as called for herein and on accompanying drawings. Parts of the plumbing division may be bid separately or in combination, at the Contractor's option; however, it shall be the responsibility of the General Contractor to assure himself that all items covered in the Plumbing Division have been included if he chooses to accept separate bids.

B. It is the intent of this specification that all materials with temperatures below ambient conditions or conveying any fluid/gas at temperatures below 70 deg. F be insulated to completely eliminate the potential for condensation. Unless specified elsewhere in these specifications, for materials that do not require and requiring occasional access, use 2" thick closed cell rubberized insulation with re-sealable fabric joints (hook and loop type).

C. Contractor shall refer to the Architectural and Structural drawings and install equipment, piping, etc. to meet building and space requirements. No equipment shall be bid on or submitted for approval if it will not fit in the space provided.

D. It is the intention of these specifications that all plumbing systems shall be furnished complete with all necessary valves, controls, insulation, piping devices, equipment, etc. necessary to provide a satisfactory installation that is complete and in good working order.

E. Contractor shall visit the site and acquaint himself thoroughly with all existing facilities and conditions which would affect his portion of the work. Failure to do so shall not relieve the Contractor from the responsibility of installing his work to meet the conditions.

F. This Contractor shall protect the entire system and all parts thereof from injury throughout the project and up to acceptance of the work. Failure to do so shall be sufficient cause for the Architect to reject any piece of equipment.

G. Provide as work of this Division (unless clearly and specifically indicated as a requirement of the Division 26 contractor on the Division 26 drawings) the following:
   1. 120V power to all fixtures, control panels, unit controllers, field devices, etc. as required.
   2. Wiring of any remote start/stop switches controlling Division 22 equipment.

1.3 DEMOLITION

A. The contractor shall visit the site prior to bid to determine the extent of work required to complete the project.

B. Contractor shall coordinate demolition with owner. All equipment shall be salvaged for owner. Locate equipment as directed by owner. All equipment and materials not salvaged by the owner shall be removed from the site and discarded at the contractor's expense.

C. Contractor shall coordinate all work with general contractor and phase work as required by project.

D. All equipment piping, etc. required to be removed to accommodate the modifications shall be removed.

E. Contractor shall maintain services to existing facilities which shall remain during and after construction is complete.

F. Contractor shall coordinate any shutdown of services with the owner. It is intended that the building will remain occupied during construction. Contractor shall schedule shut down of services with the owner in order to prevent disruption of building occupancy.

G. Contractor shall be responsible for draining down of existing systems to complete demolition. All work shall be scheduled with the owner. Contractor shall also be responsible for refilling system and removing all air in order to return the systems to proper operating conditions.

H. All shutdown of services shall be done at night during a time period approved by owner. The systems shall be required to be back up and running each morning unless otherwise approved by the owner.

1.4 GROUNDS AND CHASES

A. This Contractor shall see that all required chases, grounds, holes and accessories necessary for the installation of his work are properly built in as the work progresses; otherwise, he shall bear the cost of providing them.

1.5 CUTTING AND PATCHING

A. Initial cutting and patching shall be the responsibility of the General Contractor, with the various trades being responsible for laying out and marking any and all holes required for the reception of his work. No structural beams or joists shall be cut or thimbled without first receiving the approval of the Architect. After initial surfacing has been done, any further cutting, patching and painting shall be done at this Contractor's expense.

1.6 FILL AND CHARGES FOR EQUIPMENT

A. Fill and charge with materials or chemicals all those devices or equipment as required to comply with the manufacturer's guarantee or as required for proper operation of the equipment.

1.7 BIDDING REQUIREMENTS AND RESPONSIBILITIES

A. Prime bidder is responsible for all work, of all trades and sub-contractors bidding this project. It is the prime bidder’s responsibility, prior to submitting a bid to ensure that sub-contractors coordinate all aspects of the work between trades, sub-contractors, etc. to the fullest extent possible.

B. Prime bidder shall ensure that all sub-contractors, suppliers, equipment vendors, etc., obtain all necessary and pertinent contract document information pertaining to their work prior to the submission of a bid. Contractor shall realize that different sub-contractors may furnish equipment, accessories, devices, etc. necessary for a complete and working installation that require provision of services by another sub-contractor or trade.

C. Bidders of all or any portions of this section or division are required to review all contract documents including but not limited to Architectural drawings, Structural drawings, Mechanical drawings, Plumbing drawings, Electrical drawings, etc. to coordinate requirements and responsibilities with and through prime bidder.

D. Bidders of all or any portions of this section or division, by furnishing a bid on a portion of the prime contract are indicating that they have received all contract documents and coordinated services provided under their portion of the work with the prime bidder; they are indicating that they have expressed any pertinent questions (which would result from a detailed, thorough review of the entire set of contract documents) to the prime bidder in accordance with Division 00 & 01 requirements, prior to bidding.

E. All timely, pertinent, questions provided in writing prior to bids, in accordance with Division 00 & 01 requirements, will be clarified, defined, or otherwise explained in a written addendum and/or addendums prior to bids, in accordance in Division 00 & 01 requirements.

F. It is not the intention of these contract documents to leave any issue relating to coordination between trades or sub-contractors vaguely defined. The intention is to define all issues, coordination matters, equipment requirements, sizes, routing, etc. to the satisfaction of the prime bidder, prior to receipt of bids.

G. Bidders of all or any portions of this section or division, by virtue of the submission of a bid to the prime bidder, are indicating that they have reviewed the entire set of contract documents with due diligence and regard for the Owner's desire for a comprehensive and complete bid proposal; that they have expressed all concerns or questions requiring clarification on matters of coordination between trades and/or sub-contractors; that they have expressed any such concerns or questions in writing in accordance with Division 00 & 01 requirements.

H. Prime bidders, by submission of a comprehensive bid on the project are indicating that the subcontractors selected in their bid have complied with all Division 00 & 01 requirements, that they have indicated in writing, prior to bidding, all questions or concerns requiring clarification and/or explanation and have documented any and all specific exclusions involving work that would generally be considered to be work of their trade. The prime bidder shall coordinate all work so that anything excluded by the bidder of all or any portions of this section or division, have been addressed prior to bids in one of the following manners:
   1. The work has been confirmed, by the prime bidder, to be work of another trade or subcontractor (whose proposal is also being accepted).
   2. Clarification of the matter has been made through the prime design professional via written addendum and is clearly and mutually understood by the prime bidder and the party raising the issue/question or seeking clarification.

3. The work has been accepted as the responsibility of the prime contractor directly.

1.8 MATERIAL AND EQUIPMENT

A. The term "provide" when used in the Contract Documents shall mean “furnish and install” and includes all items necessary for the proper execution and completion of the Work.

B. Specific reference in the Specifications to any article, device, product, material, fixture, form or type of construction by name, make or catalog number, shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition; and the Contractor, in such cases, may at his option use any article, device, product, material, fixture, form or type of construction which in the judgment of the Architect expressed in writing is equal to that specified.

C. Coordinate and properly relate all Work of this Division to building structure and work of all other trades.

D. Visit premises and become thoroughly familiar with existing conditions; verify all dimensions in field. Advise Architect of any discrepancies prior to Bid Date in accordance with Division 00.

E. Do not rough-in for any item or equipment furnished by others or noted "Not in Contract" (NIC), without first receiving rough-in information from physically examining the existing equipment, receiving specific cut sheet information from the Owner’s representative, other trades and/or Architect. Rough-in services for ANIC” equipment as required, as the work progresses.

F. Provide storage and protection for all equipment and materials in accordance with requirements of Division 00 & 01. Replace any equipment and materials damaged by improper handling, storage, or protection, at no additional cost to Owner.

G. Keep premises clean in accordance with requirements of Division 00 & 01.

1.9 SUBSTITUTIONS

A. Substitutions are only allowed by approval of the Architect prior to Bid Date as stipulated in Division 00 & 01.

B. Design of systems is based on specific equipment. If the use of other manufacturer's equipment, even though approved by Architect, involves additional cost due to space requirements, foundation requirements, increased mechanical or electrical services, the cost of such extra work shall be borne by Contractor. Even though a manufacturer's name appears in the Contract Documents as having acceptable equipment, their equipment with different model numbers shall be classified as being a substitute to the equipment originally designed for and named in the Contract Documents. Substitute equipment, materials, etc., will not be allowed to deviate from Contract Document requirements. Furnish all options specified or reasonably implied from the contract documents. Specifically identify any variance in regard to submittal versus specified performance on the cover sheet of each submittal.

1.10 POST-BID VALUE ENGINEERING (V/E):

A. While it may be in the project Owner's interest to consider the first cost money saving that may be generated via alternatives and options generated via participation in Value Engineering, Division 22 contractor shall realize that substantive offers of Value Engineering (V/E), if accepted by the Owner, constitute a design-build agreement (offer and acceptance) with the owner, and drastically change the design concept of the project, as developed by the Professional of Record identified on the Contract Documents.

B. Should contractor offer, and the owner accept value engineering options that alter aspects of the system design, equipment, performance and/or performance verification or monitoring of respective systems, Division 22 contractor shall provide duly licensed professional engineering consultants working on behalf of the Division 22 contractor (including sub-contractors and equipment vendors/manufacturers) to review, approve and take professional responsibility for performance and suitability of V/E hybrid systems, materials or operational changes related to respective V/E items. The Division 22 contractor's licensed professional engineering consultants and the Division 22 contractor assume any and all responsibility for the design and suitability in terms of performance, of hybrid systems installed, as Division 22 contractor's Professional of Record, absolving the original project Professional of Record (identified on the original Contract Documents, released for the original project Bid/Negotiation) from responsibility for the V/E hybrid systems portion of the work.

C. Division 22 contractor, via the offer and acceptance of value engineering items on the project agrees to provide professional engineering design services and take full and complete responsibility for the hybrid design. Further, the Division 22 contractors (V/E Items) professional of record (either employees, or independent consultants to the Division 22 contractor) through the offer and acceptance of V/E items, agree to indemnify and hold harmless the project owner, the owner's original A/E team (Professional of Record on behalf of the owner for the original Contract Documents) their heirs and assigns in regard to the V/E changes and their impact on the Division 22 systems altered, affected or modified, in whole or in part. The Professional of Record shown on the original Contract Documents in regard to the systems altered, adjusted, revised, modified or otherwise affected by the value engineering items implemented, shall be absolved of design responsibility as a result of implementation of V/E items, and their original use of Engineering Seals used for original Contract Documents, shall not apply.

1.11 DRAWINGS AND SPECIFICATIONS

A. The specific intent of these Contract Documents is to provide the various systems, equipment, etc. to the Owner complete and in a thoroughly calibrated functional condition.

B. The Drawings shall not be construed as shop drawings. In the event of a possible interference with piping or equipment of another trade, items requiring set grade and elevations shall have precedence over other items should any major interference develop, immediately notify the Architect.

C. In laying out Work, refer to mechanical, electrical, structural, and architectural drawings at all times in order to avoid interference and undue delays in the progress of the Work.

1.12 CODES AND REGULATIONS

A. Work shall be in full accord with the most stringent interpretation of the State Sanitary Code, local ordinances, building codes, and other applicable national, local, and state regulations.

B. Equipment shall conform to requirements and recommendations of the National bureau of Fire Underwriters and National Fire Protection Association (NFPA).

C. Items provided under this Division shall comply with the American National Standards Institute (ANSI) "Specifications for Making Buildings and Facilities Accessible to and Usable by Physically Handicapped People," ANSI A 117.1

D. In the possible event of conflict between codes or regulations and Contract Documents, the most stringent interpretation of either shall govern (provided if exceeds the requirements of other codes). In the event of an irreconcilable difference between codes or regulations notify the Architect/Engineer immediately.

E. In addition to the codes heretofore mentioned, all work and equipment shall conform to the applicable portions of the following specifications, codes and/or regulations:
1. National Electrical Code (NEC)
2. National Fire Protection Association (NFPA)
3. American Society of Mechanical Engineers (ASME)
4. American Gas Association (AGA)
5. Underwriters Laboratories (UL)
6. International Plumbing Code (IPC) with Louisiana Amendments

F. All materials, equipment and accessories installed under this Contract shall conform to all rules, codes, etc. as recommended by National Associations governing the manufacturer, rating and testing of such materials, equipment and accessories. All materials shall be new and of the best quality and first class in every respect. Whenever directed by the Architect, the Contractor shall submit a sample for approval before proceeding.

G. Where laws or local regulations provide that certain accessories such as gauges, thermometers, relief valves and parts be installed on equipment, it shall be understood that such equipment be furnished complete with the necessary accessories, whether or not called for in these Specifications.

H. All unfired and fired pressure vessels shall be built in accordance with the A.S.M.E. Code and so stamped. Furnish shop certificates for each vessel. Contractor shall provide and pay for first operating certificate as per State Fire Marshal Regulations.

1.13 FEES, PERMITS, AND TAXES

A. Obtain and pay for permits required for the Work of this Division. Pay fees in connection therewith, including necessary inspection fees.

B. Pay any and taxes levied for Work of this Division, including municipal and/or state sales tax where applicable.

C. All permits, fees, certificates, etc. for the installation, inspections, plan review, service connections locations, and/or construction of the work which are required by any authority and/or agencies having jurisdiction, shall be obtained and paid for by the Contractor.

D. The Contractor shall make all tests required by the Architect, Engineer or other governing authorities at no additional cost to the Owner.

E. The Contractor shall notify the Architect and local governing authorities before any tests are made, and the tests are not to be drawn off a line covered or insulated until examined and approved by the authorities. In event defects are found, these shall be corrected and the work shall be retested.

F. Prior to requesting final inspection by the Architect, the Contractor shall have a complete coordination and adjustment meeting of all of his sub-contractors directly responsible for the operation of any portion of the system. At the time of this meeting, each and every sequence of operation shall be checked to assure proper operation. Notify the Architect in writing ten (10) days prior to this meeting, instructing him of the time, date and whom you are requesting to be present.

G. This project shall not be accepted until the above provisions are met to the satisfaction of the Architect.

1.14 MANUFACTURER'S DIRECTIONS

A. Install and operate equipment and material in strict accord with manufacturer's installation and operating instructions. The manufacturer's instructions shall become part of the Contract Documents and shall supplement Drawings and Specifications.

1.15 SUBMITTAL DATA

A. Submit shop drawings, project data, and samples in accordance with requirements of Division 00 & 01.

B. Shop drawings shall consist of published ratings or capacity data, detailed construction drawings for fabricated items, wiring and control diagrams, performance curves, installation instructions, manufacturer's installation drawings, and other pertinent data. Submit drawings showing revisions to equipment layouts due to use of alternate or substitute equipment.

C. Where approved manufacturers and suppliers of equipment, materials, etc. are unable to fully comply with Contract Document requirements, specifically call such deviations to attention of Architect on submittals. Type deviations on a separate sheet; underlined statements or notations on standard brochures, equipment fly sheets, etc. will not be accepted.

D. Approval of submittals shall not relieve Contractor from furnishing required quantities and verifying dimensions. In addition, approval shall not waive original intent of Contract Documents.

E. Failure to obtain written approval of equipment shall be considered sufficient grounds for rejection of said equipment regardless of the stage of completion of the project.

1.16 REVIEW OF MATERIALS:

A. Whenever manufacturers or trade names are mentioned in these Plans or Specifications, the words "or approved equivalent" shall be assumed to follow whether or not so stated. Manufacturers or trade names are used to establish a standard of quality only, and should not be construed to infer a preference. Equivalent products which meet the Architect's approval will be accepted; however, these products must be submitted to the Architect a minimum of ten (10) days prior to the Bid Date.

B. Submission shall include the manufacturer's name, model number, rating table and construction features.

C. Upon receipt and checking of this submittal, the Architect will issue an addendum listing items which are approved as equivalent to those specified. The contractor shall base his bid solely on those items specified or included in the "prior approval addendum", as no other item will be acceptable.

D. Prior approval of a particular piece of equipment does not mean automatic final acceptance and will not relieve the Contractor of the responsibility of assuring himself that this equipment is in complete accord with the Plans and Specifications and that it will fit into the space provided. Shop drawings must be submitted on all items of equipment for approval as hereinafter specified.

E. Before proceeding with work and/or within thirty (30) days after the award of the General Contract for this work, the Contractor shall furnish to the Architect complete shop and working drawings of such apparatus, equipment, controls, insulation, etc. to be provided in this project. These drawings shall give dimensions, weights, mounting data, performance curves and other pertinent information.

F. The Architect's approval of shop drawings shall not relieve the Contractor from the responsibility of incorrectly figured dimensions or any other errors which may be contained in these drawings. Any omission from the shop drawings or specifications, even through approved by the Architect, shall not relieve the Contractor from furnishing and erecting same.

G. Shop drawings shall be submitted in accordance with Section 013300. These submittals shall be supplied as part of this Contractor's contract. Any drawings not approved shall be resubmitted until they are approved. Submit all shop drawings at the same time. No separate items will be accepted.

1.17 PROJECT RECORD DOCUMENTS

A. Keep Project Record Documents in accordance with requirements of Division 00 & 01.

B. During construction period, keep accurate records of installations made under this Division, paying particular attention to major interior and exterior underground and concealed piping, ductwork, etc.

C. The Contractor shall obtain at his cost, two sets of blueline prints of the original bid documents by the Architect. One set shall be kept on the site with all information as

referenced below and shall update same as the work progresses. The other set will be utilized to record all field changes to a permanent record copy for the Owner.

D. If the Contractor elects to vary from the Contract Documents and secures prior approval from the Architect for any phase of the work, he shall record in a neat and readable manner, all such variances on the blueline print in red. The original bluelines shall be returned to the Architect for documentation.

E. Provide electronic (PDF) copies of all documentation included in Final Report.

F. All deviations from sizes, locations, and from all other features of the installations shown in the Contract Documents shall be recorded.

G. In addition, it shall be possible using these drawings to correctly and easily locate, identify and establish sizes of all piping, directions and the like, as well as other features of the work which will be concealed underground and/or in the finished building.

H. Locations of underground work shall be established by dimensions to columns, lines or walls, locating all turns, etc., and by properly referenced centerline or invert elevations and rates of fall.

I. For work concealed in the building, sufficient information shall be given so it can be located with reasonable accuracy and ease. In some cases, this may be by dimension. In others, it may be sufficient to illustrate the work on the drawings in relation to the spaces in the building near which it was actually installed. The Architect's/Engineer's decision in this matter will be final.

J. The following requirements apply to all "As-Built" drawings:
1. They shall be maintained at the Contractor's expense.
2. All such drawings shall be done carefully and neatly, and in a form approved by the Architect/Engineer.
3. Additional drawings shall be provided as necessary for clarifications.
4. These drawings shall be kept up-to-date during the entire course of the work and shall be available upon request for examination by the Architect/Engineer; and when necessary, to establish clearances for other parts of the work.
5. "As-built" drawings shall be returned to the Architect upon completion of the work and are subject to approval of the Architect/Engineer.

1.18 EXCAVATING AND BACKFILLING

A. Provide excavating and backfilling necessary for Work of this Division. Comply with provisions of Division 02, Site Work, if applicable.

B. Trenches shall be inspected by Code Authorities and/or Owner's Representative before and after piping is laid. Give Owner' Representative 24-hour notice for each inspection. If any trenches are filled without Owner's Representative inspection and as subsequently found to be deficient, the trenches shall be uncovered, inspected, and then re-filled, if requested by Owner's Representative.

C. Provide minimum 18 inches of cover or in compliance with local published frost line data (if greater than 18 inches) to finish grades or paving at water piping.

D. For piping, provide bell holes at trench bottom to assure uniform bearing. Accurately grade trench bottoms by instrument before laying any pipe.

E. Protect and maintain trenches in dry condition until piping has been inspected and approved. Immediately after approval, backfill trenches in tamped layers.

F. Compact fill to satisfaction of Architect and/or Owner's Representative.

1.19 CUTTING AND PATCHING

A. Comply with requirements of Division 00 & 01 regarding cutting and patching. Locate and timely install sleeves as required to minimize cutting and patching.

B. Cutting, fitting, repairing, patching, and finishing of Work shall be done by craftsmen skilled in their respective trades. Where cutting is required, cut in such a manner as not to weaken structure, partitions, or floors. Holes required to be cut must be cut or drilled without breaking out around the holes. Where patching is necessary in finished areas of the building, the Architect will determine the extent of such patching and refinishing.

C. Repairing Roadways and Walks: Coordinate all roadway work with authorities having jurisdiction. Cut and/or bore under roadways for connection of utilities as required. Coordinate work through General Contractor. Where this contractor cuts or breaks roadways, or walks to lay the piping, he shall repair or replace these sections to match existing, unless specifically identified as the responsibility of others.

1.20 PAINTING

A. Painting shall be provided by General Contractor's painting sub-contractor, unless specified otherwise. Leave exposed piping, materials, and equipment clean and free of rust, grease, dirt, etc. before and after painting.

B. Factory finished equipment, fixtures, and materials which are marred, chipped, scratched, or otherwise unacceptable shall be repaired or replaced under this Division to Architect satisfaction, at no additions cost to Owner.

C. Coordinate all painting requirements with prime bidder prior to bids.

D. Paint all exposed piping inside and outside of building. Label all piping after painting in accordance with Section 230553. Utilize industry standard paint colors for respective system unless directed otherwise by Architect. Review proposed color scheme with Architect/Engineer prior to ordering materials.

1.21 CLEANING AND ADJUSTING:

A. Upon completion of his work, the Contractor shall clean and adjust all equipment, controls, valves, etc.; clean all piping, ductwork, etc.; and leave the entire installation in good working order.

1.22 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Provide the Owner with three (3) copies of printed instructions indicating various pieces of equipment by name and model number, complete with parts lists, maintenance and repair instructions and test and balance report.

B. Copies of shop drawings will not be acceptable as operation and maintenance instructions.

C. This information shall be bound in plastic hardbound notebooks with the job name, Architect and Engineer names permanently embossed on the cover. Rigid board dividers with labeled tabs shall be provided for different pieces of equipment. Submit manuals to the Architect for approval.

D. In addition to the operation and maintenance brochure, the Contractor shall provide a separate brochure which shall include registered warranty certificates on all equipment, especially any pieces of equipment which carry warranties exceeding one (1) year.

E. The operation and maintenance brochure shall be furnished with a detailed list of all equipment furnished to the project, including the serial number and all pertinent nameplate data such as voltage, amperage draw, recommended fuse size, rpm, etc. The Contractor shall include this data on each piece of equipment furnished under this contract.

F. Contractor shall provide electronic (PDF) format copies of all Operation and Maintenance Instruction on disk.

1.23 GUARANTEE

A. The Contractor shall guarantee all materials, equipment and workmanship for a period of one (1) year from the date of final acceptance of the project. This guarantee shall include furnishing of all labor and material necessary to make any repairs, adjustments or replacement of any equipment, parts, etc. necessary to restore the project to first class condition. This guarantee shall exclude only the changing or cleaning of filters. Warranties exceeding one (1) year are hereinafter specified with individual pieces of equipment.

B. If the Contractor's office is in excess of a fifty (50) mile radius of the project, he shall appoint a local qualified contractor to perform any emergency repairs or adjustments required during the guarantee period. The name of the contractor appointed to provide emergency services shall be submitted to the Architect for his approval.

1.24 LOCAL CONDITIONS

A. The location and elevation of all utility services is based on available surveys and utility maps and are believed to be reasonably accurate; however, these shall serve as a general guide only, and the Contractor shall visit the site and verify the location and elevation of all services to his satisfaction in order to determine the amount of work required for the execution of the Contract.

B. The Contractor shall contact the various utility companies, determine the extent of their requirements and he shall include in his bid all lawful fees and payments required by these companies for complete connection and services to the building, including meters, connection charges, street patching, extensions from meters to main, etc.

C. In case major changes are required, this fact, together with the reasons therefore, shall be submitted to the Architect, in writing, not less than seven (7) days before the date of bidding. Failure to comply with this requirement will make the Contractor liable for any changes, additions, and expenses necessary for the successful completion of the project.

1.25 MINOR DEVIATIONS

A. Plans and detail sketches are submitted to limit, explain and define conditions, specified requirements, pipe sizes, etc. Structural or other conditions may require certain modifications from the manner of installation shown, and such deviations are permissible and shall be made as required. However, specified sizes and requirements necessary for satisfactory operation shall remain unchanged. It may be necessary to shift ducts or pipes, or to change the shape of ducts, and these changes shall be made as required. All such changes shall be referred to the Architect for approval before proceeding. Extra charges shall not be allowed for these changes.

B. Only typical details are shown on the Plans. In cases where the Contractor is not certain about the installation of his work, he shall ask for details. Lack of details will not be an excuse for improper installation.

C. In general, the drawings are diagrammatic and the Contractor shall install his work in a manner so that interferences between the various trades are avoided. In cases where interferences do occur, the Architect is to state which item was first installed.

1.26 VALVE TAGS

A. Secure metal tags to all valves. Labeling on all valve tags shall include type of system the valve controls and the area of building, zone, or equipment number affected by valve operation. Tag shall be 2" minimum diameter brass, engraved with code number, service and size. A framed list of the valves, giving manufacturer's name, model number, type and location shall be mounted in the main basement equipment room.

1.27 LABELING PLUMBING EQUIPMENT

A. All equipment furnished under the contract documents shall be labeled with permanent laminated plate secured to equipment. Units shall be labeled as indicated on plans and schedules.

PART 2 - PRODUCTS (Not applicable)

PART 3 - EXECUTION (Not applicable)

END OF SECTION 220000

SECTION 220500
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. This Section includes the furnishing and installation of common work results for plumbing which includes the following related components:
1. Strainers
2. Water hammer arresters
3. Valves
4. Hydrants
5. Hose bibbs and sill faucets
6. Backflow preventers
7. Pressure regulating and reducing valves
8. Pressure-temperature relief valves

1.3 SUMMARY

A. This Section specifies the water distribution piping system, including potable cold, hot, and recirculated hot water piping, fittings, and specialties within the building.

1.4 DEFINITIONS

A. Water Distribution Piping: A pipe within the building or on the premises which conveys water from the water service pipe or meter to the points of usage.

B. Water Service Piping: The pipe from the water main or other source of potable water supply to the water distributing system of the building served.

1.5 SUBMITTALS

A. Refer to Division 01 and Basic Mechanical Requirements for administrative and procedural requirements for submittals.

B. Product Data: Submit manufacturer's product data for the following products that apply to this project scope:
1. Strainers
2. Water hammer arresters
3. Valves
4. Hydrants
5. Hose bibbs and sill faucets
6. Backflow preventers

7. Pressure regulating and reducing valves
8. Pressure-temperature relief valves

C. Coordination Drawings: Prepare and submit coordination drawings for Water Distribution Piping in accordance with Division 23 - Basic Mechanical Requirements.

D. Maintenance Data: Submit maintenance and operating data. Include this data in maintenance manual in accordance with requirements of Division 01 and Division 23 - Basic Mechanical Requirements for the following products that apply to this project scope:
1. Strainers
2. Valves
3. Hose bibbs and sill faucets
4. Backflow preventers
5. Pressure regulating and reducing valves
6. Pressure-temperature relief valves

E. Quality Control Submittals:
1. Submit welders' certificates specified in Quality Assurance below.
2. Submit certification of compliance with ASME and UL fabrication requirements specified in below.
3. Submit reports specified in Part 3 of this Section.

1.6 QUALITY ASSURANCE

A. Codes and Standards
1. Plumbing Code Compliance: Comply with applicable portions of Edition 2015 of the International Plumbing Code.
2. ASME Compliance: Fabricate and stamp pressure-temperature relief valves to comply with ASME Boiler and Pressure Vessel Code.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store pipe in a manner to prevent sagging and bending.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate the installation of pipe sleeves for foundation wall penetrations.

1.9 MAINTENANCE

A. Spare Parts:
1. Furnish to Owner, with receipt, one valve key for each key operated hydrant, bibb, or faucet installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer uniformity: Conform with the requirements specified in Basic Mechanical Requirements, under "Product Options" for the following water distribution piping products.

2.2 VALVES

A. Ball, butterfly, check, and drain valves are specified in Section 22 05 19 “Plumbing Piping”.

B. Balance Cocks:
1. Threaded Ends 2" and Smaller: Class 125, bronze body, bronze plug, screw driver operated, straight or angle pattern.
2. Soldered Ends 2" and Smaller: Class 125, bronze body, bronze plug, screw driver operated, straight or angle pattern.

2.3 PIPING SPECIALTIES

A. Water Hammer Arresters: Bellows type, with stainless steel casing and bellows, pressure rated for 250 psi, tested and certified in accordance with PDI Standard WH-201.

B. Basket Strainers: Cast-iron body, 125 psi flanges, bolted type or yoke type cover; with removable non-corrosive perforated strainer basket having 1/8" perforations and lift-out handle.

C. Flexible connectors: Stainless steel bellows with a woven flexible bronze wire reinforcing protective jacket; rated for 150 psig water working pressure, 250 deg F operating temperature and suitable for up to maximum 3/4" misalignment. Connectors shall be a minimum of 12" long and have threaded or flanged ends; sweat ends are not acceptable.

D. Recessed Non-Freeze Wall Hydrants: Cast-bronze box, with chrome plated face, tee handle key, vacuum breaker, hinged locking cover, 3/4" inlet, and hose outlet. Bronze casing shall be length to suit wall thickness.

E. Backflow Preventers: Reduced pressure principle assembly consisting of shutoff valves on inlet and outlet, and strainer on inlet. Assemblies shall include test cocks, and pressure-differential relief valve located between 2 positive seating check valves, and comply with requirements of ASSE Standard 1013. Backflow preventer shall be with drain funnel.

F. Pressure Regulating Valves: Single seated, direct operated type; having bronze body with integral strainer and complying with requirements of ASSE Standard 1003.

G. Relief Valves:

1. Provide proper size for relief valve, in accordance with ASME Boiler and Pressure Vessel Codes, for indicated capacity of the appliance for which installed.
2. Combined Pressure- Temperature Relief Valves: Bronze body, test lever, thermostat, complying with ANSI Z21.22 listing requirements for temperature discharge capacity. Provide temperature relief at 210 deg. F, and pressure relief at 150 psi.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify all dimensions by field measurements. Verify that all water distribution piping may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.

B. Examine rough-in requirements for plumbing fixtures and other equipment having water connections to verify actual locations of piping connections prior to installation.

C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 JOINING PIPES AND FITTINGS

A. Copper Tubing: Solder joints in accordance with the procedures specified in ANSI B9.1, using lead free piping, solder, and flux. Lead free, when used with respect to solder and flux, refer to solder and flux containing not more than 0.2 percent lead. When used with respect to pipe and fittings, lead free refers to pipe and fittings containing not more than 6.0 percent lead.

3.3 PIPING INSTALLATION

A. Refer to the separate Division 230020 section: “Basic Mechanical Requirements”, for general piping installation instructions.

B. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

C. Install gravity drainage piping with minimum 1/32" per foot (1/4 percent) downward slope towards drain point unless specified otherwise, herein.

3.4 INSTALLATION OF VALVES

A. Installation requirements for general duty valves are specified in a separate Section of Division 23.

B. Sectional Valves: Install sectional valves on each branch and riser, close to main. For sectional valves 2" and smaller, use ball valves; for sectional valves 2-1/2" and larger, use gate or butterfly valves.

C. Shutoff Valves: Install shutoff valves on inlet of each plumbing equipment item, and on inlet of each plumbing fixture, and elsewhere as indicated. For shutoff valves 2" and smaller, use ball valves; for shutoff valves 2-1/2" and larger, use butterfly valves.

D. Drain Valves: Install drain valves on each plumbing equipment item, located to completely drain equipment for service or repair. Install drain valves at the base of each riser, at low points of horizontal runs, and elsewhere as required to completely drain distribution piping system. For drain valves 2" and smaller, use gate or ball valves; for drain valves 2-1/2" and larger, use gate or butterfly valves.

E. Check Valves: Install swing check valves on discharge side of each pump, and elsewhere as indicated.

F. Balance Cocks: Install in each hot water recirculating loop, discharge side of each pump, and elsewhere as indicated.

3.5 INSTALLATION OF PIPING SPECIALTIES

A. Install pressure regulating valves with inlet and outlet shutoff valves and balance cock bypass. Install pressure gage on valve outlet.

3.6 EQUIPMENT CONNECTIONS

A. Piping Runouts to Fixtures: Provide hot and cold-water piping runouts to fixtures of sizes indicated on plans. Connect cold water to hot and cold-water faucet connections where hot water is not provided.

B. Mechanical Equipment Connections: Connect hot and cold-water piping system to mechanical equipment. Provide shutoff valve and union for each connection, provide drain valve on drain connection. For connections 2-1/2" and larger, use flanges instead of unions.

3.7 FIELD QUALITY CONTROL

A. Inspections:
1. Do not enclose, cover, or put into operation water distribution piping system until it has been inspected and approved by the Architect.
2. During the progress of the installation, notify the Architect, at least 24 hours prior to the time such inspection must be made. Perform tests specified below in the presence of the Architect.
3. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.
4. Final Inspection: Arrange for a final inspection by the Architect to observe the tests specified below and to ensure compliance with the requirements of the plumbing code.
5. Reinspections: Whenever the Architect finds that the piping system will not pass the test or inspection, make the required corrections, and arrange for reinspection by the Architect.
6. Reports: Prepare inspection reports, signed by the Architect.

B. Piping System Test:
1. Test for leaks and defects all water distribution piping systems. If testing is performed in segments, submit a separate report for each test, complete with a diagram of the portion of the system tested.
2. Leave uncovered and unconcealed all water distribution piping until it has been tested and approved. Expose all such work for testing, that has been covered or concealed before it has been tested and approved.
3. Cap and subject the piping system to a static water pressure of 50 psi above the operating pressure without exceeding the pressure rating of the piping system materials. Isolate the test source and allow to stand for a period of 4 hours. Leaks and loss in test pressure constitute defects which must be repaired.
4. Repair all leaks and defects using new materials and retest system or portion thereof until satisfactory results are obtained.
5. Prepare reports for all tests and required corrective action.

3.8 ADJUSTING AND CLEANING

A. Cleaning and Disinfecting:
   1. Purge all new water distribution piping systems and parts of existing systems, which have been altered, extended, or repaired prior to use.
   2. Reports:
      a. Prepare reports for all purging and disinfecting activities.

3.9 STERILIZATION

A. Sterilize water lines in strict accordance with State Board of Health requirements. After flushing out, obtain approval of water sample analysis from State Board of Health and submit to Architect.

END OF SECTION 220500

STATE OF LOUISIANA
R. CRAIG CAMPBELL, II
License No. 29380
3/10/26
PROFESSIONAL
ENGINEER

SECTION 220519
PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. This Section includes the following basic mechanical materials and methods to complement other Divisions and Sections.
1. Piping materials and installation instructions common to most piping systems.
2. Pipe Specialties.
3. Sleeves.
4. Valves and Unions.
5. Shock Absorbers.
6. Escutcheons.
7. Flashing.
8. Access Panels.
9. System Accessories.

B. Pipe and pipe fitting materials are specified in individual piping system Sections.

1.3 ELECTRICAL WORK

A. All electrical equipment shall have the U.L. Label and shall meet the standards of the National Electrical Code and NEMA.

PART 2 - PRODUCTS

2.1 PIPE:

A. Sanitary Sewer Waste and Vent Lines Above and Below Slab (PVC-DWV):
1. Piping below slab, unless otherwise shown or specified, shall be constructed of solid wall Schedule 40 PVC "DWV" plastic pipe and fittings conforming to ASTM D265 and ASTM D1785 with solvent welded joints.
2. All sanitary sewer lines below the slab shall be supported at no more than 4 ft. intervals with 3/8" (minimum) round stainless steel hangers secured in the slab above.
3. Sanitary sewer pipe penetrating concrete slabs shall be wrapped with Virginia Chemical K-501, Benjamin Manufacturing Model 6200, or equal foam insulation tape.

B. Domestic Cold and Hot Water Lines, Tepid Water (if required) lines:
1. All such lines shall be Government Type "L", hard copper water tubing of standard weight and thickness as made by Mueller, Chase, Anaconda or equivalent, unless indicated otherwise. Use 95-5 lead-free solder on all piping above slab. Use Silfos 1000° lead-free solder on all piping beneath the slab.
2. In certain areas, type "L" soft copper without joints below slab shall be used only where indicated on the Plans. Piping shall be completely insulated per Section 220700.
3. Domestic cold-water lines penetrating concrete slabs shall be wrapped with "Protect-O-Sleeve" vinyl flexible tube as manufactured by Robert H. Harris Co., or equivalent. Sleeve shall have a minimum thickness of .025” (0.635 mm).
4. Domestic hot water lines shall be insulated at all penetrations through slab per insulation (see Section 220700).

C. Water Heater Relief Lines:
1. These shall be Government Type "L" hard copper.

D. Trap Primer Lines:
1. All such lines shall be Type "L" soft copper, without joints.

2.2 PIPE SPECIALTIES

A. Dielectric unions shall be used between copper and iron pipe.

2.3 PIPE HANGERS AND SUPPORTS

A. This Contractor shall furnish and install all foundations and supports required for his equipment unless indicated otherwise on the Drawings.

B. This Contractor shall furnish and install all escutcheons, inserts, thimbles, hangers, etc. required for the proper support and installation of his equipment and piping and he shall cooperate with other trades in locating and placing these items.

2.4 PROVIDE SLEEVES FOR ALL PIPES PASSING THROUGH WALLS, FLOORS, BEAMS, ETC.

A. Sleeves passing through structural members or concrete footings shall be of cast iron or Schedule 40 steel pipe. Sleeves passing through nonstructural walls or floors shall be of 26-gauge galvanized iron. Joints between sleeves and pipes passing through floors shall be made weather tight with plastic materials. Where pipes pass through water proofing membrane, flashing sleeves shall be installed.

B. Provide Grinnell, Fee & Mason, or equivalent malleable iron split ring hangers with rod supports throughout. Strap hangers or wire will not be accepted.

C. Maximum spacing of hangers for cast iron pipes shall be 5 ft.; for other than soil, use 10 ft.

D. Provide galvanized iron shields between hangers and pipe covering.

E. Provide Grinnell, Fee & Mason, Crane or equivalent heavy steel riser clamps on vertical risers at floors to support pipes.

F. Provide producer specialty, Jones Manufacturing or equal chrome plated brass escutcheons wherever pipes pass through floors, walls, or ceilings in exposed or finished areas.

G. All piping projecting from chases shall be rigidly supported in the wall or chase. Loosely supported fixtures or accessories will not be accepted.

2.5 VALVES AND UNIONS

A. Furnish and install all valves, unions, stops, connections, etc. shown on plans and necessary to make a complete system in working order. Provide valves on inlet and outlet of all equipment and fixtures and on branch lines to fixtures or groups of fixtures.

B. Ball Valves, 3" and smaller, rated for 150 PSI saturated steam pressure, 600 PSI WOG pressure; shall be 2-piece construction, bronze body conforming to ASTM B-62, conventional port, chrome-plated brass ball, replaceable TFE seats and seals, blow-out proof stem, and vinyl-covered steel handle. Provide solder ends for domestic hot and cold-water service of NIBCO Design S-580-70, Milwaukee BA-150-S or equal, threaded ends of heating hot water and low pressure steam of NIBCO Design T-580-70, Milwaukee BA-100-S or equal. At Contractor=s option, Victaulic Style 722 or 721 ball valves may be used.

C. All valves, unions, etc. where pipe is chrome plated shall have similar finish. All exposed supplies to plumbing fixtures shall be chrome plated.

D. Gate Valves, 2-Inch and Smaller: MSS SP-80; Class 125, body and bonnet of ASTM B 62 cast bronze; with threaded or solder ends, solid disc, copper-silicon alloy or bronze stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Provide Class 150 valves meeting the above where system pressure requires.

E. Gate Valves, 2-1/2-Inch and Larger: MSS SP-70; Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B; with flanged ends "Teflon" impregnated packing, and two-piece backing bland assembly.

F. Globe Valves, 2-Inch and Smaller: NSS SP-80; Class 125; body and screwed bonnet of ASTM B 62 cast bronze; with threaded or solder ends, brass or replaceable composition disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Provide Class 150 valves meeting the above where system pressure requires.

G. Butterfly Valves, 2-1/2-Inch and Larger: MSS SP-67; rated at 200 psi; cast-iron body conforming to ASTM A 126, Class B. Provide valves with field replaceable EPDM sleeve, nickel-plated ductile iron disc (except aluminum bronze disc for valves installed in condenser water piping), stainless steel stem, and EPDM O-ring stem seals. Provide lever operators with locks for sizes 2 through 6 inches and gear operators with position indicator for sizes 8 through 24 inches. Provide "Non-Leakage" full threaded lug flange body type capable of being broken down at one side of the valve remaining closed. Drill and tap valves on dead-end service or requiring additional body strength. At Contractor=s option Victaulic 300 BFV for grooved piping systems may be used.

H. Wafer Check Valves: Class 2500, cast-iron body; with replaceable bronze seat, and non-slam design lapped and balanced twin bronze flappers and stainless-steel trim and torsion spring. Provide valves designed to open and close at approximately one-foot differential pressure.

I. Select Valves with the following ends or types of pipe/tube connections:
   1. Copper Tube Size 2 Inch and Smaller: Solder ends, except provide threaded ends for heating hot water.
   2. Steel Pipe Sizes, 2 Inch and Smaller: Threaded or grooved end.
   3. Steel Pipe Sizes, 2-1/2 Inch and Larger: Grooved end or flanged.

2.6 SHOCK ABSORBERS

A. All water service to fixtures or groups of fixtures shall have concealed lead free ASSE 1010 compliant water hammer arrestors on both hot and cold-water branches. Locate shock absorbers close to fixture or at end of header.

2.7 ESCUTCHEONS

A. Provide escutcheons for all exposed lines passing through floors, walls, and ceilings. They shall be chrome plated brass and shall be of such flange size as to cover necessary penetrating openings.

2.8 FLASHING

A. Flash all vent penetrations through roof. Extend flashing approximately 10 inches in all directions at base and turn ends down into top of pipe. Off-set vents where necessary to provide 4 feet minimum clearance from other flashing such as outside walls, curbs, etc. Note: All vents shall be 40 feet from fresh air intakes.

2.9 ACCESS PANELS

A. Furnish and install access panels where valves, dampers, control boxes, etc. are concealed in walls, ceilings, floors, or otherwise inaccessible or where specifically called for on plans. Panels shall be Milcor Style DW, or Bar-Co. Model 500, J-L Industries Model WB, or equal sized as required and furnished with prime coat finish.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING:

A. All pipe shall be true and straight, without sags or traps.

B. The Contractor shall exercise care in cleaning joints after making cuts on pipe to prevent pipe particles from entering the system.

C. All pipe fittings shall be same as piping specified unless indicated otherwise.

D. Arrange, install piping approximately as indicated, straight, plumb and as direct as possible; form right angles, or parallel lines with building walls. The most practical appearance of piping runs is required. Keep pipes close to walls, partitions, ceilings; off-set only where necessary to follow walls as directed.

E. Before installing piping, check plumbing drawings with architectural, mechanical, structural, electrical drawings; make accurate layout of plumbing and HVAC piping. Where interferences may appear and departures from indicated arrangements are required, consult with other trades involved; come to agreement as to changed locations and elevations of piping; obtain approval of proposed changes. Note runs of other contractor's piping and large conduits and cooperate to achieve neat appearance.

F. Unless otherwise indicated, conceal all piping in building construction in finished areas. Install such piping in time so as not to cause delay to work of other trades and to allow ample time for tests and approval; do not cover before approval is obtained.

G. Locate groups of pipes parallel to each other and building lines; space them at distance to permit access for servicing, valves, and to create most practical appearance when racked with conduits, refrigerant, etc., provided by other contractors.

H. Keep fixture branches concealed to points above floor close to fixtures; expose only as much as necessary for final connection. Rigidly support pipes projecting from walls, chases, etc. in wall or chase to make firm, well-braced installation. Loosely supported pipe or accessory is not acceptable.

I. Install horizontal piping to coordinate with other trades and install without sags or humps.

J. Grade inside sewer piping at uniform slope of 1/4 inch per foot, minimum; where this is impossible, maintain slope as directed but in no case less than 1/8 inch per foot. Waste lines 3 inches and smaller must grade at minimum 1/4 inch per foot. See Drawings for fall on exterior sewer lines.

K. Grade other piping as specified under heading or service where used, or as directed.

L. Keep piping free from scale and dirt, protect open pipe ends wherever work is suspended during construction. To prevent foreign bodies entering and lodging in pipe, use temporary plugs or other approved material.

M. Where changes in pipe sizes occur, do not bush down; use only reducing fittings. For drainage piping changes in direction, use long sweep bends where possible; otherwise, short sweep 1/4 bends or combination Y and 1/8 bends; also, Ys in combination with other bends.

N. Provide shut off valves at all supply connections to all equipment. Supplier of equipment shall provide rough-in drawings and this contractor shall fully connect all items, supply necessary piping and fittings as required, unless otherwise noted individually.

O. Buried thermoplastic piping systems shall be installed in accordance with ASTM D2321.

P. Do not locate valves with stems below horizontal.

Q. Locate valves for easy access and operations. Where concealed, notify General Contractor of exact location in order that he may leave openings for access panels. Provide access panels.

R. Provide unions, screwed or flanged, where indicated, and in following locations even if not indicated.

S. In connection to equipment requiring disconnection for repairs or replacement. Locate between shut-off and equipment.

T. Approved expansion joints or flexible couplings shall be provided as necessary.

U. Care shall be taken in making up pipe and fittings such that the pipe does not extend into fitting sufficiently to reduce the waterway.

V. Standard, one-piece reducing fittings of approved design shall be used wherever a change in size is made. Changes in pipe sizes shall not be made by means of reducing flanges.

W. Bushings may be used only where standard, one-piece reducing fittings are not available and shall be subject to the following:
1. Bushings shall be of the face or flush type.
2. Bushings shall not be used in elbow fittings.
3. Bushings shall not be used when the reduction in size of the outlet is less than 2".
4. Bushings shall not be used in more than one outlet of any tee or two outlets of any cross fitting.

3.2 INSTALLATION OF VALVES

A. Use ball and butterfly valves for shut-off duty.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

D. Install three-valve bypass around each pressure reducing valve using throttling-type valves.

E. Install valves in horizontal piping with stem at or above the center of the pipe.

F. Install valves in a position to allow full stem movement.

G. All valves, unions, etc. where pipe is chrome plated shall have similar finish. All exposed supplies to plumbing fixtures shall be chrome plated.

H. All valves, on insulated piping shall be complete with extended lever handle stem.

3.3 PIPE MARKERS

A. Provide pipe markers and directional arrows on all piping and on both sides of all valves located above ceiling. Markers shall be as manufactured by W.H. Bradley Co., or the equivalent. All letters shall be color-coded and sized as recommended by OSHA. Samples of the type of letters to be used shall be submitted with shop drawings.

B. The following pipe and valves shall be identified:

		Piping	Valves
1.	Domestic Cold Water	X	X
2.	Domestic Hot Water Supply	X	X
3.	Domestic Hot Water Return	X	X
4.	Tepid Water Supply (if required)	X	X
5.	Tepid Water Return (if required)	X	X
6.	Sanitary Sewer Waste	X	
7.	Sanitary Sewer Vent	X	

C. Pipe markers with arrows shall indicate lines content and shall be located 20 feet on center and at each change of direction of line. Identification bands shall be color coded to match pipe markers and shall be provided 10 feet on center. Pipe identification markers shall be taped at each end and shall be taped around the entire circumference of pipe.

3.4 TEST

A. Make such tests of work as specified, or required by Architect or by State and Municipal Bureaus having jurisdiction, and under their supervision. Perform tests in presence of Architect's representative. Notify Architect two days prior to testing.

B. Provide apparatus, temporary piping connections, or other requirements necessary for tests. Take precautions to prevent damage to building or contents by tests. Contractor is required to repair and make good at his expense damage so caused.

C. For Drain, Waste, and Vent piping, use hydrostatic test to 10 feet of head. Do not use compressed air or gas.

D. Correct leaks, defects, or deficiencies discovered as result of tests. Repeat tests until test requirements are fully complied with. Caulking of pipe joints to remedy leaks is not permitted.

3.5 STERILIZATION

A. Sterilization all water lines in strict accordance with State Board of Health requirements. After flushing out, obtain approval of water sample analysis from State Board of Health and submit approval report to Architect.

END OF SECTION 220519

SECTION 220700
PLUMBING INSULATION

STATE OF LOUISIANA
R. CRAIG CAMPBELL, II
License No. 29380
3/10/26
PROFESSIONAL
ENGINEER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. Pipe insulation shall not begin until all work has been tested and found to be tight. All insulation adhesives, sealers, tapes and mastic shall meet the latest NFPA requirements and shall meet 25/50/50 flame spread and smoke developed ratings.

B. All insulation shall be installed in strict accordance with the manufacturer's recommendations.

C. All pipe insulation where recommended by the manufacturer shall be banded with aluminum bands, three to a section and with one band on each side of each fitting, valve, etc.

D. Insulation shall be continuous through walls and ceilings.

E. All valves, strainers, etc. shall be insulated to maintain the same thermal resistance rating as its adjacent piping and the covering shall extend all the way up to the equipment.

F. Use high density insulation inserts at hangers on all piping 1-1/2" and above to prevent crushing of insulation.

PART 2 - PRODUCTS

2.1 THERMAL INSULATION

A. After all work has been tested and approved, insulate as follows:
   1. Insulation shall be installed in accordance with the manufacturer's recommendations and instructions.

2.2 DOMESTIC WATER AND TEPID WATER PIPING

A. Cover all domestic cold water lines (1/2” to 2 ½”) with 1/2” thick, high density fiberglass insulation with Universal Fire-Retardant Jacket, Owens/Corning "25 ASJ/SSL", Knauf ASJ-SSL, or equal. All laps are to be sealed and stapled in place. Fittings are to be mitered segments of insulation held in place with white vapor barrier tape. In addition, cover all pipe and fittings with 0.020 PVC jacket and fitting covers equal to Zeston 25/50 PVC, Knauf 25/50 rated PVC with solvent welded joints.

B. Domestic cold water lines (2 1/2" and above) shall be insulated with 1-1/2" thick fiberglass with jacket. In addition, cover all pipe and fittings with 0.020 PVC jacket and fitting covers equal to Zeston 25/50 PVC, Knauf 25/50 rated PVC with solvent welded joints.

C. Cover all domestic hot water lines, hot water return lines, tepid supply water lines and tepid water return lines (1/2” to 2 ½”) above slab with 1" thick, high density fiberglass insulation with Universal Fire- Retardant Jacket, Owens/Corning "25 ASJ/SSL", Knauf ASJ-SSL, or equal. All laps are to be sealed and stapled in place. Fittings are to be mitered segments of insulation held in place with white vapor barrier tape. In addition, cover all pipe and fittings with 0.020 PVC jacket and fitting covers equal to Zeston 25/50 PVC, Knauf 25/50 rated PVC with solvent welded joints,

D. Domestic hot water lines, hot water return lines, tepid water lines and tepid water return lines (2 1/2" and above) shall be insulated with 1-1/2" thick fiberglass with jacket. In addition, cover all pipe and fittings with 0.020 PVC jacket and fitting covers equal to Zeston 25/50 PVC, Knauf 25/50 rated PVC with solvent welded joints.

E. All water lines on the outside of the building exposed to the weather shall be covered with 0.016” smooth aluminum jacket and elbows.

F. Domestic cold and hot water lines run below slab within building shall be insulated with 3/4" thick closed cell tube insulation. Apply two (2) coats of mastic on insulation.

2.3 WASTE LINES and P-TRAPS RECEIVING A/C CONDENSATE

A. Waste lines and P-traps receiving HVAC condensate shall be insulated with 2.33" thick 3/4 # density fiberglass ductwrap insulation with white metalized polypropylene (PSK) vapor barrier jacket. Insulation shall be sealed at all seams and joints with matching reinforced tape.

2.4 LAVATORY P-TRAP & SUPPLY LINES

A. Unless specified otherwise on drawings, insulate p-trap, tailpiece and water supplies on lavatories/sinks with white, Truebro Model 102 Handi Lav-Guard, Pro-Wrap A.D.A. lavatory insulation kit, or approved equivalent insulating system to meet A.D.A. Requirements. Provide accessories for offset tailpiece as required.

PART 3 - EXECUTION

3.3 INSULATION THROUGH HANGERS AND SLEEVES

A. The insulation shall be continuous through pipe hangers and pipe sleeves. At hangers where the pipe is supported by insulation, provide a galvanized iron protection shield. Provide pipes 2-inch i.p.s. and larger in insulation inserts at points of hanger supports. The inserts shall be of calcium silicate, cellular glass, prestressed molded glass fiber of minimum 13-pound density, or other approval material of the same thickness as adjacent insulation and not less than 13-pound density. The inserts shall have sufficient compression strength to adequately support the pipe without compressing the inserts to a thickness less than the adjacent insulation. Inserts shall be 180 degrees and not less than the length of the protection shield. Vapor barrier facing of the insert shall be the same as the facing on the adjacent insulation. Where copper clad hangers are used on domestic copper pipe, insulation may cover pipe and hanger. Provide 18-gauge metal saddles between all hangers and insulation.

END OF SECTION 220700

SECTION 220800
COMMISSIONING OF PLUMBING SYSTEM

PART 1 - GENERAL

1.1 COMMISSIONING PROCESS

A. Section includes commissioning process requirements for the plumbing – domestic hot water system, assemblies and equipment.

B. The commissioning agent (CxA) is a subcontractor directly to the general contractor for this project. The CxA has overall responsibility for planning and coordinating the commissioning process. However, commissioning involves all parties to the design and construction process, including the contractor and their subcontractors.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including general and supplementary conditions, general electrical provisions and applicable Divisions 21, 23, 26 and 28 Specification sections, apply to work of this section.

1.3 DEFINITIONS

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

B. CxA: Commissioning Agent.

C. 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 DESCRIPTION OF WORK

A. The purpose of the commissioning process is to provide the owner/operator of the facility with assurance that the Domestic Water System has been installed according to the contract documents, and will operate within the performance guidelines set out in the specifications. The CxA will provide the owner with an unbiased, objective view of the system's installation, operation, and performance. The commissioning process does not take away or reduce the responsibility of the installing contractors to provide a finished product, installed and fully functional in accordance with the contract documents.

B. Commissioning is intended to enhance the quality of system start-up and aid in the orderly completion and transfer of systems for beneficial use by the owner. The CxA will be the leader of the commissioning team, planning and coordinating all commissioning activities in conjunction with the design professionals, construction manager, subcontractors, manufacturers, and equipment suppliers.

C. The General Contractor, plumbing/mechanical Contractor, and all Division 22 sub-contractors shall be responsible for cooperating, and coordinating their work, with the CxA. They shall also be responsible for carrying out all the physical activities required for installation of components and systems, and operating them during the commissioning process as required in this Section.

1.5 REFERENCES

A. ASHE Commissioning Guideline-2010

B. ASHRAE Guideline 1-2007 The HVAC Commissioning Process

C. ASHRAE Guideline 0-2005 The Commissioning Process

1.6 PLUMBING SYSTEMS TO BE COMMISSIONED

A. Plumbing – Domestic Water systems installed under this contract are to be inspected, tested, signed off as complete and operational, and operated for commissioning agency verification as described in Part 3 of this Section. This includes but is not necessarily limited to the work listed for each system. The foregoing includes all the following:
   1. Recirculating pumps
   2. Mixing/balancing valves
   3. Operational temperatures

B. The contractor shall be responsible for carrying out all work required for commissioning these systems that is defined as a contractor responsibility in Part 3 of this Section.

1.7 PRE-FUNCTIONAL CHECKLISTS

A. The CxA will develop pre-functional checklists for every piece of equipment within the scope of the commissioning project, and those checklists shall include all items included in the specific design that require checking. Pre-functional testing of the systems is performed by the contractors.

1.8 FUNCTIONAL PERFORMANCE TEST CHECKLISTS

A. Commissioning agent will develop functional performance test checklists for every system included within the scope of the commissioning project. Start-up of major equipment will be performed by the contractor or manufactures representative and witnessed by the CxA.

1.9 MEMBERS OF THE COMMISSIONING TEAM

A. The commissioning team will be comprised of representatives from each discipline involved in the commissioning process. The core members of the team will be required to attend all meetings.

B. Team Members Appointed by Contractor(s):
   1. Representatives of each contractor, including project superintendent and subcontractors, installers, vendor, suppliers, and specialists deemed appropriate by the CxA. The individuals shall each have authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated actions.
   2. The commissioning team will meet on a regular basis as defined by the CxA in the "kick-off" meeting. The frequency of the meetings will be determined by the activity of the construction and the nearness to completion of each specialty.
   3. Non-core team members will be required to attend meetings as scheduled by the team in order to provide seamless continuity to the commissioning progress

schedule.

PART 2 - EXECUTION

2.1 COMMISSIONING RESPONSIBILITIES - CONTRACTOR TEAM MEMBERS

A. Provide the following information to the CxA for inclusion in the commissioning process:
1. Deliver submittals, systems manuals, and other documents and reports as needed.
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 systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of readiness, signed by the Contractor, certifying that the system, assemblies, equipment, components, and associated controls are ready for testing.
5. Test and inspection reports and certificates.
6. Corrective action documents.
7. Verification of testing, adjusting, and balancing reports.

2.2 CONTRACTOR/SUBCONTRACTOR RESPONSIBILITIES

A. This Section of the specifications defines the contractor's responsibilities with respect to the commissioning process. Each contractor and sub-contractor shall review this Section and carry out the work described as it applies to each Division and Section of these specifications individually and collectively.

B. Each Contractor and their subcontractors at a minimum shall assign representatives with expertise and authority to act on their behalf and shall schedule them to participate on the Commissioning Team and perform commissioning process activities including, but not limited to the following:
1. Evaluate performance deficiencies identified in test reports, and with approval of the design authority and the entity responsible for system and equipment installation, implement corrective action.
2. Cooperate with CxA for resolution of issues recorded in Action Items Log
3. Attend and participate in commissioning team meetings.
4. Integrate and coordinate commissioning process activities into the construction schedule.
5. Review and accept construction checklists provided by the commissioning agent.
6. Complete manufacturer and commissioning checklists as work is completed and provide to the commissioning agent on a regular basis.
7. Review and accept commissioning process test procedures provided by the commissioning agent.
8. Complete commissioning process test procedures.

C. Construction manager
1. Participate in construction coordination.
2. Participate in the commission process and attend all meetings.
3. Develop the project schedule.
4. Work with the CxA to incorporate the commissioning schedule into the project schedule.

5. Ensure that subcontractors perform assigned responsibilities in a timely manner to meet the schedule.
6. Submit to CxA pre-functional test forms that meet the specifications and are typically used for the start-up of major equipment and systems.
7. Participate in maintenance orientation and inspection.
8. Participate in O&M training.
9. Certify work is complete and systems are operational.

D. Subcontractors
1. Participate in commissioning team meetings.
2. Cooperate with all commissioning team members and work in a cohesive manner to accomplish the commissioning process objectives.
3. Provide schedules for O&M data submittals and equipment start-up and testing to the CxA for incorporation into the commissioning plan. Update the schedule on a regular basis throughout the construction phase.
4. Provide information to the CxA for developing the construction phase commissioning plan.
5. Ensure participation of major equipment manufacturing in appropriate start-up, testing and training activities.
6. Provide sufficient personnel to assist the CxA as required during equipment start-up, system verification and functional performance testing.

2.3 PREFUNCTIONAL EQUIPMENT AND SYSTEMS STARTUP

A. Complete the pre-functional (PF) checklist and manufacturer checklists prior to scheduling functional testing.

B. Prior to start-up, inspect, check and confirm the correct and complete installation of all equipment and systems for which pre-functional checklists are included in the commissioning plan.

C. Document the results of all inspections and checks on the checklists and sign them. If deficient or incomplete work is discovered, ensure corrective action is taken and re-check until the results are satisfactory, and the system is ready for safe startup.

D. Notify the CxA a minimum of two weeks in advance of scheduled equipment and system start-ups, so that the CxA may witness system verifications, and equipment and system start-ups.

E. Provide equipment and systems start-up resources as specified and required. If during an attempted equipment or system start-up, deficient or incomplete work is discovered that would preclude safe operation, the start-up shall be aborted until corrective action has been taken. Ensure such action is taken and verified before re-scheduling a new start-up.

2.4 FUNCTIONAL PERFORMANCE TESTING

A. Carry out performance checks to ensure that all equipment and systems fully functional and ready for the CxA to witness formal functional performance tests (FTs).

B. Operate equipment and systems for FTs in accordance with the commissioning plan and as directed by the commissioning agency. If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FTs will be stopped by the CxA.

C. Ensure that all corrections necessary for full and complete system operation as specified are completed; then with applicable sub-contractors, carry out functional performance checks to confirm correct operation before applying to the CxA to reschedule the FTs for the system in question.

D. Assign technicians who are familiar with the construction and operation of the installed systems to operate and participate in the testing of the systems, assemblies, equipment, and components.

E. Assure that all subordinate contractors (sub-sub contractors, etc) meet the requirements of this section

F. Assure that vendors and suppliers required for the commissioning process are properly coordinated, scheduled, and participate as required.

G. Certify that the systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

H. Certify that the instrumentation and control system devices have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

I. 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).

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

2.5 GENERAL TESTING REQUIREMENTS

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

B. Scope of testing shall include the integration of this system with the other systems being commissioned. 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 system relays, controllers, and sensors.

D. The CxA shall prepare detailed testing plans, procedures, and checklists.

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

F. The CxA may direct that set points be altered when simulating conditions is not practical.

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

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

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

J. Participate in specified training sessions for owner's O & M personnel.

K. Gather and submit O & M data, coordination drawings and as-built drawings to the CxA.

END OF SECTION 220800

SECTION 221400
DRAINAGE AND VENT SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. This Section specifies building sanitary drainage and vent piping systems, building condensate drainage system, building grease waste drainage and vent system, and storm drainage and vent piping systems, including drains and drainage specialties.

1.3 DEFINITIONS

A. Building Drain: That part of the lowest piping of a drainage system which receives the discharge from soil, waste, and other drainage pipes inside the walls of the building and conveys it to the building sewer.

B. Building Sewer: That part of the drainage system which extends from the end of the building drain and conveys its discharge to a public sewer, private sewer, individual sewage disposal system, or other point of disposal.

C. Drainage System: Includes all the piping within a public or private premise which conveys sewage, rain water or other liquid wastes to a point of disposal. It does not include the mains of public sewer systems or a private or public sewage treatment or disposal plant.

D. Vent System: A pipe or pipes installed to provide a flow of air to or from a drainage system, or to provide a circulation of air within such system to protect trap seals from siphonage and back pressure.

1.4 SUBMITTALS

A. Refer to Division 01 and Division 23, Basic Mechanical Requirements for administrative and procedural requirements for submittals.

B. Product Data: Submit product data for the following products that apply to this project scope:
1. Drainage piping specialties
2. Floor drains.
3. Roof Drains

C. Quality Control Submittals:
1. Submit reports specified in Part 3 of this Section.

1.5 QUALITY ASSURANCE

A. Codes and Standards:
   1. Plumbing Code Compliance: Comply with applicable portions of Edition 2015 of the International Plumbing Code.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate the installation of roof drains, flashing, and roof penetrations.

B. Coordinate flashing materials installation of roofing, waterproofing, and adjoining substrate work.

C. Coordinate the installation of drains in poured-in-place concrete slabs, to include proper drain elevations, installation of flashing, and slope of slab to drains.

D. Coordinate with installation of sanitary and storm sewer systems as necessary to interface building drains with drainage piping systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer Uniformity: conform with the requirements specified in Division 23, Basic Mechanical Requirements, under "Product Options" for the following drainage and vent systems.

2.2 DRAINAGE PIPING SPECIALTIES

A. Backwater Valves: Valve assembly shall be bronze fitted cast-iron, with bolted cover. Flapper shall provide a maximum 1/4" clearance between flapper and seat for air circulation. Valve ends shall suit piping material.

B. Trap Primers: Bronze body valve with automatic vacuum breaker, with 1/2" connections matching piping system. Complying with ASSE 1018.

C. Expansion Joints: Cast-iron body with adjustable bronze sleeve, bronze bolts with wing nuts.

D. Cleanout Plugs: Cast-bronze or brass, threads complying with ANSI B2.1, countersunk head.

E. Floor Cleanouts: Cast-iron body and frame, and adjustable round top as follows:
   1. Nickel-Bronze Top: Manufacturer's standard cast unit with the following patterns:
   2. Exposed flush type, standard non-slip scored or abrasive finish.
   3. Cast-iron Top: Manufacturer's extra-heavy duty cast unit with the following patterns:
      a. Exposed flush type, standard non-slip scored or abrasive finish.
   4. Wall Cleanouts: Cast-iron body adaptable to pipe with cast-bronze or brass cleanout plug; stainless steel cover including screws.
   5. Flashing Flanges: Cast-iron watertight stack or wall sleeve with membrane flashing ring. Provide underdeck clamp and sleeve length as required.

6. Vent Flashing Sleeves: Cast-iron calking type roof coupling for cast-iron stacks, cast-iron threaded type roof coupling for steel stacks, and cast bronze stack flashing sleeve for copper tubing.
7. Frost-Proof Vent Caps: Construct of galvanized iron, copper, or lead-coated copper, sized to provide 1" air space between outside of vent pipe and inside of flashing collar extension.
8. Vandal-Proof Vent Caps: Cast-iron body full size of vent pipe, with calked base connection for cast-iron pipes, threaded base for steel pipes.

2.3 FLOOR DRAINS

A. Floor drain type designations, descriptions, and sizes are indicated on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify all dimensions by field measurements. Verify that all drainage and vent piping and specialties may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.

B. Verify all existing grades, inverts, utilities, obstacles, and topographical conditions prior to installations.

C. Examine rough-in requirements for plumbing fixtures and other equipment having drain connections to verify actual locations of piping connections prior to installation.

D. Examine walls, floors, roof, and plumbing chases for suitable conditions where piping and specialties are to be installed.

E. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION FOUNDATION FOR UNDERGROUND BUILDING DRAINS

A. Grade trench bottoms to provide a smooth, firm and stable foundation, free from rock, throughout the length of the pipe.

B. Remove unstable, soft, and unsuitable materials the surface upon which pipes are to be laid and backfill with clean sand and pea gravel to indicate invert elevation.

C. Shape bottom of trench to fit bottom of pipe for 90-degrees (bottom 1/4 of the circumference). Fill unevenness with tamped sand backfill. At each pipe joint dig bell holes to relieve the bell of the pipe of all loads and to ensure continuous bearing of the pipe barrel on the foundation.

3.3 JOINING PIPES AND FITTINGS

A. Copper Tubing: Solder joints in accordance with the procedures specified in ANSI B9.1.

B. Cast-Iron Soil Pipe: Make lead and oakum calked joints, compression joints, and hubless joints in accordance with the recommendations in the CISPI Cast Iron Soil Pipe and Fittings Handbook, Chapter IV.

3.4 INSTALLATION

A. Refer to the separate Division 23 section: Basic Piping Materials and Methods, for general piping installation instructions.

B. Install supports and anchors in accordance with Division-23 Basic Mechanical Materials and Methods section "Supports and Anchors".

C. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into account many design considerations. So far as practical, install piping as indicated.

D. Make changes in direction for drainage and vent piping using appropriate 45-degree wyes, half-wyes, or long sweep quarter, sixth, eighth, or sixteenth bends. Sanitary tees or short quarter bends may be used on vertical stacks of drainage lines where the change in direction of flow is from horizontal to vertical, except use long-turn fittings where two fixtures are installed back-to-back and have a common drain. Straight tees, elbows, and crosses may be used on vent lines. No change in direction of flow greater than 90 degrees shall be made. Where different sizes of drainage pipes and fittings are connected, use proper size, standard increasers and reducers. Reduction of the size of drainage piping in the direction of flow is prohibited.

E. Install underground building drains to conform with the plumbing code, and in accordance with the Cast Iron Soil Pipe Institute Engineering Manual. Lay underground building drains beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install required gaskets in accordance with manufacturer=s recommendations for use of lubricants, cements, and other special installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.

F. Install building drain pitched down at minimum slope of 1/4" per foot (2 percent) for piping 3" and smaller, and 1/8" per foot (1 percent) for piping 4" and larger.

G. Extend building drain to connect to sewer piping, of size and in location indicated for service entrance to building. Sewer piping is specified in a separate section of Division 02.

H. Install sleeve and mechanical sleeve seal through foundation wall for watertight installation.

3.5 INSTALLATION OF PIPING SPECIALTIES

A. Install backwater valves in sanitary building drain piping as indicated, and as required by the plumbing code.

B. Install expansion joints on vertical risers as indicated, and as required by the plumbing code.

C. Above Ground Cleanouts: Install in above ground piping and building drain piping as indicated, and as required by plumbing code;
   1. At each change in direction of piping greater than 45 degrees;
   2. At minimum intervals of 50' for piping 3" and smaller and 80' for larger piping;
   3. At base of each vertical soil or waste stack.

D. Clean-outs Covers (extra heavy duty): Install floor and wall cleanout covers for concealed piping, types as indicated at all cleanouts.

E. Flashing Flanges: Install flashing flange and clamping device with each stack and clean-out passing through waterproof membranes.

F. Vent Flashing Sleeves: Install on stacks passing through roof, secure over stack flashing in accordance with manufacturer's instructions.

G. Frost-Proof Vent Caps: Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1" clearance between vent and pipe and roof substrate.

3.6 INSTALLATION OF FLOOR DRAINS

A. Install floor drains in accordance with manufacturer's written instructions and in locations indicated.

B. Install floor drains at low points of surface areas to be drained, or as indicated. Set tops of drains flush with finished floor.

C. Set drain elevation depressed below finished slab elevation as listed below to provide proper slope to drain:

DEPRESSION	RADIUS OF AREA DRAINED
1/2"	5'-0"
3/4"	10'-0"
1"	15'-0"
1-1/4"	20'-0"
1-1/2"	25'-0"

D. Trap all drains connected to the sanitary sewer. Provide 6" deep seal p-traps, and trap primers.

E. Install drain flashing collar or flange so that no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes, where penetrated.

F. Position drains so that they are accessible and easy to maintain.

3.7 INSTALLATION OF TRAP PRIMERS

A. Install trap primers with piping pitched towards drain trap, minimum of 1/8" per foot (1 percent). Adjust trap primer for proper flow.

3.8 CONNECTIONS

A. Piping Runouts to Fixtures: Provide drainage and vent piping runouts to plumbing fixtures and drains, with approved trap, of sizes indicated.

B. Locate piping runouts as close as possible to bottom of floor slab supporting fixtures or drains.

3.9 FIELD QUALITY CONTROL

A. Inspections:
1. Do not enclose, cover, or put into operation drainage and vent piping system until it has been inspected and approved by the Architect.
2. During the progress of the installation, notify the Architect, at least 24 hours prior to the time such inspection must be made. Perform tests specified below in the presence of the Architect.
3. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.
4. Final Inspection: Arrange for a final inspection by the Architect to observe the tests specified below and to ensure compliance with the requirements of the plumbing code.
5. Re-inspections: Whenever the piping system fails to pass the test or inspection, make the required corrections, and arrange for reinspected by the Architect.
6. Reports: Prepare inspection reports, signed by the Architect.

B. Piping System Test:
1. Test for leaks and defects all new drainage and vent piping systems and parts of existing systems, which have been altered, extended or repaired. If testing is performed in segments, submit a separate report for each test, complete with a diagram of the portion of the system tested.
2. Leave uncovered and unconcealed all new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose all such work for testing, that has been covered or concealed before it has been tested and approved.

C. Drainage and Venting System Testing Procedures:
1. Rough Plumbing: Except for outside leaders and perforated or open jointed drain tile, test the piping of plumbing drainage and venting systems upon completion of the rough piping installation. Tightly close all openings in the piping system, and fill with water to the point of overflow, but not less than 10 feet head of water. Water level shall not drop during the period from 15 minutes before the inspection starts, through completion of the inspection. Inspect all joints for leaks.
2. Finished Plumbing: After the plumbing fixtures have been set and their traps filled with water, their connections shall be tested and proved gas and water-tight. Plug the stack openings on the roof and building drain where it leaves the building, and introduce air into the system equal to a pressure of 1" water column. Use a "U" tube or manometer inserted in the trap of a water closet to measure this pressure. Air pressure shall remain constant without the introduction of additional air throughout the period of inspection. Inspect all plumbing fixture connections for gas and water leaks.
3. Repair all leaks and defects using new materials and retest system or portion thereof until satisfactory results are obtained.
4. Prepare reports for all tests and required corrective action.

3.10 ADJUSTING AND CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Clean drain strainers, domes, and traps. Remove dirt and debris.

3.11 PROTECTION

A. Protect drains during remainder of construction period, to avoid clogging with dirt and debris, and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of day or whenever work stops.

END OF SECTION 221400

STATE OF LOUISIANA
R. CRAIG CAMPBELL, II
License No. 29380
3/10/26
PROFESSIONAL
ENGINEER

SECTION 223310
DOMESTIC HOT WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged, factory-fabricated and assembled:
1. Electric storage-type water heaters
2. Thermostatic mixing valves (ASSE 1017 master mixing valves and ASSE 1070 point-of-use valves)
3. Necessary trim, controls, and accessories for heating and tempering domestic hot water

1.3 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

C. Wiring Diagrams: Power, signal, and control wiring.

D. Source and Field Quality-Control Test Reports: Indicate and interpret test results for compliance with performance requirements before shipping.

E. Field Quality-Control Test Reports: Indicate and interpret test results for compliance with performance requirements.

F. Efficiency Data Points: Submit certified efficiency data in accordance with Department of Energy (DOE) requirements under 10 CFR Part 431 for commercial electric water heaters. Efficiency data not supported by third-party published test standards shall not be permitted.

G. Warranty: Standard warranty specified in this Section.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For water heaters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Manufacturer shall have minimum five (5) years experience in production of electric water heaters.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
C. Efficiency Data per DOE 10 CFR Part 431.
D. Thermostatic mixing valves shall comply with ASSE 1017, ASSE 1070, ANSI 372 as applicable.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
B. Coordinate electrical service characteristics with Division 26.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Electric Water heaters
1. A.O. Smith
2. Rheem
3. Bradford White
4. Prior Approved Equals

B. Thermostatic Mixing Valves
1. Powers
2. Leonard Valve
3. Honeywell
4. Prior Approved Equals

2.2 CONSTRUCTION

A. Description: Water heater shall be a vertical storage-type electric water heater consisting of:
1. Glass-lined steel tank
2. Multiple incoloy or stainless steel immersion heating elements
3. Replaceable screw-in elements
4. Heavy gauge steel outer jacket
5. Non-CFC polyurethane foam insulation

B. Tank shall be rated for:
1. 150 psig working pressure
2. 180°F maximum operating temperature

C. Construction
1. Tank shall be glass-lined and fired at not less than 1,500°F to ensure molecular bonding of glass and steel.

D. Water heater shall include:
   1. ASME-rated temperature and pressure relief valve
   2. Brass drain valve
   3. Magnesium anode rods
   4. Adjustable immersion thermostats
   5. Manual reset high temperature limit control

E. Units shall be suitable for 208V, 240V, or 480V, 3-phase operation as indicated on Drawings.

F. Heating elements shall be staged to reduce electrical demand and provide incremental heating.

G. Master Mixing Valves (ASSE 1017)
   1. Valve shall:
      a. Maintain mixed water temperature within ±3°F
      b. Include thermostatic element and temperature adjustment handle
      c. Be bronze body construction
      d. Include integral check valves and strainers
      e. Include thermometers on hot, cold, and mixed outlets
   2. Valve shall be capable of delivering full design flow at minimum pressure drop indicated.
   3. Fail-safe design shall automatically reduce outlet flow upon cold water failure.

H. Point-of-Use Mixing Valves (ASSE 1070)
   1. Provide under-lavatory or fixture-mounted thermostatic mixing valves at all plumbing fixtures receiving hot water.
   2. Valve shall:
      a. Maintain outlet temperature within ±3°F
      b. Include integral check stops
      c. Be lead-free compliant
      d. Have tamper-resistant temperature adjustment

I. CONTROLS
   1. Electric water heaters shall include:
      a. Adjustable thermostat (range 90°F–180°F)
      b. Manual reset high-limit control
      c. Pilot lights indicating element operation
      d. Alarm contacts where scheduled
   2. Provide BACnet interface where indicated on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water heater installation, examine roughing-in for concrete equipment bases and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting water heater performance, maintenance, and operations.
   1. Final water heater locations indicated on Drawings are approximate. Determine exact locations before roughing-in of piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where water heaters will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WATER HEATER INSTALLATION

A. Install equipment on 4” concrete housekeeping pad.

B. Install electrical services to water heater.

C. Install control wiring to field-mounted electrical devices.

D. Provide local disconnect within sight of equipment.

3.3 THERMOSTATIC MIXING VALVE INSTALLATION

A. Install master mixing valves in accessible mechanical room locations.

B. Provide:
1. Isolation valves on hot and cold inlets
2. Balancing valve on recirculation line
3. Thermometers on hot, cold, and mixed water outlets
4. Heat trap or check valves as required

C. Point-of-use valves shall be installed per manufacturer’s instructions at fixture.

3.4 CONNECTIONS

A. Install water heaters level on concrete bases.

B. Install piping adjacent to water heater to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain and terminate with a minimum 2” air gap. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect domestic water piping to inlet and outlet water heater tappings with shutoff valve and union or flange at each connection.

E. Install piping from safety relief valves to nearest floor drain.

F. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
1. Perform installation and startup checks according to manufacturer's written instructions. Complete startup form included with water heater and return to manufacturer as described in the instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper unit operation
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   a. Verify thermostat calibration and high-limit function.
   b. Verify mixing valve temperature stability under varying flow conditions.

3.6 DEMONSTRATION

A. Engage a factory representative or a factory-authorized service representative for water heater startup and to train Owner's maintenance personnel to adjust, operate, and maintain water heaters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 223310

STATE OF LOUISIANA
R. CRAIG CAMPBELL, II
License No. 29380
3/10/26
PROFESSIONAL ENGINEER

SECTION 224000
PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. This Section includes plumbing fixtures and trim, fittings, and accessories, appliances, appurtenances, equipment, and supports associated with plumbing fixtures.

B. Products unloaded, uncreated, set in place, installed and final connections made but not furnished under this Section include:
1. Plumbing Fixtures described in Plumbing Fixture Schedule.
2. Accessories, appliances, appurtenances, and equipment specified in other sections, requiring plumbing services or fixture-related devices such as ice makers for refrigerators, as indicated.

1.3 DEFINITIONS

A. Accessible: Describes a plumbing fixture, building, facility, or portion thereof that can be approached, entered, and used by physically handicapped people.

B. Accessory: Device that adds effectiveness, convenience, or improved appearance to a fixture but is not essential to its operation.

C. Appliance: Device or machine designed and intended to perform a specific function.

D. Appurtenance: Device or assembly designed to perform some useful function when attached to or used with a fixture.

E. Equipment: Device used with plumbing fixtures or plumbing systems to perform a certain function for plumbing fixtures but that is not part of the fixture.

F. Fitting: Fitting installed on or attached to a fixture to control the flow of water into or out of the fixture.

G. Fixture: Installed receptor connected to the water distribution system that receives and makes available potable water and discharges the used liquid or liquid-borne wastes directly or indirectly into the drainage system. The term "Fixture" means the actual receptor, except when used in a general application where terms "Fixture" and "Plumbing Fixture" include associated trim, fittings, accessories, appliances, appurtenances, support, and equipment.

H. Roughing-In: Installation of piping and support for the fixture prior to the actual installation of the fixture.

I. Support: Device normally concealed in building construction, for supporting and securing plumbing fixtures to walls and structural members. Supports for urinals, lavatories, and sinks are made in types suitable for fixture construction and the mounting required. Categories of supports are:
   1. Carrier: Floor-mounted support for wall-mounted water closet, and support fixed to wall construction for wall-hung fixture.
   2. Chair Carrier: Support for wall-hung fixture, having steel pipe uprights that transfer weight to the floor.
   3. Chair Carrier, Heavy Duty: Support for wall-hung fixture, having rectangular steel uprights that transfer weight to the floor.
   4. Reinforcement: Wood blocking or steel plate built into wall construction, for securing fixture to wall.

J. Trim: Hardware and miscellaneous parts, specific to a fixture and normally supplied with it required to complete fixture assembly and installation.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.

B. Product data for each type of plumbing fixture specified, including fixture and trim, fittings, accessories, appliances, appurtenances, equipment, supports, construction details, dimensions of components, and finishes.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with requirements of ANSI Standard A117.1, "Buildings and Facilities -- Providing Accessibility and Usability for Physically Handicapped People," and Public Law 90-480, "Architectural Barriers Act, 1968," with respect to plumbing fixtures for the physically handicapped.

B. Regulatory Requirements: Comply with requirements of ATBCB (Architectural and Transportation Barriers Compliance Board) "Uniform Federal Accessibility Standards (UFAS) - 1985-494-187" with respect to plumbing fixtures for the physically handicapped.

C. Listing and Labeling: Provide electrically (battery) operated fixtures specified in this Section that are listed and labeled.
   1. The terms "listed" and "labeled" shall be as defined in the National Electrical Code, Article 100.
   2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

D. Design Concept: The drawings indicate types of plumbing fixtures and are based on the specific descriptions, manufacturers, models, and numbers indicated. Plumbing fixtures having equal performance characteristics by other manufacturers may be considered provided that deviations in dimensions, operation, color or finish, or other characteristics are minor and do not change the design concept or intended performance as judged by the Architect. Burden of proof for equality of plumbing fixtures is on the proposer.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver plumbing fixtures in manufacturer's protective packing, crating, and covering.

B. Store plumbing fixtures on elevated platforms in a dry location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work as described in plumbing fixture schedule on drawings.

2.2 PLUMBING FIXTURES, GENERAL

A. Contractor shall install all plumbing fixtures shown on accompanying Drawings. Refer to both Plumbing and Architectural, and install all fixtures shown on either.

B. Provide plumbing fixtures and trim, fittings, other components, and supports as specified in "Plumbing Fixture Schedule” identified on plans.

C. All brass must be of the best quality. Lightweight goods will not be accepted.

D. All brass pipe shall be seamless brass tubing and nipples shall be extra heavy.

E. All fittings and trim shall be chromium plated heavy brass unless otherwise specified.

F. “P” traps on lavatories and sinks shall be cast brass with cleanouts.

G. All exposed piping shall be chromium plated.

H. Provide cut-off valves at each fixture in both hot and cold-water piping.

I. For the purpose of establishing type and class of fixtures required, the following plate numbers have been taken from the Manufacturer’s Catalog as indicated Fixture manufacturers and Model numbers with prior approval will be acceptable, however fixtures and accessories shall meet standards and features consistent with basis of design fixtures and accessories identified.

J. Provide plumbing fixtures and trim, fittings, other components, and supports as specified in "Plumbing Fixture Schedule@ identified on plans.

2.3 PLUMBING FIXTURE SUPPORTS

A. Supports: ASME A112.6.1M, categories and types as required for wall-hanging fixtures specified, and wall reinforcement.
   1. Support categories are:
      a. Carriers: Supports for wall-hanging fixtures supported from wall construction.
      b. Reinforcement: 2 inches by 4 inches wood blocking between studs or 1/4 inch by 6 inches steel plates attached to studs, in wall construction, to secure floor-mounted and special fixtures to wall.
      c. Support Types: Provide support of type having features required to match fixture.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for potable cold water and hot water supplies and soil, waste, and vent piping systems to verify actual locations of piping connections prior to installing fixtures.

B. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.

C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 APPLICATION

A. Install plumbing fixtures and specified components, in accordance with designations and locations indicated on Drawings.

B. Install supports for plumbing fixtures in accordance with categories indicated, and of type required:
1. Carriers for following fixtures:
   a. Wall-hanging fixtures supported from wall construction.
2. Chair carriers for the following fixtures:
   a. Wall-hanging urinals.
   b. Wall-hanging lavatories and sinks.
   c. Wall-hanging drinking fountains and electric water coolers.
3. Heavy-duty chair carriers for the following fixtures:
   a. Fixtures where specified.
4. Reinforcement for the following fixtures:
   a. Floor-mounted sinks required to be secured to wall.
   b. Recessed, box-mounted electric water coolers.

3.3 INSTALLATION OF PLUMBING FIXTURES

A. Install plumbing fixtures level and plumb, in accordance with fixture manufacturers' written installation instructions, roughing-in drawings, and referenced standards.

B. Install water closets with closet flanges and gasket seals.

C. Install wall-hanging, back-outlet urinals with gasket seals.

D. Fasten wall-hanging plumbing fixtures securely to supports attached to building substrate when supports are specified, and to building wall construction where no support is indicated.

E. Fasten wall-mounted fittings to reinforcement built into walls.

F. Fasten counter-mounting-type plumbing fixtures to casework.

G. Secure supplies behind wall or within wall pipe space, providing rigid installation.

H. Install stop valve in an accessible location in each water supply to each fixture.

I. Install trap on fixture outlet except for fixtures having integral trap.

J. Install escutcheons at each wall, floor, and ceiling penetration in exposed finished locations and within cabinets and millwork. Use deep pattern escutcheons where required to conceal protruding pipe fittings.

K. Seal fixtures to walls, floors, and counters using a sanitary-type, one-part, mildew-resistant, silicone sealant in accordance with sealing requirements specified in Division 07. Match sealant color to fixture color.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other sections of Division 22. The Drawings indicate general arrangement of piping, fittings, and specialties. The following are specific connection requirements:
   1. Install piping connections between plumbing fixtures and piping systems and plumbing equipment specified in other sections of Division 22.
   2. Install piping connections indicated between appliances and equipment specified in other sections, direct connected to plumbing piping systems.

3.5 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Test fixtures to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly.

3.6 ADJUSTING AND CLEANING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Operate and adjust disposers, hot water dispensers, and controls. Replace damaged and malfunctioning units and controls.

C. Adjust water pressure at drinking fountains, electric water coolers, and faucets, shower valves, and flushometers having controls, to provide proper flow and stream.

D. Replace washers of leaking and dripping faucets and stops.

E. Clean fixtures, fittings, and spout and drain strainers with manufacturers' recommended cleaning methods and materials.
   1. Review the data in Operating and Maintenance Manuals. Refer to Division 01.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of fixtures for temporary facilities, except when approved in writing by the Owner.

END OF SECTION 224000

SECTION 230010
MECHANICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. Furnish all labor and material necessary to provide and install the complete mechanical portion of this Contract as called for herein and on accompanying drawings. Parts of the mechanical division may be bid separately or in combination, at the Contractor's option; however, it shall be the responsibility of the Contractor to assure himself that all items covered in the mechanical Division have been included if he chooses to accept separate bids.

B. It is the intent of this specification that all materials with temperatures below ambient conditions or conveying any fluid/gas at temperatures below 70 deg. F be insulated to completely eliminate the potential for condensation. Unless specified elsewhere in these specifications, for materials that do not require and requiring occasional access, use 2" thick closed cell rubberized insulation with re-sealable fabric joints (hook and loop type).

C. Contractor shall refer to the Architectural and Structural drawings and install equipment, piping, etc. to meet building and space requirements. No equipment shall be bid on or submitted for approval if it will not fit in the space provided.

D. It is the intention of these specifications that all mechanical systems shall be furnished complete with all necessary valves, controls, insulation, piping devices, equipment, etc. necessary to provide a satisfactory installation that is complete and in good working order.

E. Contractor shall visit the site and acquaint himself thoroughly with all existing facilities and conditions which would affect his portion of the work. Failure to do so shall not relieve the Contractor from the responsibility of installing his work to meet the conditions.

F. Contractor shall protect the entire system and all parts thereof from injury throughout the project and up to acceptance of the work. Failure to do so shall be sufficient cause for the Architect to reject any piece of equipment.

G. Provide as work of this Division (unless clearly and specifically indicated as a requirement of the Division 26 contractor on the Division 26 drawings) the following:
1. 120V power to all temperature control panels, unit controllers, field devices, etc. as required.
2. Wiring of any remote start/stop switches, occupancy sensors, manual or automatic motor speed control devices, motorized damper actuators controlling Division 23 equipment.

1.3 BIDDING REQUIREMENTS AND RESPONSIBILITIES

A. Prime bidder is responsible for all work, of all trades and subcontractors bidding this project. It is the prime bidder's responsibility, prior to submitting a bid to ensure that sub-contractors coordinate all aspects of the work between trades, sub-contractors, etc. to the fullest extent possible.

B. Prime bidder shall ensure that all sub-contractors, suppliers, equipment vendors, etc., obtain all necessary and pertinent contract document information pertaining to their work prior to the submission of a bid.

C. Bidders of all or any portions of this section or division are required to review all contract documents including but not limited to Architectural drawings, Structural drawings, Mechanical drawings, Plumbing drawings, Electrical drawings, and Fire Alarm drawing section to coordinate requirements and responsibilities with and through prime bidder.

D. Bidders of all or any portions of this section or division, by furnishing a bid on a portion of the prime contract are indicating that they have received all contract documents and coordinated services provided under their portion of the work with the prime bidder; they are indicating that they have expressed any pertinent questions (which would result from a detailed, thorough review of the entire set of contract documents) to the prime bidder in accordance with Division 01 requirements, prior to bidding.

E. All timely, pertinent, questions provided in writing prior to bids, in accordance with Division 01 requirements, will be clarified, defined, or otherwise explained in written addendum and / or addendums prior to bids, in accordance in Division 01 requirements.

F. It is not the intention of these contract documents to leave any issue relating to coordination between trades or sub-contractors vaguely defined. The intention is to define all issues, coordination matters, equipment requirements, sizes, routing, etc. to the satisfaction of the prime bidder, prior to receipt of bids.

G. Bidders of all or any portions of this section or division, by virtue of the submission of a bid to the prime bidder, are indicating that they have reviewed the entire set of contract documents with due diligence and regard for the Owner's desire for a comprehensive and complete bid proposal; that they have expressed all concerns or questions requiring clarification on matters of coordination between trades and/or sub-contractors; that they have expressed any such concerns or questions in writing in accordance with Division 01 requirements.

H. Prime bidders, by submission of a comprehensive bid on the project are indicating that the subcontractors selected in their bid have complied with all Division 01 requirements, that they have indicated in writing, prior to bidding, all questions or concerns requiring clarification and/or explanation and have documented any and all specific exclusions involving work that would generally be considered to be work of their trade. The prime bidder shall coordinate all work so that anything excluded by the bidder of all or any portions of this section or division, have been addressed prior to bids in one of the following manners:

1. The work has been confirmed, by the prime bidder, to be work of another trade or subcontractor (whose proposal is also being accepted).
    a. Clarification of the matter has been made through the prime design professional via written addendum and is clearly and mutually understood by the prime bidder and the party raising the issue/question, or seeking clarification.
    b. The work has been accepted as the responsibility of the Contractor directly.

1.4 POST-BID VALUE ENGINEERING (V/E):

A. Value Engineering (V/E) defined: For purposes of Division 23 Specifications, in accordance with all Division 01 Requirements and all Terms and Conditions of proposed contract between Owner and Contractor, Value Engineering (V/E) shall be defined as a “post bid” process, whereby the apparent low bidder (having submitted a proposal in strict accordance with Project Contract Documents, that exceeds the Owner’s available funds for construction [AFC] for this specified project offers proposed changes (“Value Engineering”) to the work. This proposed value engineering may alter or adjust aforementioned contract document requirements in exchange for financial and/or other consideration (in response to a specific request by the Owner/Owner’s Representative).

B. Value Engineering may not be considered, prior to scheduled receipt and review of Bid Proposals by the Owner and an official written request from the Owner/Owner’s Representative expressing the Owner’s desire to consider value engineering items.

C. While it may be in the project Owner’s interest to consider the first cost money saving that may be generated via alternatives and options generated via participation in Value Engineering, Division 23 contractor shall realize that substantive offers of Value Engineering (V/E), if accepted by the Owner, constitute a design-build agreement (offer and acceptance) with the owner, and drastically change the design concept of the project, as developed by the Professional of Record identified on the Contract Documents.

D. Should Contractor offer, and the owner accept value engineering options that alter aspects of the system design, equipment, performance and/or performance verification or monitoring of respective systems, Contractor shall provide duly licensed professional engineering consultants working on behalf of the Contractor (including sub-contractors and equipment vendors/manufacturers) to review, approve and take professional responsibility for performance and suitability of V/E hybrid systems, materials or operational changes related to respective V/E items. The Contractor’s licensed professional engineering consultants and the Contractor assume any and all responsibility for the design and suitability in terms of performance, of hybrid systems installed, as Contractor’s Professional of Record, absolving the original project Professional of Record (identified on the original Contract Documents, released for the original project Bid/Negotiation) from responsibility for the V/E hybrid systems portion of the work.

E. Division 23 Contractor, via the offer and acceptance of value engineering items on the project agrees to provide professional engineering design services and take full and complete responsibility for the hybrid design. Further, the Contractor’s (V/E Items) professional of record (either employees, or independent consultants to the Contractor) through the offer and acceptance of V/E items, agree to indemnify and hold harmless the project owner, the owner’s original A/E team (Professional of Record on behalf of the owner for the original Contract Documents) their heirs and assigns in regard to the V/E changes and their impact on the Division 23 systems altered, affected or modified, in whole or in part. The Professional of Record shown on the original Contract Documents in regard to the systems altered, adjusted, revised, modified or otherwise affected by the value engineering items implemented, shall be absolved of design responsibility as a result of implementation of V/E items, and their original use of Engineering Seals used for original Contract Documents, shall not apply.

1.5 MATERIAL AND EQUIPMENT

A. Specific reference in the Specifications to any article, device, product, material, fixture, form or type of construction by name, make or catalog number, shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition; and the Contractor, in such cases, may at his option use any article, device, product, material, fixture, form or type of construction which in the judgment of the Architect expressed in writing is equal to that specified.

B. Coordinate and properly relate all Work of this Division to building structure and work of all other trades.

C. Visit premises and become thoroughly familiar with existing conditions; verify all dimensions in field. Advise Architect of any discrepancies prior to Bid Date in accordance with Division 00.

D. Do not rough-in for any item or equipment furnished by others or noted "Not in Contract" (NIC), without first receiving rough-in information or determining rough-in requirements from physically examining the existing equipment, receiving specific cut sheet information from the Owner's representative, other trades and/or Architect. Rough-in services for ANIC" equipment as required, as the work progresses.

E. Provide storage and protection for all equipment and materials in accordance with requirements of Division 00 and Division 01. Replace any equipment and materials damaged by improper handling, storage, or protection, at no additional cost to Owner.

F. Keep premises clean in accordance with requirements of Division 00 and Division 01.

1.6 SUBSTITUTIONS

A. Substitutions are allowed under La. R.S. 38:2291 and La R.S. 38:2292. Any requests for prior approval (as provided for under La. R.S. 38:2295) including any re-submitted data, shall be received by the Architect/Engineer a minimum of ten (10) working days prior to bid date. The Contractor shall recognize that it may be necessary to submit certain requests for prior approval sooner than the final date listed in the Instructions to Bidders, depending upon the complexity and completeness of the submittal. If, in the opinion of the Architect/Engineer, there is neither sufficient time available nor adequate descriptive data attached to the submittal, the submittal will not be considered. Except as otherwise specified, materials and equipment shall be new and bear the approval label of the Underwriters Laboratories, Inc. for the type of installation required.

B. Basis of design of systems is based on specific equipment for performance, size, shape, color, construction material, etc... If the use of other manufacturer's equipment, even though approved by Architect, involves additional cost due to space requirements, foundation requirements, increased mechanical or electrical services, the cost of such extra work shall be borne by the contractor. Even though a manufacturer's name appears in the Contract Documents as having acceptable equipment, his equipment shall be classified as being a substitute to the equipment originally designed for and named in the Contract Documents. Substitute equipment, materials, etc., will not be allowed to deviate from basis of design requirements.

C. All requests for prior approval shall identify where proposed material matches or exceeds the performance of the equipment specified. In addition, such submittal shall also clearly identify all deficiencies compared to specified product. Submittal of general cut sheets will be returned rejected.

1.7 DRAWINGS AND SPECIFICATIONS

A. The specific intent of these Contract Documents is to provide the various systems, equipment, etc. to the Owner complete and in a thoroughly calibrated and functional condition.

B. The Drawings shall not be construed as shop drawings. In the event of a possible interference with piping or equipment of another trade, items requiring set grade and elevations shall have precedence over other items. Should any major interference develop, immediately notify the Architect.

C. In laying out Work, refer to Contract Documents at all times in order to avoid interference and undue delays in the progress of the Work.

D. Furnish all plumbing fixtures (with required accessories) shown on either the plumbing drawings or the architectural drawings. Review Architectural casework elevations and identify fixtures indicated. Provide fixtures indicated. Rough-in for all fixtures as work progress. Verify plumbing fixtures required from review of Mechanical and Architectural drawings, prior to fixture shop drawing submittal.

1.8 CODES AND REGULATIONS

A. Work shall be in full accord with the most stringent interpretation of the State Sanitary Code, local ordinances, building codes, and other applicable national, local, and state regulations.

B. Equipment shall conform to requirements and recommendations of the National Bureau of Fire Underwriters and National Fire Protection Association (NFPA).

C. Items provided under this Division shall comply with the American National Standards Institute (ANSI) "Specifications for Making Buildings and Facilities Accessible to and Usable by Physically Handicapped People," ANSI A 117.1

D. In the possible event of conflict between codes or regulations and Contract Documents, notify the Architect immediately. Codes and Standards represent minimum requirements. These specifications may exceed requirements in various codes and standards.

1.9 FEES, PERMITS, AND TAXES

A. Obtain and pay for permits required for the Work of this Division. Pay fees in connection therewith, including necessary inspection fees.

B. Pay any and all taxes levied for Work of this Division, including municipal and/or state sales tax where applicable.

1.10 MANUFACTURER'S DIRECTIONS

A. Install and operate equipment and material in strict accord with manufacturer's installation and operating instructions. The manufacturer's instructions shall become part of the Contract Documents and shall supplement Drawings and Specifications.

1.11 SUBMITTAL DATA

A. Submit shop drawings, project data, and samples in accordance with requirements of Division 01.

B. Shop drawings shall consist of published ratings or capacity data, detailed construction drawings for fabricated items, wiring and control diagrams, performance curves, installation instructions, manufacturer's installation drawings, and other pertinent data. Submit drawings showing revisions to equipment layouts due to use of alternate or substitute equipment.

C. Where approved manufacturers and suppliers of equipment, materials, etc. are unable to fully comply with Contract Document requirements, specifically call such deviations to attention of Architect on submittals. Type deviations on a separate sheet; underlined statements or notations on standard brochures, equipment fly sheets, etc. will not be accepted.

D. Approval of submittals shall not relieve Contractor from furnishing required quantities and verifying dimensions. In addition, approval shall not waive original intent of Contract Documents.

E. Failure to obtain written approval of equipment shall be considered sufficient grounds for rejection of said equipment regardless of the stage of completion of the project.

1.12 PROJECT RECORD DOCUMENTS

A. Keep Project Record Documents in accordance with requirements of Division 00 and/or Division 01.

B. During construction period, keep accurate records of installations made under this Division, paying particular attention to major interior and exterior underground and concealed piping, ductwork, etc.

1.13 EXCAVATING AND BACKFILLING

A. Provide excavating and backfilling necessary for Work of this Division. Comply with provisions of Division 31, Earth Work, if applicable.

B. Trenches shall be inspected by Code Authorities and/or Owner's Representative before and after piping is laid. Give Owner' Representative 24-hour notice for each inspection. If any trenches are filled without Owner's Representative inspection and as subsequently found to be deficient, the trenches shall be uncovered.

C. Inspected, and then re-filled, if requested by Owner's Representative.

D. Provide minimum 18 inches of cover or in compliance with local published frost line data (if greater than 18 inches) to finish grades or paving at water piping.

E. For piping, provide bell holes at trench bottom to assure uniform bearing. Accurately grade trench bottoms by instrument before laying any pipe.

F. Protect and maintain trenches in dry condition until piping has been inspected and approved. Immediately after approval, backfill trenches in tamped layers.

G. Compact fill to satisfaction of Architect and/or Owner's Representative.

1.14 CUTTING AND PATCHING

A. Comply with requirements of Division 00 and Division 01 regarding cutting and patching. Locate and timely install sleeves as required to minimize cutting and patching.

B. Cutting, fitting, repairing, patching, and finishing of Work shall be done by craftsmen skilled in their respective trades. Where cutting is required, cut in such a manner as not to weaken structure, partitions, or floors. Holes required to be cut must be cut or drilled without breaking out around the holes. Where patching is necessary in finished areas of the building, the Architect will determine the extent of such patching and refinishing.

C. Repairing Roadways and Walks: Coordinate all roadway work with authorities having jurisdiction. Cut and/or bore under roadways for connection of utilities as required. Coordinate work through Contractor. Where this Contract cuts or breaks roadways, or walks to lay the piping, he shall repair or replace these sections to match existing, unless specifically identified as the responsibility of others.

1.15 PAINTING

A. Painting shall be provided under Division 09, unless specified otherwise. Leave exposed piping, materials, and equipment clean and free of rust, grease, dirt, etc. before and after painting.

B. Factory finished equipment, fixtures, and materials which are marred, chipped, scratched, or otherwise unacceptable shall be repaired or replaced under this Division to Architect satisfaction, at no additional cost to Owner.

C. Coordinate all painting requirements with prime bidder prior to bids.

D. Paint all exposed piping inside and outside of building. Label all piping after painting in accordance with Section 230553. Utilize industry standard paint colors for respective system unless directed otherwise by Architect. Review proposed color scheme with Division 23 Requirements prior to ordering materials.

1.16 GUARANTEE

A. The Contractor shall guarantee all materials, equipment and workmanship for a period of one (1) year from the date of final acceptance of the project. This guarantee shall include furnishing of all labor and material necessary to make any repairs, adjustments or replacement of any equipment, parts, etc. necessary to restore the project to first class condition. This guarantee shall exclude only the changing or cleaning of filters. Warranties exceeding one (1) year are hereinafter specified with individual pieces of equipment.

B. If the Contractor's office is in excess of a fifty (50) mile radius of the project, he shall appoint a local qualified contractor to perform any emergency repairs or adjustments required during the guarantee period. The name of the contractor appointed to provide emergency services shall be submitted to the Architect for his approval.

PART 2 - PRODUCTS

2.1 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Furnish manufacturers operating and maintenance instructions, parts lists and sources of supply for replacements in accordance with Division 01.

B. Provide the following operations and maintenance data:
1. Complete sets of final and correct shop drawings, maintenance and replacement parts manuals, and operating instructions, for equipment supplied.
2. Bind each set within a common binder. Index and organize with a table of contents, to permit quick and convenient reference.
3. Provide a minimum of five (5) days of instruction in operation and maintenance of equipment to Owner’s Representative maintenance force. Design a 2-week period, convenient to Owner’s Representative, during which qualified personnel, including manufacturers' technicians and authorized factory trainers shall be available for Architect/Owner's Representative instruction.

2.2 RECORD DRAWINGS

A. Provide "Record Drawings" in accordance with the Division 01, General Requirements, indicating in a neat and accurate manner a complete record of all revisions of the original design of the work.
1. Include all changes and provide for an accurate record, on reproductions of the Contract drawings or on appropriate shop drawings, all deviations between the work shown and work installed.

B. Submit for approval bound sets of the required drawings, manuals and operating instructions.

2.3 IDENTIFICATION MARKINGS

A. General: Apply identification tags, markers, etc. after insulation and field painting are completed.

PART 3 - EXECUTION

3.1 COORDINATION AND LAYOUT

A. Study Drawings and Specifications to ensure completeness of work required.
1. Include supplementary items normal to manufacturers' requirements or standard accepted trade practices as necessary to complete work, though not specifically indicated or specified.

B. Verify measurements and conditions in field before starting work.

C. Examine materials to which work is to be applied and notify the Architect/Owner's Representative, in writing, of any conditions existing which are detrimental to proper and expeditious installation of work.
 1. Starting of work shall be construed as acceptance of conditions.

D. Confer with other trades, install work to avoid interference with other trades, and possible necessary adjustments to conform to structural conditions and work of other trades.

E. Coordinate and set inserts and locate openings in floors and walls in new construction.
 1. Locate pipes and ducts to avoid interference with other work shown on the drawings and as directed by the Architect/Owner's Representative.
 2. Keep all concealed pipes and ducts within the enclosing construction provided.
 3. Arrange exposed work neatly in parallel runs and parallel with walls or structure, with uniformly spaced hangers and supports, and within the spaces assigned for each kind of work.

F. Make coordinated layouts showing concrete work required for housekeeping pads, equipment bases and inertia masses which are cast in place, including the location of anchors and dowels.
 1. Coordinate the scheduling and placing of the concrete to suit the mechanical work schedules.
 2. Concrete housekeeping pads are to cover the full area of each piece of equipment. Concrete bases are to be of dimension and heights to suit the equipment. The forming and placing of concrete shall be provided under this specification section.

3.2 MAINTENANCE OF EQUIPMENT AND SYSTEM PRIOR TO FINAL ACCEPTANCE

A. Maintain all installed equipment and systems in accordance with the manufacturer's published instructions, until final acceptance by the Architect/Owner's Representative, and take such measures as necessary to ensure adequate protection of all equipment and materials during delivery, storage, installation, operating and shut-down conditions.
 1. This responsibility shall include all provisions required to meet the conditions incidental to the delays pending final test of systems and equipment.
 2. Maintain and periodically clean all equipment until final acceptance.

B. After installation of systems has been completed, operate the system to determine the capability of the equipment and controls to conform to the requirements of the drawings and specifications prior to performance testing.

3.3 DAMAGED EQUIPMENT

A. Any and all equipment, parts, components, etc., provided under this division which is damaged by the Contract or which is received in damaged condition during shipping, transit, handling, or during installation shall be replaced. Dented, or damaged non-structural equipment jackets or surface casings such as but not limited to water heater jackets, boiler jackets, chiller insulation jackets, etc., shall either be repaired or replaced at the option of the Owner's Representative. If repaired, the finished product shall match original equipment exactly.

B. Any equipment which develops surface rust, either through improper storage, handling or installation, shall be refinished by grinding the affected area down to bare (white) metal, then prepared with a rust preventive primer and finished with the original manufacturer's touch-up paint to match existing color.

3.4 EQUIPMENT INSTALLATION

A. Locate and set equipment anchor bolts, dowels and aligning devices for all equipment requiring them. Coordinate requirements of concrete work with Contractor and other trades.
   1. Level the equipment and grout solid between the equipment and the surface below. Grout to be premixed grout mixed in accordance with manufacturer's specifications.

B. The field assembly, installation and alignment of equipment is to be done under field supervision provided by the manufacturer or with inspections, adjustments and approval by the manufacturer.

C. Equipment startup.
   1. Contractor shall provide qualified start-up personnel, certified by equipment manufacturer, to inspect and approve equipment and to supervise the operating tests of the equipment. System commissioning shall be performed in accordance with ASHRAE standards.

D. Equipment and system test operation.
   1. Note: Equipment and system test operation is separate and apart from additional requirements of training and demonstration. Refer to individual sections for requirements regarding training and demonstration. Notify the Owner's Representative in advance of beginning the equipment and system test operation. All equipment testing/demonstration shall be performed in the presence of the Architect/Owner's Representative. A minimum of seven (7) days notice is required before equipment and system testing.
   2. Each piece of equipment shall be operated in its system as long as required to provide proper functioning.
   3. Perform an operating test of each complete system for twenty-four hours continuous operation as a minimum, or as long as required to provide coordination and proper functioning of all related systems and controls.
   4. The operating criteria for each test shall be determined in advance with the Owner's Representative approval whenever seasonal conditions shall not produce a full design load on any equipment or system.
   5. Certify to the Owner's Representative that all equipment is functioning properly.
   6. Should the apparatus fail to meet the Contract requirements, adjust, repair or replace all defective or inoperative parts and again conduct the complete performance tests.

3.5 CLEANING AND ADJUSTING OF SYSTEMS

A. Blow out, clean and flush each system of piping, and equipment to thoroughly clean the systems.
   1. Clean all materials and equipment, and leave in condition ready to operate and receive succeeding finishes where required.
   2. Adjust and align all equipment interconnected with couplings or belts.
      a. Adjust valves of all types and operating equipment of all types to provide proper operation.
      b. Remove and clean elements in all steam trap bodies.

c. Clean all strainers. Replace temporary construction screens with new permanent screens.

B. Permanent equipment operated during construction shall not be abused or be used in service different from its design application.
1. Temporary disposable filters shall be used during temporary operation.
2. All expendable media, including belts used for temporary operation and similar expendable materials shall be replaced just prior to acceptance.
3. Packing boxes of equipment operated during construction must be replaced just prior to system acceptance, using materials and methods specified by the supplying manufacturer.

C. Equipment furnished with factory finishes where damaged shall be retouched and repainted to present a new appearance.

D. Furnish and maintain protection for all of the work whether completed or in progress.
1. Furnish and install coverings and enclosures as required.

E. New and existing operating equipment and systems shall be clean and dust free inside and out.
1. Concealed and unoccupied areas such as plenums, pipe and duct spaces and Equipment Rooms shall be free of rubbish and swept, vacuumed or wiped clean at time of acceptance.

3.6 CONTRACTOR REQUESTED FIELD OBSERVATIONS

A. During the course of, and at stages appropriate to the progress of construction, the Contractor may request field observations of the design professional. If the field observation is a request of and by the Contractor, the Contractor shall provide all necessary ladders, scaffolding, lifts, safety harnesses or other equipment in order for the Architect to safely and adequately perform the requested observations.
1. Requests for observations shall be made a minimum of seven (7) days in advance of the requested date of observation.
2. All equipment, ladders, lifts, safety nets, scaffolding, etc., shall be provided and in place for the use of the Architect.
3. All equipment panel covers, electrical panels, or other equipment shall be opened by the Contractor for viewing by the Architect.
4. The Contractor shall make available a mechanic or technician of that field in order to answer questions of the designer, make any and all adjustments and/or corrections and to assist the Architect.

3.7 TESTING AND BALANCING

A. Refer to Specifications Section 230593.

3.8 PAINTING

A. General painting is typically performed by the Division 09 Contractor. This Contract shall however, either perform specialized painting as called for below in the following conditions or he shall advise the Contractor of these requirements as follows:
1. Thoroughly clean all surfaces, requiring prime painting, of rust, loose scale, oil and grease.
2. Dry surfaces before painting.

3. Do not paint controls, nameplates, labels or sprinklers.

B. Paint all equipment unless otherwise specified not to be painted at the factory with one prime coat of rust prohibitive paint.

C. Provide field painting as follows:
1. All exposed iron work, including un-insulated ferrous piping and conduit system components, hangers, supports, equipment bases, and apparatus; prime coat with a red lead-free paint.
2. Un-insulated duct work and casing exposed to view and exposed galvanized surfaces of conduit and piping and of equipment prime painted at the shop: Prime coat, zinc chromate for galvanized surfaces.
3. Inside of all duct work where visible through registers and grilles: One coat of flat black paint.

3.9 CONNECTIONS TO EQUIPMENT

A. Provide mechanical connections to equipment and fixtures requiring such connections which are supplied by Architect/Owner’s Representative or under other divisions.

B. Provide unions, nipples, adapters, valves, flexible connections, and other trim required for final connections for each such fixture or item of equipment, as required for complete operation, servicing, and maintenance.

3.10 WORKMANSHIP

A. Perform all work in a practical, neat and workmanlike manner with mechanics skilled in work, and using the best practices of the trade involved.

B. No work shall be concealed until it has been inspected and approved by the Architect/Owner’s Representative.

C. Workmanship or materials not meeting with requirements of the specifications and drawings and satisfaction of the Architect/Owner’s Representative shall be rejected and immediately replaced in an acceptable manner, without additional cost to the Architect/Owner’s Representative.

3.11 LUBRICATION

A. All equipment furnished, installed or connected under this division, shall be inspected for proper lubrication when connected and before operation of the equipment is begun, as recommended by the Manufacturer.

B. The Contractor for the work of this division shall be held responsible for any damage to equipment that is operated without having been properly lubricated.

3.12 USE OF PREMISES AND CLEANING

A. Remove and dispose of all waste materials and rubbish due to all construction operations under the Contract, except as otherwise noted, and keep the building free from rubbish and dirt caused by his and/or his Sub-Contractors' employees.
1. During the entire progress of the work, rubbish removal shall be made frequently so as to prevent any potential safety or health hazard.

B. Upon completion of the work, remove all protection, paint, putty, and other stains from all fixtures and glass and leave the premises thoroughly broom cleaned.

3.13 CUTTING, ALTERING AND PATCHING

A. Provide all cutting, chasing, drilling, altering and rough patching required for the work of this division.

B. Do all shoring, bracing, cutting, patching, piecing out, filling in, repairing and refinishing of all present work as made necessary by the alteration and the installation of new work.

C. All holes and openings occurring in the existing floors after equipment, partitions, floors, steel work, conduits and pipes are removed or installed shall be closed up with materials similar to the adjacent work.

D. The size and location of items requiring an opening, chase or other provisions to receive it shall be given by the trade requiring same in ample time to avoid undue cutting of any new work to be installed. These provisions shall not relieve the Contractor from keeping other trades informed as to the required opening, chases, etc., nor from responsibility for the correctness thereof, nor for cutting and repairing after the new work is in place.

E. Include all cutting, repairing and patching in connection with the work that may be required to make the several parts come together properly and fit it to receive or be received by the work of other trades, as shown on the drawings and/or specified, or reasonably implied by the drawings and specifications.

F. All repairing, patching, piecing-out, filling-in, restoring and refinishing shall be neatly done by mechanics skilled in their trade to leave same in condition satisfactory to the Architect/Owner’s Representative.

G. Materials and their methods of application for patching shall comply with applicable requirements of the specifications.
   1. Materials and workmanship not covered by the specifications and items of work exposed to view adjoining existing work to remain shall conform to similar materials and workmanship existing in or adjacent to the spaces to be altered.

H. Cutting, repairing and patching shall include all items shown on the drawings, specified in the specifications or required by the installation of new work or the removal of existing work.

I. Remove partitions, walls, suspended ceilings, etc., as necessary to perform the required alterations or new construction work.
   1. Avoid damage to construction and finishes that are to remain.

J. Protect and be responsible for the existing building, facilities and improvements if any.

   1. Any disturbance or damage to the work, the existing building, and improvements, or any impairments of facilities resulting from the construction operations, shall be promptly rectified, with the disturbed, damaged, or impaired work, restored, repaired or replaced at no extra cost.

K. All alterations which are not indicated on the drawings nor specified herein but necessary to make good existing work disturbed by reason of the work shall be restored to a condition satisfactory to the Architect/Owner's Representative.

L. All holes in masonry floors and walls are to be core drilled.

M. Disturbed concrete and /or cement floor areas shall be patched with approved type latex mortar.
   1. When cement mortar is used for patching, the surfaces shall be depressed a minimum depth of one inch (1").

N. Reinstall all weather protection work in waterproof manner.

O. Openings in roofs:
   1. Openings in roofs shall be kept properly plugged and caulked at all times, except when being worked on, to preclude the possibility of flooding due to storms or other causes. After completion of work, openings shall be permanently sealed.

P. Temporary openings.
   1. All temporary openings cut in walls, floors or ceilings for pipe or duct work shall be closed off with non-combustible material except when mechanics are actually working at the particular opening.

3.14 USE OF PERMANENT SYSTEMS:

A. Heating System:
   1. The Contractor may, at his option, utilize the permanent heating systems provided under this Contract to provide space heating prior to Project completion date. The fuel for such space heating and for required tests of heating equipment shall be provided by Contractor.
   2. The heating system shall be operated only by qualified personnel, and shall be operated with all auxiliaries, and in accordance with manufacturer's' instructions and good operating practice. If at any time the Owner's Representative determines that the equipment is being improperly operated or maintained, Contractor may be directed to disconnect its use.
   3. Heating systems shall be operated and controlled to prevent temperature in any room or space in any building from exceeding 90 deg. F.
   4. Systems may be activated without diffusers and registers in place, but filters with same efficiency as those specified shall be provided both in air handling equipment and at return air grille locations. Filter return air entering duct work, to prevent return air duct work from accumulating dust or otherwise becoming dirty.
   5. Contractor shall, prior to final acceptance of the Work, place heating systems and related equipment in a condition equal to new.

B. Air Conditioning System:
   1. The Contractor may, at his option, utilize the permanent air conditioning systems provided under this Contract to provide space cooling prior to the Project completion date.
   2. The fuel, electricity or other energy required for space cooling and for any subsequent operation or testing shall be provided for by the Contractor.

3. The cooling system shall be operated only by fully qualified personnel and shall be operated with all auxiliaries, and in accordance with manufacturer's instructions and good operating practice. Start up of equipment for use by the Contractor shall not commence any warranty period.
4. Cooling systems shall be operated and controlled to prevent temperature in any room or space in any building from falling below 70 deg. F.
5. Systems may be activated without diffusers and registers in place, but filters with same efficiency as those specified shall be provided both in air handling equipment and at return air grille locations. Filter all return air entering duct work, to prevent return air duct work from accumulating dust or otherwise becoming dirty.

6. Contractor shall, prior to final acceptance of the Work, place cooling systems and related equipment in a condition equal to new.

3.15 PENETRATIONS THROUGH FIRE SEPARATIONS

A. Pack annular space between sleeve and pipe (insulation) and / or conduit in fire rated construction with fire retardant putty, sealant and / or caulk in accordance with listed assemblies utilized on the project. Material shall be non-asbestos based and installed in accordance with manufacturers instructions for fire rating required.

B. Penetrations of multiple items and penetrations with annular space greater than 1/2" shall be provided with approved backing material in accordance with manufacturer's instructions.

C. Fire retardant sealer and system shall meet ASTM E-84, ASTM E-814, and UL-1479.

END OF SECTION 230010

STATE OF LOUISIANA
R. CRAIG CAMPBELL, II
License No. 29380
3/10/26
PROFESSIONAL
ENGINEER

SECTION 230020
BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. This Section specifies the basic requirements for mechanical installations and includes requirements common to more than one section of Division 23. It expands and supplements the requirements specified in sections of Division 01.

1.3 ACCESSIBILITY

A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing. Verify exact location and placement of all access panels with/through Architect prior to any equipment rough-in.

B. Extend all grease fittings to an accessible location.

C. Refer to the Division 08 Section: Access Doors.

1.4 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 23 for rough-in requirements.

1.5 MECHANICAL INSTALLATIONS

A. Coordinate mechanical equipment and materials installation with other building components.

B. Verify all dimensions by field measurements.

C. Arrange for chases, slots, and openings in other building components to allow for mechanical installations.

D. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.

E. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

F. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials.

G. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.

H. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

I. Coordinate the installation of mechanical materials and equipment above ceilings with suspension system, light fixtures, and other installations.

J. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

1.6 MECHANICAL COORDINATION DRAWINGS

A. Prepare and submit a set of coordination drawings showing major elements, components, and systems of mechanical equipment and materials in relationship with other building components. Prepare drawings to an accurate scale of 1/4"=1'-0" or larger. Indicate the locations of all equipment and materials, including clearances for installing and maintaining insulation, servicing and maintaining equipment, valve stem movement, and similar requirements. Indicate movement and positioning of large equipment into the building during construction.

B. Prepare floor plans, reflected ceiling plans, elevations, sections, and details to conclusively coordinate and integrate all installations. Indicate locations where space is limited, and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Mechanical equipment room layouts.
2. Specific equipment installations, including:
    a. Ductwork and diffusers.
    b. Pumps and piping connections
    c. Air Handling equipment, fan coils and terminal units with accessories requirements.
3. Work in pipe spaces, chases, trenches, and tunnels.
4. Exterior wall penetrations.
5. Ceiling plenums which contain piping, ductwork, or equipment in congested arrangement.
6. Installations in mechanical riser shafts, at typical sections and crucial offsets and junctures.
7. Division 23 Contractor shall furnish drawings, to Contractor, once approved by reviewing Architect, to fully coordinate with all trades and subcontractors required. Failure to fully coordinate via this process shall not relieve the contractor of his responsibility to coordinate structural supports, electrical service routing of mechanical systems and provisions for required access.

1.7 CUTTING PATCHING AND SEALING OF PENETRATIONS

A. This Article specifies the cutting and patching of mechanical equipment, components, and materials to include removal and legal disposal of selected materials, components, and equipment.

B. Refer to the Division 01 Section: CUTTING AND PATCHING for general requirements for cutting and patching.

C. Refer to Division 26 Section for BASIC ELECTRICAL REQUIREMENTS for requirements for cutting and patching electrical equipment, components, and materials.

D. Do not endanger or damage installed Work through procedures and processes of cutting and patching.

E. Arrange for repairs required to restore other work, because of damage caused as a result of mechanical installations.

F. No additional compensation will be authorized for cutting and patching Work that is necessitated by ill-timed, defective, or non-conforming installations.

G. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
1. Uncover Work to provide for installation of ill-timed Work.
2. Remove and replace defective Work.
3. Remove and replace Work not conforming to requirements of the Contract Documents.
4. Remove samples of installed Work as specified for testing.
5. Install equipment and materials in existing structures.
6. Upon written instructions from the Architect, uncover and restore Work to provide for Architect observation of concealed Work.

H. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including, but not limited to removal of mechanical piping, heating units, plumbing fixtures and trim, and other mechanical items made obsolete by the new Work.

I. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

J. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

K. Locate identify, and protect mechanical and electrical services passing through remodeling or demolition area and serving other areas required to be maintained operational. When transit services must be interrupted, provide temporary services for the affected areas and notify the Owner prior to changeover.

L. Seal all penetrations of building envelope air and water tight. For complete closure of openings, where necessary, provide 1/8" thick elastomeric barrier anchored to materials penetrating building envelope and adjacent envelope surfaces involved - seal connections with caulk and mechanical fasteners. Refer to Architectural Sections on joints and sealants. Seal all conduit systems communicating between conditioned and unconditioned spaces. Coordinate all work with and through prime bidder and other trades. Unless otherwise directed, caulk sealant shall be long lasting polyurethane based products, resistant to UV exposure, installed in accordance with manufactures instructions. Sealant joints shall withstand building pressures variance with respect to ambient of 0.25 inches water gauge, with no leakage in terms of air and or water vapor.

1.8 MECHANICAL SUBMITTALS

A. Refer to the Conditions of the Contract (General and Supplementary) and Division 01 Section: Submittal Procedures for submittal definitions, requirements, and procedures.

B. Submittal of bound shop drawings, product data, and samples will be accepted only when submitted by the Contractor. Data submitted from subcontractors and material suppliers directly to the Architect will not be processed.

PART 2 - PRODUCTS

2.1 PRODUCT OPTIONS AND SUBSTITUTIONS

A. Refer to the Instructions to Bidders for requirements in selecting products and requesting substitutions.

2.2 PRODUCT LISTING

A. Prepare listing of major mechanical equipment and materials for the project. A sample schedule is included at the end of this Section to complete this requirement.

B. Provide all information requested.

C. Submit this listing as a part of the submittal requirement specified in the Division 01.

D. When two or more items of same material or equipment are required (plumbing fixtures, pumps, valves, air conditioning units, etc.) they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, pipe, tube, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units, and similar items used in Work, except as otherwise indicated.

E. Provide products which are compatible within systems and other connected items.

2.3 NAMEPLATE DATA

A. Provide permanent operational data nameplate on each item of power operated mechanical equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliance, and similar essential data. Locate nameplates in an accessible location.

2.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

B. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.

C. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

2.5 RECORD DOCUMENTS

A. Refer to the Division 01 Section: Closeout Procedures for requirements. The following paragraphs supplement the requirements of Division 01.

B. Mark Drawings to indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers and other control devices, filters, boxes, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.); Change Orders; concealed control system devices.

C. Mark Specifications to indicate approved substitutions, Change Orders, actual equipment and materials used.

2.6 OPERATION AND MAINTENANCE DATA

A. Refer to the Division 01 Section for Project Closeout or Operation and Maintenance Data for procedures and requirements for preparation and submittal of maintenance manuals.

B. In addition to the information required by Division 01 for Maintenance Data, include the following information:
   1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
   2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down, and emergency instructions; and summer and winter operating instructions.
   3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
   4. Servicing instructions and lubrication charts and schedules.

C. Submit in accordance with Section 017800.

D. Use multiple binders if a single binder would exceed 2-1/2 inches in thickness; arrange the data in the same sequence as the specification sections; delete or mark through extraneous data.

E. Provide tab pages with metal or plastic reinforced holes to separate each major item or closely related group of items with typed item names on the tabs. Supply a table of contents at the beginning of each volume listing at items, the manufacturers and the name, address and phone number of the nearest authorized service representative.

F. A copy of the completed manual shall be submitted to the Contracting Officer one week before the user instruction for perusal. This copy will be returned to the Contractor with the user, comments. These comments shall be incorporated in the final copies of the manual. The Contractor shall obtain a signed receipt for the manual.

G. The O & M Manual outline shall be prepared in two parts along the lines suggested in the 2011 HVAC Applications, Chapter 39.

H. All contents shall be project specific, typewritten.

2.7 WARRANTIES

A. Refer to individual equipment specifications for warranty requirements.

B. Compile and assemble the warranties specified in Division 23, into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.

C. Provide complete warranty information for each item to include product or equipment to include date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

2.8 CLEANING

A. Refer to the Division 01 Section for general requirements for final cleaning.

B. Refer to Division 230593 Section: TESTING, ADJUSTING, AND BALANCING for requirements for cleaning filters, strainers, and mechanical systems prior to final acceptance.

PART 3 - EXECUTION

3.1 WARRANTIES

A. Refer to the Division 01 Section for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements.

B. Compile and assemble the warranties specified in Division 23, into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.

C. Provide complete warranty information for each item to include product or equipment to include date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

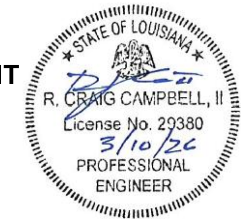
3.3 CLEANING

A. Refer to the Division 01 Section for general requirements for final cleaning.

B. Refer to Division 23 Section: TESTING, ADJUSTING, AND BALANCING for requirements for cleaning filters, strainers, and mechanical systems prior to final acceptance.

END OF SECTION 230020

SECTION 230510
ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT



PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. Compliance with National Electric Code Requirements
1. Minimum Requirements:
a. The requirements of this Division supercede the Aminimum" requirements of National Codes such as NEC in many areas. Where reference to this National Code is made, it is understood that the requirements of these codes are meant to indicate the Aminimum" requirements required by these Contract Documents and are not to infer that these Aminimum" requirements eliminate or in any way diminish the requirements of individual sections of these Contract Documents.
b. Wherever compliance with this National Code is required, it shall be taken as a minimum requirement and applicable whenever the Contract Documents are silent with respect to specific requirements or installation procedures. The Contractor shall as a minimum, comply with the more stringent of the requirements.

B. Interlock Wiring for Mechanical Equipment
1. Interlocks & Wiring of Mechanical Equipment: It is the intent of the contract documents to note or include most of the obvious physical wiring, conduit, relays, and necessary interlocks between various pieces of mechanical/electrical equipment. Plans, details, specifications and drawings however, do not typically indicate the exact extent and encompassment of all required mechanical/electrical interlocks, routing, control voltages, conduit, wiring diagrams, etc., between mechanical and electrical devices and equipment that may be required for the proper operation and sequencing of equipment. Also, typically not indicated on the drawings is the differentiation between field installed and factory provided wiring because of the significant differences in requirements between various equipment manufacturer=s requirements and/or job site conditions. It is the responsibility of this contractor to first verify that all mechanical related items affecting other trades are properly coordinated, accounted for and included in pricing prior to bid date. Additional costs for interlocks after bids are received will not be allowed for failure to coordinate. Reference is made to coordination and responsibility of providing the required wiring diagrams and requirements between the various subs, etc. It remains however, the responsibility of this Contractor as further described in the following articles, to properly coordinate, be responsible for, and to allow for any and all costs associated with the requirements of the equipment manufacturer=s recommendations in order to preserve guarantees and warranties. (Note: For

informational purposes only) - Typical mechanical/electrical/control/wiring interlocks covered under this section include but are not limited to the following examples:
a. Domestic water pump interlocks with aquastats & thermostats.
b. Exhaust fans and supply fan general ventilation interlocks.
c. Smoke detector interlocks with supply air fans.
d. Hi-Limit Temperature (firestat) interlocks with supply air fans.
e. Lo-Limit Temperature (freezestat) interlocks with supply air fans.
f. Interlocks between automatic safety float switches in emergency drain pans and respective fan motors and/or condensing units.
g. Interlocks between Air Handling Unit “Kill” switches and fan motor starters.
h. Damper interlocks between required fire suppression systems.
i. Fresh air damper interlocks with supply air fans.
j. Two speed fan motors, number of conductors, and interlocks between motor starters and fan speed controllers.
k. High limit temperature interlocks with unit heater thermostats.
l. High and low water level limit interlocks with sump and ejector pumps.
m. All other factory wired mechanical equipment requiring field installed connections and interfaces.

1.3 SUMMARY OF RESPONSIBILITY

A. In order to ensure proper operation of mechanical equipment installed, it is the intent of this section of the specifications to ensure that the Division 23 Contractor is the ultimate party responsible for the proper electrical installation of the equipment provided under the technical specifications of this Division. Unless the Division 23 Contractor is fully licensed and qualified to provide a complete electrical installation, he shall obtain the services of a fully qualified electrical Contractor to perform those services required to provide a complete and operational system. If, however, the services of other Contractors or sub-contractors are required by the Division 23 Contractor in order that the equipment provided is to operate and perform as specified, the Division 23 Contractor shall obtain, pay for, and coordinate the services of such Contractor(s) in order to provide a complete a fully operational mechanical system. The Division 23 Contractor shall be fully responsible for the work of all sub-contractors and shall fully warrant their work in accordance with the requirements of Division 01 of these specifications.

B. This section includes the basic requirements for field installed electrical conduits, power circuits, breakers, wiring, interlocks, and other electrical components which are to become an integral part of mechanical equipment provided under Division 23. All work performed under this section shall fully as a minimum, comply with Division 26 Specifications and National Electric Code - (latest edition) and shall be provided as listed below:
1. All “field-installed” interlock and/or control/power wiring necessary to provide a complete and operating mechanical system shall be ultimately provided by, and be the responsibility of the Division 23 Contractor. These components shall include, but are not limited to the following examples:
a. Automatic Temperature Control panels
b. Installation and connection of factory installed motors
c. Variable frequency drives
d. Motors (single & multi-speed)
e. Motor starters (single and multi-speed) for all Division 23 equipment
f. Fire protection control panels
g. Supply, return, & exhaust fan interlocks
h. Plumbing fixture automatic flush valves
i. Interlocks between domestic water circulating pumps & aquastats

j. Exhaust fan/supply fan interlocks
k. Filters at AHU's
l. AHU, hi-limit temperature interlocks, lo-limit temperature interlocks, smoke detectors, and other interlocks related to Life Safety protection.
m. Other various interlocks between items of mechanical equipment, safeties, and field wired interconnections.

C. It is the responsibility of the Division 23 Contractor to fully coordinate the electrical requirements of his mechanical equipment with the Division 26 Contractor prior to bidding and to ensure that other contractors and divisions are made aware of the requirements of his equipment that he intends to provide. The Division 23 Contractor shall provide wiring and control diagrams of all mechanical, air conditioning, ventilation, plumbing and /or fire protection equipment clearly delineating between factory wiring and field installed wiring. The mechanical contractor shall ensure that all field installed wiring, interlocks, etc., required to provide a complete and operable system are inclusive with his bid.

D. Specific electrical power requirements (i.e., horsepower and electrical characteristics) where known, for mechanical equipment are scheduled on the Drawings or within the body of the individual technical specifications.

E. Low Voltage Wiring: Low voltage wiring is not typically shown on the contract documents or plans. It remains however, the responsibility of the Division 23 Contractor to fully coordinate the low voltage electrical requirements of his mechanical equipment with the Division 26 Contractor prior to bidding and to ensure that other Contractors and Divisions are made aware of the requirements of his equipment that he intends to provide. The Division 23 Contractor shall also provide the low voltage wiring and control wiring diagrams of all mechanical, air conditioning, ventilation, plumbing and /or fire protection equipment clearly delineating between factory wiring and field installed wiring.
1. The Division 23 Contractor shall coordinate with the Division 26 Contractor for all necessary power requirements.

1.4 REFERENCES

A. NEMA Standards MG 1: Motors and Generators

B. NEMA Standard ICS 2: Industrial Control Devices, Controllers, and Assemblies.

C. NEMA Standard 250: Enclosures for Electrical Equipment.

D. NEMA Standard KS 1: Enclosed Switches.

E. As a minimum, comply with National Electrical Code (NFPA 70).

1.5 SUBMITTALS

A. Motors, Starters, & VFD Drives: Provide manufacturer=s product data. If starters are an integral part of packaged mechanical equipment, then a separate starter submittal is not required.

B. Submit product data for motors, starters, variable frequency drives and other electrical components with submittal data required for the equipment for which it serves, as required by the individual equipment specification sections.

1.6 QUALITY ASSURANCE

A. All electrical components and materials shall be UL labeled.

PART 2 - PRODUCTS

2.1 MOTORS

A. The following are basic requirements for simple or common motors. For special duty motors, more detailed and specific requirements are specified in Section 230513 – “Electric Motors”.
   1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
   2. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.
   3. Temperature Rating: Rated for 50 deg. C environment with maximum 50 deg. C temperature rise for continuous duty at full load (Class A Insulation).
   4. Starting capability: Frequency of starts as indicated by automatic control system, and not less than 5 evenly time spaced starts per hour for manually controlled motors.
   5. Service Factor: 1.15 for poly-phase motors and 1.35 for single phase motors.
   6. Motor construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque.
      a. Frames: NEMA Standard No. 48 or 54; use driven equipment manufacturer's standards to suit specific application.
      b. Bearings: Ball or roller or pillow block bearings with inner and outer shaft seals; re-greaseable, except permanently sealed where motor is normally inaccessible for regular maintenance; designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor; for fractional horsepower, light duty motors, sleeve type bearings are permitted.
   7. Enclosure Type: Open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation; totally enclosed, fan cooled for exterior applications or where specifically indicated on drawings.
   8. Overload protection: Built-in thermal overload protection.
   9. Noise rating: "Quiet"
   10. Efficiency: "Premium Energy Efficient" motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112, test method B. If efficiency not specified, motors shall have a higher efficiency than "average standard industry motors", in accordance with IEEE Standard 112, test method B.
   11. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

2.2 STARTERS, ELECTRICAL DEVICES, AND WIRING

A. Motor Starter Characteristics:
   1. Enclosures: Unless otherwise specifically identified, provide NEMA 1, general purpose enclosures with padlock ears, except in wet or exterior locations, where enclosures shall be NEMA 3R with conduit hubs, or units in hazardous or dust laden atmospheres or other locations which shall have NEC rating for that particular proper class and division.
   2. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.

B. Magnetic Starters:
   1. Refer to Section 230514 – “Motor Starters” for full requirements of motor starters.

2. As a minimum, provide the following items on each motor starter:
   a. Maintained contact push buttons and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
   b. Trip-free thermal overload relays, each phase.
   c. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division 23- ABuilding Automation System” controls sections.
   d. Built-in 120 volts control circuit transformer, fused from line side, where incoming electrical service exceeds 240 volts.
   e. Lockable AOff” position handle.
   f. H-O-A selector switch.
   g. Externally operated manual reset.
   h. Under-voltage release or protection.

C. Motor connections:
   1. Flexible conduit, weatherproof type where installed in damp or wet locations as defined by the NEC, except where plug-in electrical cords are specifically indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify equipment physical size and clearances required.

B. Verify electrical interlocks required.

3.2 THERMAL STOPS & BARRIERS

A. Thermal Barriers: Where electrical equipment, conduit, wiring, etc., penetrates or comes into contact with cold or hot mechanical equipment, provide thermal barriers to prevent intrusion of unconditioned air into mechanical equipment or to prevent electrical devices from sweating or accumulating condensation.
   1. Examples: Examples of the above include but are not limited to:
      a. Air handling conduit penetrations at or into AHU casings.
      b. Smoke detectors attachment to hot or cold ductwork.

3.3 TRAINING & DEMONSTRATION

A. Provide training as described in individual technical specifications.

END SECTION 230510

SECTION 230513
ELECTRIC MOTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. This Section includes basic requirements for all motors connected to mechanical equipment. It includes motors that are factory-installed as part of equipment and appliances as well as field-installed motors.

1.3 QUALITY ASSURANCE

A. As a minimum, comply with applicable local, state and federal codes.

B. As a minimum, comply with applicable requirements of recognized industry associations which promulgate standards for the various trades. (See individual Sections of Division 23).

C. Employ only qualified personnel for this work. Employ competent, qualified mechanics to supervise the work.

D. As a minimum, comply with ASHRAE Standard 90.1 - 1999 (or latest edition) for motors.

E. As a minimum, comply with NFPA 70, "National Electrical Code." (Latest Edition)

F. NRTL Listing: Provide NRTL listed motors.

G. Term "Listed": As defined in "National Electrical Code," Article 100.

H. Listing Agency Qualifications: "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

I. As a minimum, comply with NEMA Standard MG 1, "Motors and Generators."

J. As a minimum, comply with UL 1004, "Motors, Electric."

PART 2 - PRODUCTS

2.1 MOTORS, GENERAL

A. General: Requirements below apply to motors covered by this Section except as otherwise indicated, for motors classified as simple or common motors (Section 230510).
   1. Motors 1.0 HP and Larger: Polyphase.

2. Motors Smaller Than 1.0 HP: Single-phase.
3. Frequency Rating: 60 Hz.
4. Voltage Rating: Determined by voltage of circuit to which motor is connected for the following motor voltage ratings (utilization voltages):
   a. 120 V Circuit: 115 V - motor rating.
   b. 208 V Circuit: 200 V - motor rating.
   c. 240 V Circuit: 230 V - motor rating.
   d. 480 V Circuit: 460 V - motor rating.
5. Service factors indicated for motors are minimum values and apply at frequency and utilization voltage at which motor is connected. Provide motors which will not operate in service factor range when supply voltage is within 10 percent of motor voltage rating.
6. Capacity: Sufficient to start and operate connected loads at designated speeds in indicated environment, and with indicated operating sequence, without exceeding nameplate ratings. Provide motors rated for continuous duty at 100 percent of rated capacity.
7. Temperature Rise: Based on 40 deg. C ambient except 50 deg. C when otherwise indicated in equipment specifications or on equipment schedules on Plans.
8. Enclosure: Open drip proof except where exposed to elements, weather, or where specifically called for on Drawings and/or equipment specifications.

B. Manufacturers
1. Acceptable Manufacturers: Subject to the following requirements, provide motors from one of the following manufacturers:
   a. Baldor
   b. Marathon
   c. U.S. Motors
   d. General Electric
   e. Reliance

2.2 POLYPHASE MOTORS

A. General: Squirrel-cage induction-type conforming to the following requirements except as otherwise indicated in equipment specifications.
1. NEMA Design Letter Designation: "B" with 1.15 Service Factor.
2. Multi-Speed Motors: Separate winding for each speed.
3. Energy Efficient Motors: Premium Efficiency.

B. Variable Speed Motors for Use with Solid-State Drives:

1. NEMA Standard MG 1, Part 31, ADefinite Purpose Inverter Fed Motors”, continuous duty, Design B, squirrel-cage induction units with ratings, characteristics, and features coordinated with and approved by the drive manufacturer. The motor shall include 1600-volt slot and phase paper insulation for protection against damage due to reflected waves.
2. Internal Thermal Overload Protection for Motors: Protection automatically opens control circuit arranged for external connection. Protection operates when winding temperature exceeds safe value calibrated to the temperature rating of the motor insulation.
3. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading of the application.

2.3 SINGLE-PHASE MOTORS

A. General: Conform to the following requirements except as otherwise indicated.

B. Energy Efficient Motors: One of the following types as selected to suit the starting torque and other requirements of the specific motor application.
1. Permanent Split Capacitor.
2. Split-Phase Start, Capacitor-Run.
3. Capacitor-Start, Capacitor-Run.

C. Shaded-Pole Motors: Use only for motors smaller than 1/20 hp.

D. Internal Thermal Overload Protection for Motors: For motors so indicated, protection automatically opens the power supply circuit to the motor, or a control circuit arranged for external connection. Protection operates when winding temperature exceeds a safe value calibrated to the temperature rating of the motor insulation. Provide device that automatically resets when motor temperature returns to normal range except as otherwise indicated.

E. Bearings, belt connected motors, and other motors with high radial forces on motor shaft shall be ball bearing type. Sealed, pre-lubricated sleeve bearings may be used for other single-phase motors.

2.4 MOTOR EFFICIENCIES

A. Premium Efficiency Motors:
1. All motors shall bear the NEMA APremium” label and shall meet or exceed the following nominal energy efficiency levels prescribed below for Design A or B continuous rated:

(The remainder of this page intentionally left blank)

Table 1 Nominal Efficiencies For NEMA Premium" Induction Motors
Rated 600 Volts or Less (Random Wound)

2.5	Open Drip Proof			Totally Enclosed Fan Cooled		
HP	6-Pole	4-Pole	2-Pole	6-Pole	4-Pole	2-Pole
1	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0
200	95.4	95.8	95.0	95.8	96.2	95.4
250	95.4	95.8	95.0	95.8	96.2	95.8
300	95.4	95.8	95.4	95.8	96.2	95.8
350	95.4	95.8	95.4	95.8	96.2	95.8
400	95.8	95.8	95.8	95.8	96.2	95.8
450	96.2	96.2	95.8	95.8	96.2	95.8
500	96.2	96.2	95.8	95.8	96.2	95.8

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: The following requirements apply to field-installed motors.

B. Install motors in accordance with manufacturer's published instructions and the following:
   1. Direct Connected Motors: Mount securely in accurate alignment.
   2. Belt Drive Motors: Use adjustable motor mounting bases. Align pulleys and install belts. Use belts identified by the manufacturer and tension belts in accordance with manufacturer recommendations.

3.2 COMMISSIONING

A. Check operating motors, both factory and field-installed, for unusual conditions during normal operation. Coordinate with the commissioning of the equipment for which the motor is a part.

B. Report unusual conditions.

C. Correct deficiencies of field-installed units.

3.3 TRAINING AND DEMONSTRATION

A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner's maintenance personnel on the following:
   1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
   2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 01, for Closeout Submittals and Division 23, Section 230020 - "Basic Mechanical Requirements."
   3. Provide Service Manuals for each motor specified.

B. Provide three (3) hours of factory authorized training to Owner’s operating personnel.
   1. Schedule training with at least seven (7) days advanced notice to Owner=s Representative.
   2. Refer to Section 230010 - AMechanical General Provisions” for video taping requirements.

END OF SECTION 230513

SECTION 230514
MOTOR STARTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. All motor starters specified under this section shall be provided by the same manufacturer.

B. All motor starters installed in return air plenums shall be plenum rated.

C. Extent of motor starter work is indicated by drawings and schedules. All motors and mechanical equipment provided with motors supplied by the Division 23 Contractor shall be also provided with Motor Starters and/or Variable Frequency Drives. It is the responsibility of the Division 23 Contractor to ensure that all Motor Starters/VFD’s are sized and suitable for the intended purpose of the mechanical equipment provided.

D. Disconnecting means unless integral to the Starter/VFD shall be provided by the Division 26 Contractor.

E. Types of motor starters specified in this section include the following:
1. Magnetic.
2. Manual.

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacturer of motor starters, of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects utilizing motor starters similar to that required for the project.

C. NEC Compliance: As a minimum, comply with NEC as applicable to wiring methods, construction and installation of motor starters.

D. NFPA Compliance: As a minimum, comply with applicable requirements of NFPA 70E "Standard for Electrical Safety Requirements for Employee Workplaces".

E. UL Compliance: As a minimum, comply with applicable requirements of UL 468A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors", and UL 508, "Electrical Industrial Control Equipment", pertaining to installation of motor starters.

F. IEE Compliance: As a minimum, comply with applicable requirements of IEE STD 241, "Recommended Practice for Electric Power Systems in Commercial Buildings" pertaining to motor starters.

G. NEMA Compliance: As a minimum, comply with applicable portions of NEMA Standard ICS 2, "Industrial Control Devices, Controllers and Assemblies", Maximum), pertaining to motor controllers/starters and enclosures.

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's data on motor starters.

B. Shop Drawings: Submit layout drawings of motor starters showing accurately scaled equipment locations and spatial relationships to associated motors.

C. Wiring Diagrams: Submit wiring diagrams for motor starters showing connections to electrical power panels, feeders, and equipment. Clearly differentiate between portions of wiring that are manufacturer-installed and portions to be field-installed.

D. Maintenance Stock - Fuses: For types and ratings required, furnish additional fuses, amounting to one set for every 10 installed units, but not less than 5 sets of each.

1.5 DELIVERY & STORAGE

A. Motor Starter(s) shall be stored and handled per manufacturer's recommendations.
1. Deliver motor starter(s) from the factory properly secured, crated, and protected with factory plastic shrink wrap or other protective wrap.
2. Lift and support motor starter(s) with the manufacturer's designated lifting or supporting points.
3. Disassemble and reassemble motor starter(s) as required for movement into the final location following manufacturer's written instructions.
4. Deliver motor starter(s) as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.
5. Store motor starter(s) to prevent damage to starter(s). Store units out of the elements and maintain factory protective covering until ready for installation.

B. Lift and support motor starter(s) with the manufacturer's designated lifting or supporting points.

C. Disassemble and reassemble motor starter(s) as required for movement into the final location following manufacturer's written instructions.

D. Deliver motor starter(s) as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering motor starters which may be incorporated in the work are as follows:
1. Allen-Bradley Co.
2. Cutler Hammer Products, Eaton Corp.

3. General Electric Co.
4. GTE Products Corp.
5. Gould, Inc.
6. Square D Co.
7. Westinghouse Corp.
8. Siemens, Inc.

2.2 MOTOR STARTERS

A. General: Except as otherwise indicated, provide motor starters and ancillary components which as a minimum, comply with manufacturer's standard materials, design and construction in accordance with published product information, and as required for complete installation.

B. Magnetic Starter Requirements: Provide magnetic starters for motors 3/4 hp and larger, and for smaller motors where interlock or automatic operation with other equipment is indicated. Include the following accessories for all starters:
1. Provide UL Listing as a unit. Starters assembled with only UL components will not be acceptable.
2. Maintained-contact push buttons and pilot lights, properly arranged for single-speed or multi-speed operation as indicated.
3. Trip-free thermal adjustable overload relays, each phase.
4. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Section 230900 – “Building Automation System” sections.
5. Built-in 120-volt control circuit transformer with fused secondary, fused from line inside, where service exceeds 240 volts.
6. Pilot Light; Red - AOn”
7. Pilot Light; Green - AOff”
8. Auxiliary Contact Block
9. Externally operated manual AReset” overload relay button mounted on door/cover of the unit.
10. 2-Point terminal strip with AH-O-A” Selector switch
11. Hinged cabinet cover. Lift cover is not acceptable.
12. Enclosure - Rated for exposure indicated on plans unless otherwise specifically indicated.
13. Under-voltage release or protection.
14. Lockable Handle AOFF” position switch.

C. AC Fractional HP Manual Starters: Provide manual single-phase fractional HP manual motor starters, of sizes and ratings indicated. Equip with manually operated quick-make, quick-break toggle mechanisms; and with one-piece melting alloy type thermal units. Starter to become inoperative when thermal unit is removed. Provide starters with double break silver alloy contacts, visible from both sides of starter; green pilot lights, and switch capable of being padlocked AOFF”. Enclose starter unit in NEMA Type 1, 12, 4X, or 3R general purpose enclosure suitable for surface mounting according to the environment in which the starter is installed. Coat with manufacturer's standard color finish.

D. Full Voltage Non-Reversing Starters: Starters for three phase motors 10 horsepower and below.
1. Provide combination type starter/disconnect, full voltage non- reversing (FVNR), with magnetic NEMA rated contactors rated for horsepower of motor served.
2. Adjustable trip magnetic circuit breaker disconnect (motor circuit protector) capable of being padlocked in the open position (power off).

3. 10K AIC minimum fault rating with higher rating, when necessary, due to available fault levels.
4. Starters shall have a fused 100VA minimum control transformer (120V, unless required otherwise).
5. Provide HOA switch, push to test operating pilot light, solid state overload relays set for actual motor nameplate full load amps, and phase failure and phase reversal protection relays.
6. Provide minimum two (2) N.O. and two (2) N.C. auxiliary contacts and terminal blocks factory pre-wired for field wiring.
7. Starters shall be housed in a NEMA 1 enclosure for indoor applications and NEMA 3R enclosure for outdoor or wet locations. NEMA 12 enclosures shall be provided for installation in return air plenums or dirty/dusty indoor locations. NEMA 4X Stainless Steel enclosures shall be installed in corrosive environments.
8. Coat with manufacturer's standard color finish.

PART 3 - EXECUTION

3.1 INSTALLATION OF MOTOR STARTERS

A. Install motor starters, in accordance with equipment manufacturer's written instructions and with recognized industry practices; complying with applicable requirements of NEC, UL, and NEMA standards, to ensure that products fulfill requirements.

B. Coordinate with other work including motor and electrical wiring/cabling work, as necessary to interface installation of motor starters with other work.

C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std 486A.

D. Install fuses in fusible disconnects, if any.

3.2 ADJUSTING AND CLEANING

A. Inspect electrical starter's operating mechanisms for malfunctioning and, where necessary, adjust units for free mechanical movement.

B. Touch-up scratched or marred surfaces to match original finish.

3.3 FIELD QUALITY CONTROL

A. Subsequent to connecting wire/cables, energize motor starter circuitry and demonstrate functioning of equipment in accordance with requirements; where necessary correct malfunctioning units, and then retest to demonstrate compliance. Ensure that direction of rotation of each motor fulfills requirements.

3.4 TRAINING & DEMONSTRATION

A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner's maintenance personnel on the following:
   1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.

2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 01, Section 017780 - "Closeout Submittals" and Division 23, Section 230020 - "Basic Mechanical Requirements."
3. Provide Service Manual for each motor starter specified.

B. Provide three (3) hours of factory authorized training.
1. Refer to Section 230010 - AMechanical General Provisions” for video taping requirements.
2. Schedule training with Owner’s Representative with at least seven (7) days notice.

END OF SECTION 230514

SECTION 230515
VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. All Variable Frequency Drives (VFD's) specified under this section shall be provided by the same manufacturer.

B. All VFD's installed in return air plenums shall be plenum rated.

C. Extent of motor starter and/or variable frequency drive work is indicated by drawings, schedules and specifications. All motors and mechanical equipment provided with motors supplied by the Division 23 Contractor shall be also provided with Motor Starters and/or Variable Frequency Drives. It is the responsibility of the Division 23 Contractor to ensure that all VFD=s are sized and suitable for the intended purpose of the mechanical equipment provided.

D. The Division 23 Contractor shall provide the Motor Starters and VFD's to the Division 26 Contractor for mounting, installation, and connection by the Division 26 Contractor. Disconnecting means unless integral to the Starter/VFD shall be provided by the Division 26 Contractor.

1.3 SECTION INCLUDES

A. Variable Frequency Drives (VFDs): This section includes stand alone Variable Frequency Drives, Drives that are integral to equipment, and Variable Frequency Drives located within Motor Control Centers.
   1. All Variable Frequency Drives shall be of the same manufacturer. Variable Frequency Drives located in mechanical rooms as Free-Standing Units and Variable Frequency Drives located in Motor Control Centers shall be of the same manufacturer. Drives that are integral to the equipment being installed shall be of the same manufacturer as the equipment in which they are installed.
   2. Variable Frequency Drives shall be plenum rated where installed in mechanical rooms which are used as return air plenums.
   3. Variable Frequency Drives (VFD's), Variable Speed Controllers (VSD's), and Adjustable Speed Drives are also referred to as AC Drives and their nomenclature shall be used interchangeably.
   4. Drives are for use with NEMA "B" or NEMA "E", MG-1 design AC motors.
   5. Drives coordinated short circuit current shall be rated in accordance with UL 508C AStandard for Safety for Power Conversion Equipment". Drives which do not bear the short circuit current on the drive nameplate shall not be permitted.

6. Drives shall also be tested in accordance with NEMA ICS 7.1 "Safety Standard for the Construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems."

1.4 REFERENCES

A. ANSI/NFPA 70 - National Electric Code

B. IEC 60068, Part 2-3

C. NEMA ICS

D. UL 50, 98, 507, 508, 508C, 991

E. OSHA 1910.95 - AC Drive Controller Acoustical Noise

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include the following:
1. General Electric Company
2. Allen Bradley
3. Cuttler Hammer
4. Square D Company
5. Aesa Brown Boveri (ABB)
6. Danfoss
7. Yaskawa

2.2 GENERAL

A. Environmental Ratings:
1. The "Service Voltage" for the Project is 480/3/60.
2. The AC Drive shall meet IEC 60664-1 Annex A and NEMA ICS 1, UL, and CSA standards.
3. For indoor installation, the AC Drive shall be designed to operate in an ambient temperature environment from 0 to 40 deg C (32 to 104 deg F).
4. For outdoor installation, the AC Drive shall be designed to operate in an ambient temperature environment from -18 to 50 deg C (0 to 122 deg F).
5. The storage temperature range shall be -25 to 60 deg C (-13 to 149 deg F)
6. The maximum humidity shall be 90 % at 40 deg C (104 deg F) non-condensing.
7. The AC Drive shall meet the IEC 60721-3-3M3 operational vibration specification.
8. Drives shall be plenum rated where installed in return air plenums.

B. Construction:
1. For indoor installation the AC Drive power converter shall be enclosed in a Type 12K enclosure with top and bottom conduit knockouts with a circuit breaker disconnect, industrial rated operator controls, user terminal strip connections, and by-pass controls.

2. For outdoor installation the AC Drive power converter shall be enclosed in a Type NEMA 3R enclosure with industrial rated operator controls, user terminal strip connections, and by-pass controls. NEMA 4X enclosures shall be provided near cooling towers and other corrosive environments.
3. The enclosure shall provide dedicated user terminals for power and control device connection.
4. Provisions shall be included for locking the disconnect in the “OFF” position with a padlock.
5. All enclosure heat sink fans shall be front accessible and shall not require the removal of the AC Drive converter.

C. Harmonic Mitigation:

1. The electrical distribution system shall be designed to meet IEEE-519-1992 with the addition of line reactors. These line reactors shall be mounted inside the drive enclosure.

D. Furnish complete variable frequency drives including internal unit mounted disconnects meeting the requirements of NEC 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 unit shall be capable of being provided single source power by the Division 26 Contractor without the need of an externally mounted disconnecting means or fused disconnect switch.

E. All VFD’s shall be rated for “constant torque” at temperatures stated in section 2.2, A and shall be capable of operating in location shown on contract documents.
1. Provide internal cooling fans sized and rated for the conditions stated above.
2. The controller, bypass assembly, disconnect switch and controls shall be by the same manufacturer, factory installed, and shall be self-contained in a single convection cooled cabinet.
3. All terminal blocks provided for field wiring shall be pre-wired at the factory.

F. The VFD shall utilize Pulse Width Modulated (PWM) design with latest generation IGBT’s.
1. Unit shall be UL listed and rated.
2. Unit shall have output current rating of 110% of motor FLA for one (1) minute.
3. Unit shall take incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors.
4. The motor current shall closely approximate a sine wave.
5. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control and to negate the need for motor derating.
6. Provide short circuit and ground fault protection.
7. Provide non-volatile memory.
8. Provide and be capable of single-phase input operation with 50% VFD derating.
9. Minimum efficiency shall be 97% at full load, full speed.
10. Unit shall be capable of operation on an AC line containing line notching and up to 10% THD and capable of operation with motor disconnected from output.
11. VFD to be compatible with NEMA Design “B” motors.
12. VFD shall report to the Building Automation System (BAS) via a direct N2 connection.

G. An advanced sine wave approximation and voltage vector control shall be used to allow operation at rated motor shaft output at nominal speed with no derating. This voltage vector control shall minimize harmonics to the motor to increase motor efficiency and life.

H. Reference Signal:
   1. In the event of loss of the reference signal. The VFD shall alarm and go to one of the following user programmable conditions:
      a. Stop
      b. Maintain last reference
      c. Go to pre-set speed
      d. Go to maximum speed

I. The VFD shall include a full-wave diode bridge or SCR rectifier and maintain a fundamental power factor near unity regardless of speed or load. If SCR’s are utilized, they shall be gated fully on once precharge is complete.

J. 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. Local representative panel shop assembly for option panels is not acceptable. The appropriate UL stickers shall be applied to both the drive and option label, in the case where these are not contained in one panel.

K. The VFD shall have a DC link reactor to minimize power line harmonics. VFDs without a DC link reactor shall provide a 3% impedance line reactor.

L. 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 currently continuously, 110% of rated current for 60 seconds and 150% of rated current for up to 0.3 seconds while starting.

M. The VFD shall be able to provide full torque at any selected speed up to base speed to allow driving direct drive fans without derating.
   1. The VFD shall be provided with a selectable soft start, linear, or S-curve start function.
   2. Provide selectable ramp to stop, coast, brake, and S-curve stop function.

N. An automatic energy optimization selection feature shall be provided standard in the drive. This feature shall automatically and continually monitor the motors speed and load and adjust the applied voltage to maximize energy savings.

O. 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 and decouple the motor from the load to run the test.

2.3 PROTECTIVE FEATURES

A. Class 10 I square root electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor application.
B. Phase-to-phase and phase to neutral short circuit protection. Drive 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.

C. Protection against input transients, loss of AC line phase, short circuit, ground fault, over voltage, under voltage, drive over temperature and motor over temperature. The VFD shall display faults in plain English. Codes are not acceptable.

D. Protect VFD from sustained or intermittent 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 285 volts for 480-volt units.

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

F. Drive shall maintain logic control and shall not fault for 2 seconds after a power loss.

G. Drive shall have semi-conductor rated input fuses to protect power components.

H. To prevent breakdown of the motor winding insulation, the dV/dt must be below 1500 V/msec per IEC recommendations. The supplier shall include with the quotation the V/dt values of the drive.

I. Drive shall include a Asignal loss detection" circuit to sense the loss of the control signal, and shall be programmable to react as desired in such instance.

J. Drive shall catch a rotating motor operating forward or reverse up to full speed.

K. VFD shall be rated for a minimum 60,000 amp interrupting capacity (AIC).

L. Drive shall include UL 508C programmable electronic motor overload.

M. Drive shall continue to operate without faulting until input voltage exceeds 604 volts on 480-volt drives.

2.4 INTERFACE FEATURES

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

B. Provide a 24 V DC output signal to indicate that the drive is in Auto/Remote mode.

C. Digital manual speed control. Potentiometers are not acceptable.

D. Lockable, alphanumeric backlit display keypad that can be remotely mounted up to 10 feet away using standard 9-pin cable.

E. All keypads shall be identical and interchangeable.
F. Drive shall be capable of being operated with the keypad removed.

G. All drives shall utilize the same control keypad.

H. To setup multiple drives, it shall be possible to upload all setup parameters to the drive's keypad, place that keypad on all other drives in turn and download the setup to each drive.

I. Display shall be programmable to display in English.

J. The display shall have minimum of four lines, with 20 small characters or eight large characters on each line.

K. Three (3) lines of the display shall allow free programming so that the exact unit controlled by the drive can be identified.

L. 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 drive when the keypad is removed.

M. A quick setup menu with the most common HVAC parameters shall be provided on the drive eliminating the need for macros.

N. The drive shall be fitted with an RS 485 serial communications port with capability for remote monitoring signals.

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

P. Floating point control interface shall be provided to increase/decrease speed in response to switch closures.

Q. Sleep mode shall be provided to automatically stop the drive when speed drops below set “sleep” level for a specified time. Drive automatically restarts when speed command exceeds set “wake” level.

R. Run permissive circuit shall be provided to accept a “system ready” signal to assure that the drive does not start until dampers or other auxiliary equipment are in the proper state for drive operation.

S. An elapsed time meter and kWh meter shall be provided.

T. The following displays shall be accessible from the control panel in actual units:
1. Reference Signal Value in actual units
2. Output Frequency in Hz or percent
3. Output Amps
4. Motor HP
5. Motor KW
6. KWH
7. Output Voltage
8. No Load Warning
9. DC Bus Voltage
10. Drive Temperature in degrees
11. Motor Speed in engineering units per application (in percent speed, GPM, CFM). Drive will read out the selected engineering unit either in a linear, square or cubed relationship to output frequency as appropriate to the unit chosen.

U. Up to four-meter displays can be shown at once on the display. This allows the actual value of the follower signal to be shown simultaneously with the drive’s response to that signal for ease in commissioning.

V. Drive will sense the loss of load and signal a no load/broken belt warning or fault.

W. The VFD shall have temperature controlled internal cooling fans for quiet operation and minimized losses. Fan shall be sized for ambient conditions in which drive is installed. Drives that overheat in Mechanical spaces (ambient temperatures at 120 deg. F or below) for the installed load, shall be removed and replaced with suitable new unit, at no cost to Owner.

X. The VFD shall store in memory the last four (4) faults (minimum) and record all operational data.

Y. Seven (7) programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.

Z. Two (2) programmable relay outputs, one form C 240 V AC, one Form A 50 V AC, shall be provided for remote indication of drive status.

AA. Two programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include 0-10V dc, 0-20 mA and 4-30mA.

BB. Two programmable analog outputs shall be provided for indication of drive status. These outputs shall be programmable for output speed, voltage, frequency, amps and input kW.

2.5 ADJUSTMENTS

A. VFD shall have an adjustable carrier frequency.

B. Seven (7) preset speeds shall be provided.

C. Two (2) acceleration and two (2) deceleration ramps shall be provided. Acceleration and deceleration time shall be adjustable over the range from 0 to 3,600 seconds to base speed. The shape of these curves may be automatically contoured to prevent tripping.

D. Four current limit settings shall be provided.

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

F. The number of restart attempts shall be selectable from 0 through 20 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.

2.6 BYPASS

A. Provide a manual bypass consisting of a door interlocked main fused disconnect padlockable in the “Off” position, a built-in motor starter and a four position DRIVE/OFF/LINE/TEST switch controlling three contactors. In the drive position, the motor is operated at an adjustable speed from the drive. In the “Off” position, the motor and drive are disconnected. In the LINE position, the motor is operated at full speed from the A/C power line and power is disconnected from the drive so that service can be performed. In the TEST position, the motor is operated at full speed from the AC line power. This allows the drive to be given an operational test while continuing to run the motor at full speed in bypass. Supplemental, normally closed, dry contact shall be furnished with the drive and interlocked with the drives safety trip circuitry to stop the motor whether in DRIVE or BYPASS mode in case of an external safety fault.

2.7 SERVICE CONDITIONS

A. Unit shall be suited to operate in environmental temperatures up to 122 deg. F (50 deg. C), and up to 90% relative humidity (non-condensing) expected for environment in which installed. Provide high-capacity cooling fans and enclosures rated for ambient conditions.

B. Input AC line voltage variation, -10 to +10% of nominal with full output. Input frequency - +/- 5% 50/60 Hz. 3-phase, 3-wire, phase sequence insensitive.

C. Service Factor: 1.0

D. No side clearance shall be required for cooling of any NEMA 1 units, or of any NEMA 12 units of less than 75 HP at 460 volts. All power and control wiring shall be done from the bottom of the drive, unless otherwise noted or coordinated differently from that stated by Contractor.

2.8 QUALITY ASSURANCE

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

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

2.9 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.

B. 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.

C. Submit a Harmonic Distortion Analysis for the jobsite location.

D. The drives shall conform to the “Made in USA” requirement.

E. Indicate all field wiring and factory wiring clearly in submittal. All field wiring other than work shown to be part of Division 26 work on electrical drawings shall be by Division 23 Contractor furnishing drives.

PART 3 - EXECUTION

3.1 START-UP SERVICE

A. Installation of drives shall be in compliance and in accordance with manufacturer’s instructions, drawings, and recommendations.

B. The manufacturer shall provide start-up, testing, and commissioning of the variable frequency drive(s); to certify and inspect the installation of the drive; and to verify all circuits by a factory certified service/technical representative who is experienced in start-up and repair services. The technical representative shall be the same personnel that will provide the factory service and warranty repairs at the customer's site. Sales personnel and other agents who are not factory certified technicians for VFD field repair 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.

3.2 WARRANTY

A. The VFD shall be warranted by the Contractor for a period of three (3) years (36 months) from date of substantial completion of the project and not from date of shipment or installation. The contractor shall include in his bid, all manufacturer's "extended warranty" costs associated with this requirement. The Warranty shall include all 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.
   1. Refer to Specification Section 230020 – "Basic Mechanical Requirements" for additional requirements of warranties and guarantees.

B. Documentation:
   1. The AC Drive manufacturer shall provide a comprehensive 8 2" x 11" bound instruction/installation manual that includes wiring diagrams, layout diagrams, and outline dimensions. The manual shall be in a 3-hole binder and punched for insertion into a shop manual supplied by the installing Contractor.

3.3 EXAMINATION

A. Contractor and factory start-up technician shall verify that job site conditions for installation meet factory recommended and code-required conditions for VFD installation prior to shop drawing submittal. These conditions shall be re-verified 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. Factory certified service technician, by virtue of completing the "start-up" of the drive, is certifying that actual environmental/code required conditions have been found to be satisfactory, or have been corrected to manufacturer's satisfaction (if originally found unsatisfactory). A start-up sheet signed by the factory certified service technician shall be bound into the final Operation and Maintenance Manuals turned over to the Owners Representative.

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

3.4 TRAINING & DEMONSTRATION

A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner's maintenance personnel on the following:
   1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.

2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 01, Section "Closeout Submittals" and Division 23, Section 230020 - "Basic Mechanical Requirements."
3. Provide Service Manuals for each variable frequency drive specified.

B. Provide four (4) hours of factory authorized training.
1. Schedule training with Owner’s Representative with at least seven (7) days notice.
2. Refer to Section 230010 – “Mechanical General Provisions” for videotaping requirements.

END OF SECTION 230515

STATE OF LOUISIANA
R. CRAIG CAMPBELL, II
License No. 29380
3/10/26
PROFESSIONAL
ENGINEER

SECTION 230519
METERS AND GAUGES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. This Section includes meters and gauges used in mechanical systems.

1.3 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 01 Specification Sections.

B. Product data for each type of meter, gauge, and fitting specified. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit a meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.

C. Product certificates signed by manufacturers of meters and gauges certifying accuracies under specified operating conditions and compliance with specified requirements.

D. Maintenance data to include in the "Operating and Maintenance Manuals" specified in Division 01. Include data for the following:
1. Test plugs.
2. Thermometers and thermometer wells
3. Pressure gauges

1.4 QUALITY ASSURANCE

A. Comply with applicable portions of American Society of Mechanical Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges.

B. Design Criteria: The Drawings indicate types, sizes, capacities, ranges, profiles, connections, and dimensional requirements of meters and gauges and are based on the specific manufacturer types and models indicated. Meters and gauges having equal performance characteristics by other manufacturers may be considered, provided that deviations do not change the design concept or intended performance as judged by the Architect. The burden of proof for equality of meters and gauges is on the proposer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Direct-Mounting Filled-System 5” Dial Type, Adjustable Thermometers:
i. Weksler Type 332 CCI
ii. Weiss Instruments, Inc.
b. Pressure Gauges:
i. Weskler Type AAO
ii. Weiss Instruments, Inc.
c. Test Plugs:
i. Flow Design, Inc.
ii. Watts Regulator Co.

2.2 THERMOMETERS, GENERAL

A. Scale Range: Temperature ranges for services listed as follows:
1. Domestic Hot Water and Heating Hot Water: 30 to 240 deg F, with 2-degree scale divisions.
2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions.
3. Chilled Water: 0 to 100 deg F, with 2-degree scale divisions).

B. Accuracy: Plus, or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

2.3 DIRECT-MOUNTING FILLED-SYSTEM DIAL THERMOMETERS

A. Description: Nominal 5” Vapor-actuated universal-angle dial thermometer.

B. Case: Drawn stainless steel or cast aluminum, with 4-1/2-inch -diameter glass lens.

C. Adjustable Joint: Finish to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

D. Thermal Bulb: Copper with phosphor-bronze Bourdon pressure tube.

E. Movement: Brass, precision geared.

F. Scale: Progressive satin-faced nonreflective aluminum with permanently etched markings.

G. Stem: Copper-plated steel, aluminum, or brass for a separable socket of length to suit installation.

2.4 THERMOMETER WELLS

A. Description: Brass or stainless-steel thermometer well.
B. Pressure Rating: Not less than piping system design pressure.

C. Stem Length: To extend to center of pipe.

D. Extension for Insulated Piping: 2 inches nominal, but not less than thickness of insulation.

E. Threaded Cap Nut: With chain permanently fastened to well and cap.

2.5 PRESSURE GAUGES

A. Description: ASME B40.1, Grade A phosphor-bronze Bourdon-tube pressure gauge, with bottom connection.

B. Case: Drawn steel, brass, or aluminum with 4-1/2-inch -diameter glass lens.

C. Connector: Brass, 1/4-inch.

D. Scale: White-coated aluminum, with permanently etched markings.

E. Accuracy: Plus, or minus 1 percent of range span.

F. Range: Conform to the following:
1. Vacuum: 30 inches Hg of vacuum to 15 psig of pressure.
2. Fluids Under Pressure: 2 times operating pressure.

2.6 PRESSURE-GAUGE ACCESSORIES

A. Syphons: 1/4-inch straight coil of brass tubing with threads on each end.

B. Snubbers: 1/4-inch brass bushing with corrosion-resistant porous-metal disc of material suitable for system fluid and working pressure.

2.7 TEST PLUGS

A. Description: Nickel-plated brass-body test plug in 1/2-inch fitting.

B. Body: Length as required to extend beyond insulation.

C. Pressure Rating: 500 psig minimum.

D. Core Inserts: 2 self-sealing valve types, suitable for inserting a 1/8-inch outside-diameter probe from a dial thermometer or pressure gauge.

E. Core Material: According to the following for fluid and temperature range:
1. Air, Water, Oil, and Gas: 20 to 200 deg F, neoprene rubber.
2. Air and Water: Minus 30 deg to 275 deg F, ethylene-propylene-diene-terpolymer (EPDM) rubber.

F. Test-Plug Cap: Gasketed and threaded cap, with retention chain.

G. Test Kit: Provide test kit consisting of 1 pressure gauge and gauge adapter with probe, 2 bimetal dial thermometers and a carrying case.

H. Pressure Gauge and Thermometer Ranges: Approximately 2 times systems operating conditions.

PART 3 - EXECUTION

3.1 METER AND GAUGE APPLICATIONS

A. General: Where indicated, install meters and gauges of types, sizes, capacities, and with features indicated.

3.2 METER AND GAUGE INSTALLATION, GENERAL

A. Install meters, gauges, and accessories according to manufacturers' written instructions for applications where used.

3.3 THERMOMETER INSTALLATION

A. Install thermometers and adjust vertical and tilted positions.

B. Install in the following locations and elsewhere as indicated:
1. At inlet and outlet of each pump.
2. At inlet and outlet of each chiller.
3. At inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. At inlet and outlet of each hydronic heat exchanger (building side)
5. At inlet and outlet of each hydronic heat recovery unit.
6. At inlet and outlet of each thermal storage tank/water heater.

C. Thermometer Wells: Install in vertical position in piping tees where thermometers are indicated.
1. Install wells with stem extending to center of pipe.
2. Fill wells with oil or graphite and secure caps.

3.4 PRESSURE GAUGE INSTALLATION

A. Install pressure gauges in piping tee with pressure gauge valve located on pipe at most readable position.

B. Install in the following locations and elsewhere as indicated:
1. At suction and discharge of each pump.
2. At discharge of each pressure-reducing valve.
3. At inlet and outlet of each chiller.
4. At chilled water service (central loop) inlets and outlets.

C. Pressure Gauge Needle Valves: Install in piping tee with snubber. Install syphon instead of snubber for steam pressure gauges.

3.5 TEST PLUG INSTALLATION

A. Install test plugs in piping tees where indicated, located on pipe at most readable position. Secure cap.

3.6 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. The Drawings indicate the general arrangement of piping, fittings, and specialties.

B. Install meters and gauges adjacent to machines and equipment to allow servicing and maintenance.

3.7 ADJUSTING AND CLEANING

A. Calibrate meters according to manufacturer's written instructions, after installation.

B. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.

C. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touch-up paint.

END OF SECTION 230519

SECTION 230523
HVAC VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. All valves specified under this section shall be provided by the same manufacturer.

B. This Section includes general duty valves common to most mechanical and plumbing piping systems. Valves identified in this section include:
1. Globe Valves
2. Ball Valves
3. Butterfly Valves

C. Special purpose valves such as automatic control valves, are specified in the individual piping system specifications.

1.3 SUBMITTALS

A. Submittal Format:
1. Provide submittal data categorized by use, type, and size.

B. Product Data: Include the following:
1. Body material
2. Valve design
3. Pressure and temperature classification
4. End connection details
5. Seating materials
6. Trim material and arrangement
7. Dimensions and required clearances
8. Installation instructions
9. Include pressure drop curve or chart for each type and size valve.

C. Maintenance Data: Submit maintenance data and spare parts list for each type of valve. Include this data in Maintenance Manuals.

1.4 QUALITY ASSURANCE

A. Single Source Responsibility: Provide valves of same type and same manufacturer.

B. Valve Identification: As a minimum, comply with the MSS SP-25 “Standard Marking System” for valves, fittings, flanges and unions.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves for shipping as follows:
1. Ensure valves are dry and internally protected against rusting and galvanic corrosion.
2. Protect valve ends against mechanical damage to threads, flange faces, and weld end preps.
3. Set valves in best position for handling. Globe, and gate valves shall be closed to prevent rattling; ball and plug valves shall be open to minimize exposure of functional surfaces; butterfly valves shall be shipped closed or slightly open; and swing check valves shall be blocked in either closed or open position.

B. Storage: Use the following precautions during storage:
1. Do not remove the valve end protectors unless necessary for inspection; then reinstall for storage.
2. Protect valves against weather. Where practical store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement and protect in watertight enclosures.
3. Handling: Valves whose size requires handling by crane or lift shall be slung or rigged to avoid damage to exposed valve parts. Handwheels and stems, in particular, shall not be used as lifting or rigging points.

1.6 EXTRA MATERIALS

A. Provide two (2) re-packing kits for each size and type of valve.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide valves from one of the manufacturers listed except for specialty valves.
1. Nibco
2. Watts
3. Milwaukee
4. Hammond
5. Conbraco (Apollo)

2.2 TYPICAL GENERAL-PURPOSE VALVE FEATURES

A. General: As a minimum, comply with ASME B31.9 for building services piping, and ASME B31.1 for power piping.

B. Valve Design: Except for quarter turn valves, only valves having a rising stem, or rising outside screw and yoke stems shall be permitted; except, non-rising stem valves may be used only where headroom prevents full extension of rising stems.
1. Pressure and Temperature Ratings: Valves shall be as scheduled and required to suit system pressures and temperatures.

2. Sizes: Unless otherwise indicated, provide valves of same size as upstream pipe size.
3. Operators: Provide the following special operator features:
    a. Handwheels: Fastened to valve stem, for valves other than quarter turn.
    b. Lever Handle: On quarter-turn valves 6 inch and smaller, except for plug valves. Provide one wrench for every 10 plug valves.
    c. Gear drive operators: On quarter-turn valves 8 inches and larger.
    d. Chain operators: Provide chain operator on all OS&Y or gear-operated valves 6 inches and larger which are located higher than 8'-0" above finished floor. Chain shall extend down to 6'-6" above finished floor.
4. Extended Stems: Where insulation is specified, provide extended stems arranged to receive thickness of insulation specified.
5. End Connections: As specified within the individual valve specifications.
    a. Threads: As a minimum, comply with ANSI B2.1.
    b. Flanges: As a minimum, comply with ANSI B16.1 for cast iron, ANSI B16.5 for steel, and ANSI B16.24 for bronze valves.
    c. Solder-Joint: As a minimum, comply with ANSI B16.18. - Caution: Where soldered end connections are used, use solder having a melting point below 840 deg F for gate, globe, and check valves; below 421 deg F for ball valves.
    d. Butt Weld: As a minimum, comply with ANSI B16.25

C. Typical Valve Features:
1. Operators: Provide the following special operator features.
    a. Hand Wheels: Hand wheels shall be fastened to valve stem, for valves 6 inches and below and for all valves other than quarter turn valves.
    b. Lever Handles: On all quarter turn valves six inches and smaller, except for plug valves. Provide one wrench for every ten (10) plug valves of each size.
    c. Gear Operators: Provide gear operators on all valves eight inches and larger.
    d. Chain Operators: Provide chain operators on valves located 8'-0" or more above finished floor in central plants, mechanical equipment rooms or attics.

2.3 BALL VALVES

A. (HVAC Chilled Water and Hot Water Heating & Drain lines) Ball Valves - 1 Inch and Smaller:
1. Pressure: Rated for 150 psi WSP/600 psi WOG pressure
2. Construction: 2-piece construction
3. Body: Cast Bronze conforming to ASTM B 584
4. Tailpiece: Brass Hex Rod
5. Port: Full port
6. Ball: chrome-plated brass ball
7. Seal: Reinforced PTFE, 15% glass filled
8. Stem: Brass round rod - blowout proof stem
9. Washer: Reinforced PTFE, 15% glass filled
10. Packing: PTFE
11. Packing Nut: Brass Hex Rod
12. Handle: Vinyl-covered steel, zinc coated, locking On/Off handle
13. Handle Nut: Steel w/zinc coating
14. Provide solder ends for all copper tube connections, (i.e. domestic hot and cold-water service).

15. Provide screwed ends for all steel pipe connections, (i.e. - drain lines, chilled water lines, hot water heating lines, and condenser water lines).
16. Provide union upstream of all screwed valves.

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Watts	B-6800-LL	B-6801-LL
Nibco:	T-585-70	S-585-70
Milwaukee:	BA-400/BA-475-B	BA-450/BA-485-B
Hammond	8901	8911

B. (HVAC Chilled Water) Ball Valves - 1-1/4 Inch to 2-1/2 Inch:
1. Pressure: Rated for 150 psi WSP/400 psi WOG pressure
2. Construction: 3-piece construction
3. Body: Bronze body conforming to ASTM B 62
4. Port: Full port
5. End Cap: Bronze ASTM B 62
6. Stem: Brass ASTM B 16
7. Ball: Chrome-plated brass ball
8. Seats: PTFE, 15% glass filled
9. Stem Washer: PTFE, 15% glass filled
10. Gland: Brass ASTM B 16
11. Stem Seal: PTFE
12. Handle: Vinyl-covered, zinc plated steel with locking On/Off handle
13. Body Seal: PTFE
14. Body Bolt: Steel ASTM A 307
15. Body Nut: Steel ASTM A 307

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Watts	B-6800-LL	B-6801-LL
Conbraco (Apollo):	82-100	82-200
Nibco:	T-595-Y-LL	S-595-Y-LL
Milwaukee:	BA-300	BA-350
Hammond	8604	8614

2.4 BUTTERFLY VALVES

A. (HVAC Chilled Water) Butterfly Valves - 2-1/2 Inch and Larger: MSS SP-67; 200 psi, cast iron lug type body conforming to ASTM A 126, Class B material standards. Valves shall have field replaceable EPDM sleeve, with ASTM-B 148 UNS C95200 Grade A aluminum bronze disc, 416 stainless steel stem, bronze bearings, and EPDM O-ring stem seals. Sizes 2 through 6 inches shall have lever operators with locks, and sizes 8 through 24 inches shall have gear operators with position indicator. All butterfly valves 2" thru 12" shall be rated at 200 psi working pressure. All butterfly valves 14" and larger shall be rated at 150 psi working pressure. Valves installed in ADead-End” applications shall be shall be rated for 150 psi working pressure for valves 2" thru 12" and 100 psi for 14" and above. All valves shall be lug type, drilled and tapped with the following construction:

1. Body: Cast Iron ASTM A 126, Class B
2. Lever: 10 position memory stop iron construction
3. Disc: Aluminum Bronze ASTM B 148, Alloy 954/955

4. Stem: Stainless Steel ASTM A 582, Type 416
5. Nameplate: Aluminum
6. Key: Steel ASTM A-108 Grade 1045
7. Bushing: Bronze ASTM B-584 Grade C83600
8. Main Bearing: Nylon
9. Dirt Seal: Buna-N, ASTM D2000
10. Stem Seal: Buna-N, ASTM D2000
11. Sleeve: EPDM, ASTM D2000
12. Pin: Stainless Steel
13. Lower Dirt Seal: BUNA-N, ASTM D2000
14. Seat: EPDM
15. Provide chain operator where valve is located higher than 8'-0" AFF

LUG BODY

MANUFACTURER	LEVER	GEAR
Watts	BF-03-121-15	BF-03-121-15
Conbraco-Apollo:	6L-14X-01	6L-14X-02
Nibco:	N150-2-3-5-LH	N150-2-3-5-GO
Hammond	6200	6200
Milwaukee	CL223E/ML323E	ML323E

2.5 SPECIALITY VALVES

A. Stop Valves: 2" & 3/4" (female; cup): Interchangeable stem and bonnet assemblies, 125 lb. CWP to 100 deg F, Max Temp 180 deg F. Provide end cap and chain.
1. Spec: MSS SP-80; Type 1, Class 125 CWP
2. Body: Cast Copper-based Alloy (C84400), threaded or solder ends
3. Bonnet: Cast Copper-based Alloy (C84400)
4. Seat Disk Screw: Stainless Steel, Type 430
5. Seat Disc: Buna-N
6. Stem: Cold-formed Copper Alloy
7. Packing Nut: ASTM B-16 Brass
8. Packing: Graphite Impregnated Fibers
9. Handwheel: Aluminum
10. Handle Screw: Carbon Steel - Dichromate finish
11. Identification Plate: Aluminum

MANUFACTURER	CLASS 125
Watts	SWT
Milwaukee:	F-2974-MSC
Nibco:	75, 75-K, 725

B. Gage Cocks: Brass, tee handle, male to female, 200 psi working pressure, 1/4". Conbraco 41 Series or approved equal.

C. Drain Valves: Bronze ball valve, garden hose end, cap and chain - 3/4".

1. Manufacturers:
   a. Watts B-6000-CC
   b. Milwakee BA-110-H.

2.6 BALANCING VALVES

A. Low to Medium Flow HVAC Balancing Valves:
1. Threaded Ends 3” and Smaller: Furnish and install as shown on plans and with manufacturer's recommendations calibrated balancing valves. All valves 1/2” to 3” pipe size shall be of bronze body/brass ball construction. Valves to be of the "blow-out" proof bottom loaded stem design. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated nameplates and be leak-tight at full working pressure. All valves to have pressure gauge tappings across valve seat area, with internal check valves and drip caps. End connections shall be threaded. Watts Regulator CSM-61-M1-T, Bell & Gossett ACircuit Setter”, or approved equal.
2. Solder Ends 2” and Smaller: Furnish and install as shown on plans and with manufacturer's recommendations calibrated balancing valves. All valves 1/2” to 2” pipe size shall be of bronze body/brass ball construction. Valves to be of the "blow-out" proof bottom loaded stem design. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated nameplates and be leak-tight at full working pressure. All valves to have pressure gauge tappings across valve seat area, with internal check valves and drip caps. End connections shall be solder ends. Watts Regulator CSM-61-M1-S, Bell & Gossett, or approved equal.
3. Flanged Ends 4”and Larger: Furnish and install as shown on plans and with manufacturer's recommendations calibrated balancing valves. Valves shall be of bronze body/brass plug construction. Valves to be of the "blow-out" proof bottom loaded stem design. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated nameplates and be leak-tight at full working pressure. All valves to have pressure gauge tappings across valve seat area, with internal check valves and drip caps. End connections shall be flanged. Watts Regulator CSM-81-M1-F, Bell & Gossett, or approved equal.

B. Medium to High Flow HVAC Balancing Valves:
1. Grooved Ends 2 1/2" thru 12": Approved balancing valves shall have to 1/4" NPT brass metering ports with check valves and gasketed caps located on both sides of valve seat. Two additional 1/4" NPT connections with brass plugs are to be provided on the opposite side of the metering ports for use as drain connections. Drain connections and metering ports are to be interchangeable for measurement flexibility when valves are installed in tight locations. The valve must be capable of field conversion from the factory-standard straight pattern to an optional angle pattern with standard tools and no additional parts, allowing the valve to be used as a replacement for angles or elbows, with the conversion to not affect the valves accuracy. The valve body shall be ductile iron with industrial standard grooved ends. Valve stem and plug disc shall be bronze with ergonomically designed hand-wheel with multi-turn hand-wheel adjustments. Sizes 2 1/2" and 3"-five turns, 4" to 6"-six turns, 8" and 10"-twelve turns, and 12"-fourteen turns. Watts flange adapters shall be supplied to prevent rotation. Watts Regulator CSM-91, Bell & Gossett, or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior through the end ports, for cleanliness, freedom from foreign matter and corrosion. Remove special packing materials, such as blocks used which prevents disc movement during shipping and handling.

B. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the position in which it was shipped.

C. Examine threads on both the valve and the mating pipe for form (out-of-round or local indentation) and cleanliness.

D. Examine mating flange faces for conditions which might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size and material, and for freedom from defects and damage.

E. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

3.2 VALVE END SELECTION

A. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select valves with the following ends or types of pipe/tube connections:
1. Copper Tube Size 2 Inch and Smaller: Solder ends.
2. Steel Pipe Sizes 3 Inch and Smaller: Threaded.
3. Steel Pipe Sizes 4 Inch and Larger: Flanged

3.3 VALVE INSTALLATIONS

A. General Application: Use gate, ball, and butterfly valves for shut-off duty; globe ball, and butterfly for throttling duty.
1. Refer to piping system specification sections for specific valve applications and arrangements.
2. At all OS&Y or gear operated valves located 8'-0" above finished floor, provide chain operator. Chain shall extend down to 6'-0" above finished floor.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves and unions for each fixture and item of equipment in a manner to allow equipment removal without system shut-down. Unions are not required on flanged devices.

D. Install valves in horizontal piping with stem at or above the center of the pipe.

3.4 SOLDER CONNECTIONS

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket, using steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket in same manner.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate to fully open position.

E. Remove the cap and disc holder of swing check valves with composition discs.

F. Insert tube into valve socket making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.

G. Apply heat evenly to outside of valve around joint until solder will melt upon contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating the valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.5 THREADED CONNECTIONS

A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

D. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.6 FIELD QUALITY CONTROL

A. Testing: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks; replace valve if leak persists.

3.7 ADJUSTING AND CLEANING

A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare to receive finish painting or insulation.

END OF SECTION 230523

SECTION 230529
HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. This Section includes hangers and supports for mechanical systems piping and equipment.

1.3 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 01 Specification Sections.

B. Product data for each type of hanger and support.

C. Submit pipe hanger and support schedule showing manufacturer's Figure No., size, location, and features for each required pipe hanger and support.

D. Welder certificates signed by Contractor certifying that welders comply with requirements specified under the "Quality Assurance" Article.

E. Shop drawings for each type of hanger and support, indicating dimensions, weights, required clearances, and methods of component assembly.

1.4 QUALITY ASSURANCE

A. Qualify welding processes and welding operators according to AWS D1.1 "Structural Welding Code--Steel."
   1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

B. Qualify welding processes and welding operators according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

C. Listing and Labeling: Provide hangers and supports that are listed for their intended use.
   1. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Hangers, Supports, and Components: Factory-fabricated according to MSS SP-58.
   1. Components include galvanized coatings where installed for piping and equipment that will not have a field-applied finish.
   2. Pipe attachments include nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.

B. Thermal-Hanger Shield Inserts: 100-psi average compressive strength, waterproofed calcium silicate, encased with sheet metal shield. Insert and shield cover entire circumference of pipe and are of length indicated by manufacturer for pipe size and thickness of insulation.

C. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used. Fasteners for fire protection systems include UL listing and FM approval.

2.2 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36, steel plates, shapes, and bars, black and galvanized.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex-head, track bolts and nuts.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Grout: ASTM C 1107, Grade B, nonshrink, nonmetallic.
   1. Characteristics include post-hardening, volume-adjusting, dry, hydraulic-cement-type grout that is nonstaining, noncorrosive, nongaseous and is recommended for both interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.
   3. Water: Potable.
   4. Packaging: Premixed and factory-packaged.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger requirements are specified in the Section specifying the equipment and systems.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping specification Sections.

3.2 HANGER AND SUPPORT INSTALLATION

A. General: Comply with MSS SP-69 and SP-89. Install hangers, supports, clamps, and attachments to properly support piping from building structure.

B. Arrange for grouping of parallel runs of horizontal piping supported together on field-fabricated, heavy-duty trapeze hangers where possible.

C. Install supports with maximum spacings complying with MSS SP-69.

D. Where pipes of various sizes are supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

E. Install building attachments within concrete or to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Install reinforcing bars through openings at top of inserts.

F. Install concrete inserts in new construction prior to placing concrete.

G. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install according to fastener manufacturer's written instructions. Do not use in lightweight concrete slabs or in concrete slabs less than 4 inches thick.

H. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

I. Heavy-Duty Steel Trapezes: Field-fabricate from ASTM A 36 steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

J. Support fire protection systems piping independent of other piping.

K. Install hangers and supports to allow controlled movement of piping systems, permit freedom of movement between pipe anchors, and facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

L. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so that maximum pipe deflections allowed by ASME B31.9 "Building Services Piping" is not exceeded.

N. Insulated Piping: Comply with the following installation requirements.

1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.9.

2. Saddles: Install protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.

3. Shields: Install MSS Type 40, protective shields on cold piping with vapor barrier. Shields span an arc of 180 degrees and have dimensions in inches not less than the following:

THICKNESS NPS (Inches)	LENGTH (Inches)	
1/4 to 3-1/2	12	0.048
4	12	0.060
5 and 6	18	0.060
8 to 14	24	0.075
16 to 24	24	0.105

4. Pipes 8 Inches and Larger: Include pressure treated wood inserts.
5. Insert Material: Length at least as long as the protective shield.
6. Thermal-Hanger Shields: Install with insulation of same thickness as piping.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural steel stands to suspend equipment from structure above or support equipment above floor.

B. Grouting: Place grout under supports for equipment, and make a smooth bearing surface.

C. Provide housekeeping pads where indicated on plans.

3.4 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for pipe and equipment supports.

B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for manual shielded metal-arc welding, appearance and quality of welds, methods used in correcting welding work, and the following:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so that no roughness shows after finishing, and so that contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 ESCUTCHEONS, SLEEVES AND RISER CLAMPS

A. Contractor shall furnish and install all escutcheons, inserts, thimbles, hangers, etc. required for the proper support and installation of his equipment and piping and he shall cooperate with other trades in locating and placing these items.

B. Contractor shall furnish and install all piping sleeves required. Sleeves passing through structural members or concrete footings shall be of cast iron or Schedule 40 steel pipe. Sleeves passing through nonstructural walls or floors shall be of 26-gauge galvanized iron.

Joints between sleeves and pipes passing through floors shall be made weather tight with plastic materials. Where pipes pass through water proofing membrane, flashing sleeves shall be installed. Sleeves of structural members shall be as detailed on structural plans.

C. Provide malleable iron split ring hangers with rod supports as specified. Strap hangers or wire will not be accepted. Spacing of hangers shall be as required above by MSS Standards. Maximum spacing shall no case exceed the following: For cast iron pipes 5ft.; for other than soil pipes 10 ft.

D. Provide galvanized iron shields between hangers and pipe covering.

E. Provide heavy steel riser clamps on vertical risers at floors to support pipes.

F. Provide chrome plated brass escutcheons wherever pipes pass through floors, walls or ceilings in exposed or finished areas.

G. All piping projecting from chases shall be rigidly supported in the wall or chase. Loosely supported piping, fixtures or accessories will not be accepted.

3.7 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint and paint exposed areas immediately after erection of hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal is specified in Division 09 Section "Paints and Coatings."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 230529

SECTION 230548
VIBRATION ISOLATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. Work in this Section includes but is not limited to the following:
   1. Vibration isolation for piping, and equipment.
   2. HVAC Equipment isolation bases.
   3. Flexible piping connections.

B. Provide vibration isolation on all mechanical equipment, piping, and ductwork as indicated on equipment installation details or where recommended by equipment manufacturer.
   1. All equipment, piping and ductwork shall be mounted or suspended from vibration isolators to reduce the transmission of vibration and mechanically transmitted sound to the building structure.
   2. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.

C. All isolation materials and equipment shall be provided by the same manufacturer.

D. Any variance or non-compliance with this section shall be corrected by the contractor in a manner approved by the Owner=s Representative.

E. Provide minimum static deflection of isolators for equipment in accordance with weight supported and associated seismic zone.

1.3 SECTION INCLUDES

A. Mountings:
   1. Spring Mountings
   2. Restrained:
      a. Spring

B. Hangers:
   1. Spring & Neoprene
   2. Spring Only

C. Bases:
  1. Concrete Forms
    a. Welded Base

D. Flexible Rubber Connectors

1.4 SUBMITTALS

A. Submit under provisions of Division 01, “Submittal Procedures”.

B. Shop Drawings: Indicate inertia bases and locate vibration isolators, with static and dynamic load on each.
  1. Submit details of equipment bases including dimensions, structural member sizes, and support point locations.
  2. Submit details of isolation hangers for ceiling hung equipment, piping, and ductwork.
  3. Submit details of mountings for floor supported equipment, piping and ductwork.
  4. All hanger, mounting or pad drawings shall indicate deflections and model numbers as well as any other requirements within the specifications.
  5. Spring diameters, rated loads and deflections, heights at rated load and closed height shall be provided for all springs in tabular form.
  6. Provide complete flexible connector details.

C. Product Data:
  1. Provide schedule of vibration isolator type with location and load on each.
  2. Provide schedules of flexibly mounted equipment, referenced by drawing number.
  3. Provide catalog cuts or data sheets on vibration isolators.

D. Manufacturer's Installation Instructions: Indicate special procedures and setting dimensions.

E. Manufacturer's Certificate: Certify that isolators are properly installed and adjusted to meet or exceed specified requirements.

1.5 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Division 01- “Closeout Procedures” and “Closeout Submittals”.

B. Record actual locations of isolation hangers including attachment points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
  1. Peabody
  2. Kinetics

3. Mason Industries, Inc.
4. Vibration Elimination Co., Inc.

B. Substitutions: Under provisions of Division 01- “Submittal Procedures”.

2.2 MOUNTINGS

A. Type “B” Isolation - Spring Isolators:
1. Design: Free standing, laterally stable without housing.
2. Construction: All metal surfaces shall be neoprene coated
a. Provide molded neoprene cup or 1/4" neoprene acoustical friction pad between baseplate and support.
b. Provide leveling bolts rigidly attached to the equipment being isolated.
c. Installed and operating heights shall be the same.
3. Ratio of spring diameter divided by the compression spring height shall be no less than 0.8.
4. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.
5. Submittals shall include spring diameters, deflection, compression spring height, and solid spring height.
6. Sufficiently rigid to prevent misalignment or undue stress on machine, and to transmit design loads to isolators and snubbers.
7. Mountings shall be Type “SLF” as manufactured by Mason Industries, Inc. or approved equal.

B. Type “D” Isolation - Restrained Mountings:
1. Design: Steel springs similar to Type “B” isolators described above but with neoprene acoustical pads within a rigid sided housing.
a. When equipment is at full operating weight, springs shall be adjustable to assume the weight placed and the temporary spacers removed.
b. Spacers shall be removable without changing the installed or operating weights.
c. Restraining bolts shall have large rubber grommets to provide cushioning in the vertical and horizontal modes.
d. The hole through the bushing shall be a minimum of 3/4" diameter larger than the restraining bolt.
e. Horizontal clearances on the side of the isolator between the spring assembly and the housing itself shall be a minimum of 2" to avoid bumping and interference with the spring action.
f. Provide vertical limit stop that are out of contact during normal operation.
2. Construction: Vertical stop limits to prevent spring extension when weight of equipment is removed
a. Temporary steel spacers shall be provided between the upper and lower housings.
b. Housing shall serve as blocking during erection.
c. Housing and springs shall be powder coated and hardware shall be electro-galvanized.
3. Mountings shall be Type “SLR” as manufactured by Mason Industries, Inc. or approved equal.

2.3 HANGERS

A. Type “F” Isolation - Spring & Neoprene Hangers:
1. Spring Isolators: Similar to Type “B” previously described except with rigid steel frames containing 1 1/4" thick neoprene elements at the top with spring seated in a steel washer reinforced neoprene cup at the bottom.
   a. For Exterior and Humid Areas: Provide hot dipped galvanized housings and neoprene coated springs.
   b. Code: Color code springs for load carrying capacity.
2. Spring hangers shall be Type “30N” as manufactured by Mason Industries, Inc. or approved equal.

B. Type “H” Isolation - Hangers:
1. Hangers shall be manufactured with minimum characteristics as in Specification Type “B”, but without the neoprene element.
2. Springs shall be seated in a steel washer reinforced neoprene cup that has a neoprene bushing projecting through the bottom hole to prevent rod to hanger contact.
3. Spring diameters and the lower hole sizes, shall be large enough to allow the hanger rod to swing through a 30-deg. arch from side to side before contacting the cup bushing.
4. If ducts are suspended by flat strap iron, the hanger assembly shall be modified by the manufacturer with an eye on top of the box and on the bottom of the spring hanger rod to allow for bolting to the hanger straps.
5. Submittals on either of the above hangers shall include a scale drawing of the hanger showing the 30-deg. capability.
6. Hangers for rods shall be Type “30" or for straps, Type “W30N” as manufactured by Mason Industries, Inc as basis of design.

2.4 HORIZONTAL TYPE THRUST RESTRAINTS

A. Type “I” Isolation - Restraints:
1. When total air thrust exceeds 10% of the isolated weight, floor mounted or suspended air handling equipment shall be protected against excessive displacement by the use of horizontal thrust restraints.
2. The restraints shall consist of a modified Specification B spring mounting.
3. Restraint springs shall have the same deflection as the isolator springs.
4. The assembly shall be preset at the factory and fine-tuned in the field to allow for a maximum of 1/4" movement from stop to maximum thrust.
5. The assemblies shall be furnished with rod and angle brackets for attachment to both the equipment and duct work or the equipment and the structure.
6. Restraints shall be attached at the center line of thrust and symmetrically on both side of the unit.
7. Horizontal thrust restraints shall be Type “WB” as manufactured by Mason Industries, Inc. or approved equal.

2.5 BASES

A. Type “L” Isolation - Bases:
1. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating concrete bases.

a. Bases for split case pumps shall be large enough to provide support for suction and discharge elbows.
b. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6".
c. The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity.
d. Forms shall include minimum concrete reinforcing consisting of 2" bars welded in place of 6" centers running both ways in a layer 1-1/2" above the bottom.
e. Forms shall be furnished with steel templates to hold the anchor bolt sleeves and anchor mounting locations to maintain a 1" clearance below the base.
f. Forms shall be factory painted with rust preventive prime coat suitable and ready for final finish coat.
g. Wooden formed bases leaving a concrete rather than a steel finish are not acceptable.
h. Base shall be Type “BMS” or Type “BMK” as manufactured by Mason Industries, Inc. or equal.

2.6 FLEXIBLE RUBBER CONNECTORS

A. Type “O” Isolation -Connectors:
1. Rubber expansion joints shall be peroxide cured EPDM throughout with Kevlar tire cord reinforcement.
   a. Substitutions must have certifiable equal or superior characteristics.
2. Raised face rubber flanges shall encase solid steel rings to prevent pull out. Flexible cable wire is not acceptable.
3. Size 1-1/2" through 14"shall have a ductile iron external ring between the two spheres.
   a. Sizes 16" through 24" may be single sphere.
   b. Sizes 3/4" through 2" may have one sphere, bolted threaded flange assemblies and cable retention.
4. Minimum ratings through 14" shall be 250 psi at 170 deg. F and 215 psi at 250 deg. F., 16" through 24", 180 psi at 170 deg. F and 150 psi at 250 deg. F.
   a. Higher published rated connectors may be used where required.
5. Safety factors shall be a minimum of 3/1.
   a. All expansion joints must be factory tested to 150% of maximum pressure for 12 minutes before shipment.
6. The piping gap shall be equal to the length of the expansion joint under pressure.
   a. Control rods passing through 2" thick Neoprene washer bushings large enough to take the thrust at 100psi of surface area may be used on unanchored piping where the manufacturer determines the condition exceeds the expansion joint rating without them.
7. Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer.
8. All expansion joints shall be installed on the equipment side of the shut off valves.

9. Expansion joints shall be “SAFEFLEX”, Type “SFDEJ”, Type “SFEJ”,Type“ SFDCR” or Type “SFU” and Control Rods “CR” as manufactured by Mason Industries, Inc. or approved equal.

2.7 PIPE RISER ISOLATION

A. Type “U” Isolation - Isolators:
1. All vertical risers shall be supported by spring isolators designed to support the riser filled with water.
2. Assigned loads must be within the building design load limits at the support points.
3. Neutral central resilient anchors close to the center of the run shall direct movement up and down.
4. Anchors shall be capable of holding an upward force equal to the water weight when the system is drained.
5. If one level cannot accommodate this force, anchors can be located on 2 or 3 adjacent floors.
6. Resilient guides shall be spaced and sized properly depending on the pipe diameter.
7. Submittals must include the initial load, initial deflection, change in deflection, final load and change in load at all spring and anchor support locations, as well as guide spacing.
8. The initial spring deflection shall be a minimum of 3/4" or four times the thermal movement at the isolator location whichever is greater.
9. Calculations shall include pipe stress at end conditions and branch off locations and the manufacturer must include installation instructions.
10. Calculations must be stamped and signed by a licensed registered professional engineer.
11. Proper provisions shall be made for seismic protection in seismic zones. Support spring isolators shall be of Type “B”, Anchors of Type “R” and telescoping guides of Type “S” equipment.
12. The isolation vendor shall provide and design all brackets and clamps and anchors at riser spring guide and anchor locations.
13. The contractor shall install and adjust all isolators under the supervision and/or direction of the isolation vendor or his appointed representative.

2.1 DUCT ISOLATION

A. Type “V” Isolation - Isolators:
1. All air ducts with a cross section of two (2) sq. ft. or greater shall be isolated from building structure by Type “H” hangers or Type “B” floor supports with a minimum deflection of 3/4".
2. Isolators shall continue for a minimum length of 50 ft. from the equipment being served.
3. If air velocity exceeds 1,000 fpm, hangers or supports shall continue for an additional 50 ft. from the unit or as further defined on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all isolators in strict accordance with manufacturer's instructions.

B. Install isolation for motor driven equipment.

C. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
   1. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.
   2. The Contractor shall not install any equipment, piping, duct, or conduit which makes rigid connections with the building unless isolation is not specified. “Building” includes, but is not limited to, slabs, beams, columns, studs and walls.
   3. Coordinate work with other trades to avoid rigid contact with building.
   4. Rooftop equipment isolators shall be bolted to the equipment and structure. Mountings must be designed to withstand and resist 110 mph wind loads. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust when thrust forces exceed 10% of the equipment weight. Horizontal thrust restraints shall be Type “I” restraints.
   5. Where piping passes through walls, floors, or ceilings, the vibration isolation manufacturer shall provide Type “Q” seals.
   6. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the Contractor=s expense.
   7. Any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection shall be brought to the attention of the Owner’s Representative prior to installation.
   8. Locate isolation hangers as near to the overhead support structure as possible.

D. Bases:
   1. Set steel bases for one-inch clearance between housekeeping pad and base.
   2. Set concrete inertia bases for 2-inch clearance between housekeeping pad and base.
   3. Adjust equipment level.
   4. Provide painting for final finish coat.

E. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.

F. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.

G. Provide pairs of horizontal limit springs on fans with more than 6.0-inch 1.5 static pressure, and on hanger supported, horizontally mounted axial fans.

H. Provide resiliently mounted equipment, piping, and ductwork with seismic snubbers. Each inertia base shall have minimum of four seismic snubbers located close to isolators. Snub equipment designated for post disaster use to 0.05-inch maximum clearance. Other snubbers shall have clearance between 0.15 inch and 0.25 inch.

I. Support piping connections to isolated equipment resiliently for scheduled distance as follows:
   1. Up to 4 Inch Diameter: First three points of support.

2. 5 to 8 Inch Diameter: First four points of support.
3. 10-inch Diameter and Over: First six points of support.
4. Select three hangers closest to vibration source for minimum 1.0-inch static deflection or static deflection of isolated equipment. Select remaining isolators for minimum 1.0-inch static deflection or 2 static deflection of isolated equipment.

J. Connect wiring to isolated equipment with flexible hanging loop.

3.2 TRAINING AND DEMONSTRATION

A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner's maintenance personnel on the following:
1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 01, "Closeout Submittals".
3. Provide Service Manuals for each vibration isolator specified.

B. Provide three (3) hours of factory authorized training.
1. Schedule training with seven (7) days advanced notice.
2. Refer to “Mechanical General Provisions”.

3.3 EQUIPMENT ISOLATION SCHEDULE

ISOLATED EQUIPMENT	ISOLATOR	DEFLECTION * (inches)
Piping Risers	U	0.75"
A/C Ductwork	V	0.35"
DOAS Unit	B	1.0”
Air Cooled Chillers	D	1.0”
Chilled Water Pumps	B	1.0”
VAV Boxes	F	1.0”
General Exhaust Fans	H	0.75”

Note: All deflections are based upon slab on grade construction. For other applications, consult the isolation manufacturer and equipment schedules and adjust deflection accordingly.

NIH Comment #64

END OF SECTION 230548

STATE OF LOUISIANA
R. CRAIG CAMPBELL, II
License No. 29380
3/10/26
PROFESSIONAL ENGINEER

SECTION 230553
MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. Section Includes:
1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Valve tags.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Black.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 3/4 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1/2” high for pipes smaller than 1”, 3/4" high for pipes 1” or larger.

2.4 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25

feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Pipe Label Color Schedule shall comply with OSHA and ANSI A13.1 Standards (Verify exact color with owner prior to installation. Color scheme to match existing labels if applicable):
1. Chilled-Water Piping:
   a. Background Color: Green.
   b. Letter Color: White.
2. Potable Domestic Cold Water Piping:
   a. Background Color: Green.
   b. Letter Color: White.
3. Domestic Hot Water Piping:
   a. Background Color: Blue.
   b. Letter Color: White.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, color scheme and with piping system abbreviation.

END OF SECTION 230553

SECTION 230593
TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. This Section specifies the requirements and procedures total mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.

B. Test, adjust, and balance the following mechanical systems:
1. Supply air systems, all pressure range
2. Fresh Air
3. Exhaust Air
4. AHUs
5. Fans
6. Chiller
7. Pumps
8. Fire, smoke, and combination fire/smoke damper operation
9. Verify temperature control system operation
10. Duct Leakage of ducted all systems.

C. Provide assistance to Division 23 and Division 26 Contractor and project Architect in system commissioning process. Identify all system variances of greater than 10% and make required measurements, adjustments, etc. to bring systems into compliance to satisfaction of project Architect.

D. THE TEST AND BALANCE CONTRACTOR SHALL BE RESPONSIBLE FOR CHECKING OUT AND REPORTING EACH SEQUENCE OF HEATING, COOLING AND CONTROL INTERLOCK OPERATION FOR THE EQUIPMENT REFERENCED ABOVE.

1.3 DEFINITIONS

A. Systems testing, adjusting, and balancing is the process of checking and adjusting all the building environmental systems to produce the design objectives. It includes:

1. The balance of air distribution;
2. Adjustment of total system to provide design quantities;
3. Electrical measurement;
4. Verification of performance of all equipment and automatic controls;

B. Test: To determine quantitative performance of equipment.

C. Adjust: To regulate the specified fluid flow rate and air patterns at the terminal equipment (e.g., reduce fan speed, throttling).

D. Balance: To proportion flows within the distribution system (submains, branches, and terminals) according to specified design quantities.

E. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.

F. Report forms: Test data sheets arranged for collecting test data in logical order for submission and review. These data should also form the permanent record to be used as the basis for required future testing, adjusting, and balancing.

G. Terminal: The point where the controlled fluid enters or leaves the distribution system. These are supply inlets on water terminals, supply outlets on air terminals, return outlets on water terminals, and exhaust or return inlets on air terminals such as registers, grilles, diffusers, louvers, and hoods.

H. Main: Duct or pipe containing the system's major or entire fluid flow.

I. Submain: Duct or pipe containing part of the systems' capacity and serving two or more branch mains.

J. Branch main: Duct or pipe serving two or more terminals.

K. Branch: Duct or pipe serving a single terminal.

1.4 SUBMITTALS

A. Agency Data:
   1. Submit proof that the proposed testing, adjusting, and balancing agency meets the qualifications specified below.

B. Engineer and Technicians Data:
   1. Submit proof that the Test and Balance Engineer assigned to supervise the procedures, and the technicians proposed to perform the procedures meet the qualifications specified below.

C. Procedures and Agenda: Submit a synopsis of the testing, adjusting, and balancing procedures and agenda proposed to be used for this project.

D. Maintenance Data: Submit maintenance and operating data that include how to test, adjust, and balance the building systems. Include this information in maintenance data specified in Division 01 and Section 230020.

E. Sample Forms: Submit sample forms, if other than those standard forms prepared by the AABC or NEBB are proposed.

F. Certified Reports: Submit testing, adjusting, and balancing reports bearing the seal and signature of the Test and Balance Engineer. The reports shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below:

1. Draft reports: Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on the approved forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.
2. Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 2 complete sets of final reports.
3. Report Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents. Divide the contents of the binder into the below listed divisions, separated by divider tabs:
4. General Information and Summary
   a. Air Systems
   b. Hydronic Systems
   c. Temperature Control Systems
   d. Special Systems
5. Report Contents: Provide the following minimum information, forms and data:
   a. General Information and Summary: Inside cover sheet to identify testing, adjusting, and balancing agency, Contractor, Owner, Architect, Engineer, and Project. Include addresses, and contact names and telephone numbers. Also include a certification sheet containing the seal and name address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentations used for the procedures along with the proof of calibration.
   b. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on the standard report forms prepared by the AABC and NEBB, for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form
6. Provide electronic (PDF) copies of all documentation included in the Final Report.

G. Calibration Reports: Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

H. At the front of the Report, the TAB Contractor shall provide a summary sheet identifying system operational variances problems, etc. recommended corrective measures that in the opinion of the TAB Contractor should be enacted by the Mechanical Contractor prior to retesting. Submit to project Architect as work progresses with resolution documented for inclusion in final report.

1.5 QUALITY ASSURANCE

A. Test and Balance Engineer's Qualifications: A Professional Engineer (independent consultant), registered in the State in which the services are to be performed, and having testing, adjusting, and balancing experience on projects with testing and balancing requirements similar to those required for this project.

B. Pre-Balancing Conference: Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a conference with the Architect and representatives of installers of the mechanical systems. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.

1.6 PROJECT CONDITIONS

A. Systems Operation: Systems shall be fully operational prior to beginning procedures.

1.7 SEQUENCING AND SCHEDULING

A. Test, adjust and balance air conditioning systems during summer season and heating systems during winter season, including at least a period of operation at outside conditions within 5 deg F wet bulb temperature of maximum summer design condition, and within 10 deg F dry bulb temperature of minimum winter design condition. Take final temperature readings during seasonal operation.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 PRELIMINARY PROCEDURES FOR AIR SYSTEM BALANCING

A. Before operating the system, perform these steps:
   1. Obtain design drawings and specifications and become thoroughly acquainted with the design intent.
   2. Obtain copies of approved shop drawings of all air handling equipment, outlets (supply, return, and exhaust) and temperature control diagrams.
   3. Compare design to installed equipment and field installations.
   4. Walk the system from the system air handling equipment to terminal units to determine variations of installation from design.
   5. Check filters for cleanliness.
   6. Check dampers (both volume and fire) for correct and locked position, and temperature control for completeness of installation before starting fans.
   7. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a crosscheck with required fan volumes.
   8. Determine best locations in main and branch ductwork for most accurate duct traverses.
   9. Place outlet dampers in the full open position.
   10. Prepare schematic diagrams of system "as-built" ductwork and piping layouts to facilitate reporting.
   11. Lubricate all motors and bearings.
   12. Check fan belt tension.
   13. Check fan rotation.

3.2 PRELIMINARY PROCEDURES FOR HYDRONIC SYSTEM BALANCING

A. Before operating the system perform these steps:
1. Open valves to full open position. Close coil bypass valves.
2. Remove and clean all strainers.
3. Examine hydronic systems and determine if water has been treated and cleaned.
4. Check pump rotation.
5. Clean and set automatic fill valves for required system pressure.
6. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
7. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
8. Set temperature controls so all coils are calling for full flow.
9. Check operation of automatic bypass valves.
10. Check and set operating temperatures of chilled water heat exchangers to design requirements.
11. Lubricate all motors and bearings.
12. Test VAV boxes and electric heating coils.
13. Test sequencing of all motorized dampers, smoke dampers, etc.

3.3 MEASUREMENTS

A. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage.

B. Provide instruments meeting the specifications of the referenced standards.

C. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.

D. Apply instrument as recommended by the manufacturer.

E. Use instruments with minimum scale and maximum subdivisions and with scale ranges proper for the value being measured.

F. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5 percent. When measuring a single point, repeat readings until 2 consecutive identical values are obtained.

G. Take all reading with the eye at the level of the indicated value to prevent parallax.
H. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.

I. Take measurements in the system where best suited to the task.

3.4 PERFORMING TESTING, ADJUSTING, AND BALANCING

A. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards.

B. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.

C. Patch insulation, ductwork, and housings, using materials identical to those removed.

D. Seal ducts and piping, and test for and repair leaks.

E. Seal insulation to re-establish integrity of the vapor barrier.

F. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.

G. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.5 RECORD AND REPORT DATA

A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms.

B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.

C. Prepare a summary sheet of noted variances in excess of ± 10% of design value. Include all such variances, recommended resolutions and ultimate result in Appendix “A” to TAB Final Report.

3.6 DEMONSTRATION

A. Training:
1. Train the Owner's maintenance personnel on troubleshooting procedures and testing, adjusting, and balancing procedures. Review with the Owner's personnel, the information contained in the Operating and Maintenance Data specified in Division 01 and 230020.
2. Schedule training with Owner through the Architect with at least 7 days prior notice.

END OF SECTION 230593

SECTION 230620
HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. This Section includes piping systems for chilled water piping and heating water piping. Piping materials and equipment specified in this Section include:
1. Pipes, fittings, and specialties;
2. Special duty valves;
3. Hydronic specialties.

1.3 SYSTEM DESCRIPTION

A. General: The hydronic piping systems are the "water-side" of an air-and-water or all-water air conditioning system. Hydronic piping systems specified in this Section include 2-pipe, chilled water piping system. These systems are classified by ASHRAE as Low Water Temperature, Forced, Recirculating systems.

B. Chilled Water System: The chilled water system includes new and independent chilled water supply and return piping mains connected to pumps and chillers. Design flow rates and water temperatures are specified in the various equipment specifications and schedules.

C. Heating Water System: The heating water system includes new and independent chilled water supply and return piping mains connected to pumps and boilers. Design flow rates and water temperatures are specified in the various equipment specifications and schedules.

D. Control sequences and temperature reset schedules are specified in the temperature control specifications.

1.4 SUBMITTALS

A. Product Data, including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties and accessories, and installation instructions for each hydronic specialty and special duty valve specified.
1. Furnish flow and pressure drop curves for diverting fittings and calibrated plug valves, based on manufacturer's testing.

B. Maintenance Data for hydronic specialties and special duty valves, for inclusion in operating and maintenance manual specified in Division 01 and Division-23 Section 23 0020 "Basic Mechanical Requirements."

C. Welders' certificates certifying that welders comply meet the quality requirements specified in Quality Assurance below.

D. Certification of compliance with ASTM and ANSI manufacturing requirements for pipe, fittings, and specialties.

E. Reports specified in Part 3 of this Section.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the provisions of the following:
1. ASME B 31.9 "Building Services Piping" for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.
2. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 01.
3. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators.
4. BOCA Basic National Mechanical Code.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate the installation of pipe sleeves for foundation wall penetrations.

1.7 EXTRA STOCK

A. Maintenance Stock: Furnish a sufficient quantity of chemical for initial system start-up and

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers Uniformity: Conform with the requirements specified in Basic Mechanical Requirements under product options for the following hydronic system products.

2.2 PIPE AND TUBING MATERIALS

A. General: Refer Section 23 13 21 Hydronic Piping.

2.3 GENERAL DUTY VALVES

A. General duty valves (i.e., gate, check, ball, and butterfly valves) are specified in Division 23 Section 230523 "HVAC Valves" Special duty valves are specified below by their generic name; refer to Part 3 Article "VALVE APPLICATION" for specific uses and applications for each valve specified.

2.4 SPECIAL DUTY VALVES

A. Calibrated Plug Valves: 125 psig water working pressure, 250 deg F maximum operating temperature, bronze body, plug valve with calibrated orifice. Provide with connections for portable differential pressure meter with integral check valves and seals. Valve shall have integral pointer and calibrated scale to register degree of valve opening. Valves 2 inches and smaller shall have threaded connections and 2-1/2 inches valves shall have flanged connections.

B. Pump Discharge Valves (Triple Duty Valves): Valve shall be globe valve design rated for 175 psig working pressure, 250 deg F maximum operating temperature, cast-iron body, brass disc and EPDM rubber seat, stainless steel stem and spring, and "Teflon" packing. Valves shall have flanged connections and straight pattern as indicated. Features shall include non-slam check valve with spring-loaded weighted disc, calibrated nameplate with multi-turn stem for adjustment to permit regulation of pump discharge flow and shutoff, and a rubber memory button to allow the valve to be re-balanced to its original position after shut-off or maintenance. Valve shall include pressure and temperature ports.

2.5 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 125 psig working pressure, 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; and having 1/8-inch discharge connection and 1/2-inch inlet connection.

B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 125 psig working pressure, 240 deg F operating temperature; and having 1/4-inch discharge connection and 1/2-inch inlet connection.

C. Pump Suction Diffusers: Suction diffuser body shall be cast iron and included a flow cone to eliminate recirculation and direct flow out of the body and into the pump suction. Valve shall be flanged to flanged and rated for 175 psig working pressure, 250 deg F maximum operating temperature. Suction diffuser shall include a full length 4-plane 304 stainless steel removable straightening vane, full length removable 304 stainless steel orifice cylinder with 3/16” perforations and 51% open area, and full length removable 16 mesh bronze start-up strainer. Unit shall include pressure and temperature ports and adjustable support foot.

D. Air Separators: Air separators shall be centrifugal type with flanged inlet and outlet tangential to the vessel shell. Unit shall direct accumulated air to an air vent located at the connection on top of unit. A blow down connection at the bottom of the unit shall allow for routine cleaning. Vessel shell diameter shall be 3 times the nominal inlet/outlet pipe diameter with a minimum vessel volume for sufficient velocity reduction. The air separator shall be constructed and stamped for 125 psig at 350 deg F in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code and registered with the National Board of Boiler and Pressure Vessel Inspectors. Unit shall be with an enamel paint.

E. Expansion Tanks: Expansion tanks shall be an vertical floor mounted ASME rated pre-charged bladder-type pressure vessel constructed of carbon steel and designed to absorb the expansion forces of heating/cooling system water while maintaining proper system pressurization under varying operating conditions. The heavy duty Butyl rubber bladder shall contain system water thereby eliminating tank corrosion. Expansion tanks shall include an integral bladder integrity monitor and sight glass. Tank shall be factory pre-charged at 40 psi and rated for 125 psi at 240 deg F.

F. Buffer Tank: Furnish and install buffer tank to increase system water volume where indicated on plans. The tank shall incorporate a baffle to promote tank water storage temperature stratification. The system water connections must be flanged. The tank shall be constructed in accordance with the most recent addendum of Section VIII Division 1 of the ASME Boiler and Pressure Vessel Code and constructed and stamped for 125 Psi working pressure @ 450°F.

PART 3 - EXECUTION

3.1 PIPE APPLICATIONS

A. Install drawn copper tubing with wrought copper fittings and solder joints for 2 inches and smaller, above ground, within building. Install Type K, annealed temper copper tubing for 2 inches and smaller without joints, below ground or within slabs.

B. Install steel pipe with threaded joints and fittings for 2 inches and smaller, and with welded joints for 2-1/2 inches and larger.

3.2 PIPING INSTALLATIONS

A. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

B. Use fittings for all changes in direction and all branch connections.

C. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

D. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

E. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1-inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

F. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

G. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4-inch ball valve, and short 3/4-inch threaded nipple and cap.

H. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6 inches shall be steel; pipe sleeves 6 inches and larger shall be sheet metal.

I. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity. Refer to Division 07 for special sealers and materials.

J. Install piping at a uniform grade of 1 inch in 40 feet upward in the direction of flow.

K. Make reductions in pipe sizes using eccentric reducer fitting installed with the level side up.

L. Install branch connections to mains using Tee fittings in main with take-off out the bottom of the main, except for up-feed risers which shall have take-off out the top of the main line.

M. Install unions in pipes 2 inches and smaller, adjacent to each valve, at final connections each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

N. Install dielectric unions to join dissimilar metals.

O. Install flanges on valves, apparatus, and equipment having 2-1/2-inch and larger connections.

P. Install flexible connectors at inlet and discharge connections to pumps (except inline pumps) and other vibration producing equipment.

Q. Install strainers on the supply side of each control valve, pressure reducing valve, pressure regulating valve, solenoid valve, inline pump, and elsewhere as indicated. Install nipple and ball valve in blow down connection of strainers 2 inches and larger.

R. Anchor piping to ensure proper direction of expansion and contraction. Expansion loops and joints are indicated on the Drawings and specified in Division-23.

3.3 HANGERS AND SUPPORTS

A. General: Hanger, supports, and anchors devices are specified in Section 230529 "HANGERS & SUPPORTS." Conform to the table below for maximum spacing of supports:

B. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet in length.
2. Adjustable roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe roller complete - MSS Type 44 for multiple horizontal runs, 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

C. Install hangers with the following minimum rod sizes and maximum spacing:

Nom. Pipe Size-Inches	Max. Span-Ft.	Min. Rod Size-Inches
1	7	3/8
1-1/2	9	3/8
2	10	3/8
3	12	1/2
3-1/2	13	1/2
4	14	5/8
5	16	5/8
6	17	3/4
8	19	7/8
10	22	7/8
12	23	7/8

D. Support vertical runs at each floor.

3.4 PIPE JOINT CONSTRUCTION

A. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe fittings and valves as follows:
   1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
   2. Align threads at point of assembly.
   3. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).
   4. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

B. Damaged Threads: Do not use pipe with threads which are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

C. Welded Joints: Comply with the requirement in ASME Code B31.9-"Building Services Piping."

D. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.

3.5 VALVE APPLICATIONS

A. General Duty Valve Applications: Refer to Section 23 for requirements.
   1. Shut-off duty: Use ball, and butterfly valves
   2. Throttling duty: Use ball, and butterfly valves
   3. Install shut-off duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, and elsewhere as indicated.
   4. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, elsewhere as indicated.

B. Install calibrated plug valves on the outlet of each heating or cooling element and elsewhere as required to facilitate system balancing.

C. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.

D. Install check valves on each pump discharge and elsewhere as required to control flow direction.

E. Install pump discharge valves with stem in upward position; allow clearance above stem for check mechanism removal.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in the system and elsewhere as required for system air venting.

B. Install automatic air vents at high points in the system and elsewhere as required for system air venting.

C. Install suction diffusers on the suction end of all pumps.

D. Install air separators in the chilled water and heating water systems where indicated on plans. Provide and install air vent on top of air separator with isolation valve for system air relief.

E. Install pressurized bladder type expansion tank on floor for the chilled water system where indicated on plans.

F. Install buffer tank on floor for the chilled water system where indicated on plans.

3.7 FIELD QUALITY CONTROL

A. Preparation for testing: Prepare hydronic piping in accordance with ASME B 31.9 and as follows:
1. Leave joints including welds uninsulated and exposed for examination during the test.
2. Provide temporary restraints for expansion joints which cannot sustain the reactions due to test pressure. If temporary restraints are not practical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
5. Install relief valve set at a pressure no more than 1/3 higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.

B. Testing: Test hydronic piping as follows:
1. Use ambient temperature water as the testing medium, except where there is a risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping system components.
2. Use vents installed at high points in the system to release trapped air while filling the system. Use drains installed at low points for complete removal of the that liquid.
3. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated.
4. Examine test equipment to ensure that it is tight and that low-pressure filling lines are disconnected.

5. Subject piping system to a hydrostatic test pressure which at every point in the system is not less than 1.5 times the design pressure. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test. Make a check to verify that the stress due to pressure at the bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength, or 1.7 times the "SE" value in Appendix A of ASME B31.9, Code For Pressure Piping, Building Services Piping.
6. After the hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.

3.8 ADJUSTING AND CLEANING

A. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.

B. Mark calibrated name plates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

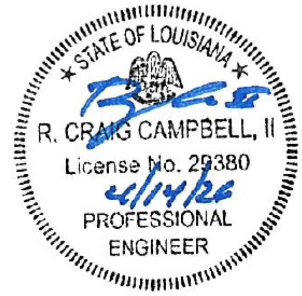
C. Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.9 COMMISSIONING

A. Fill system, verify that system is free of air and system is free of all dirt and debris.

B. Before operating the system perform these steps:
1. Open valves to full open position. Close coil bypass valves.
2. Remove and clean strainers.
3. Check pump for proper direction of correct improper wiring.
4. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Check operation of automatic bypass valves.
7. Lubricate motors and bearings.

END OF SECTION 230620



SECTION 230713
MECHANICAL INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. Extent of mechanical insulation required by this section is indicated on drawings and schedules, and by requirements of this section.

B. This Section includes:
1. Piping insulation including fittings and valves.
2. Duct insulation
3. Mechanical equipment insulation.

C. Cover and insulate all valves, fittings, and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run and piping system. Install factory molded, pre-cut or field cut and fabricated units (at installer's option) except where specifically noted otherwise.

D. Maintain the integrity of vapor jackets on all pipe insulation, duct insulation, equipment insulation and protect during construction to prevent puncture or other damage.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections:
1. Product data for each type of mechanical insulation identifying k-value, thickness, and accessories.
2. Manufacturer's installation recommendations.
3. Material certificates, signed by the manufacturer, certifying that materials as a minimum, comply with specified requirements where laboratory test reports cannot be obtained.
4. Material test reports prepared by a qualified independent testing laboratory. Certify insulation meets specified requirements.

1.4 QUALITY ASSURANCE

A. Fire Performance Characteristics: Conform to the following characteristics for insulation including facings, cements, and adhesives, when tested according to ASTM E 84, by UL or other testing or inspecting organization acceptable to the authority having jurisdiction. Label insulation with appropriate markings of testing laboratory.

1. Interior Insulation: Flame spread rating of 25 or less and a smoke developed rating of 50 or less.
2. Exterior Insulation: Flame spread rating of 75 or less and a smoke developed rating of 150 or less.

1.5 SEQUENCING AND SCHEDULING

A. Schedule piping and duct insulation application only after the testing of piping and duct systems is complete and accepted.

B. Schedule insulation application after installation and testing of heat trace tape is complete and accepted.

C. Schedule insulation of walls and ceiling to correspond with installation of pipe hangers, supports and equipment.

PART 2 - PRODUCTS

2.1 GENERAL

A. Pipe insulation shall not begin until all work has been tested and found to be tight. All insulation adhesives, sealers, tapes and mastic shall meet the latest NFPA requirements and shall meet 25/50 flame spread and smoke developed ratings.

B. All insulation shall be installed in strict accordance with the manufacturer's recommendations.

C. All pipe insulation where recommended by the manufacturer shall be banded with aluminum bands, three to a section and with one band on each side of each fitting, valve, etc.

D. Insulation shall be continuous through walls and ceilings.

E. All valves, strainers, etc. shall be insulated the same as its adjacent piping and the covering shall extend all the way up to the equipment.
   1. USE HIGH DENSITY INSULATION INSERTS AT HANGERS ON ALL PIPING 1-1/2" AND ABOVE TO PREVENT CRUSHING OF INSULATION.

2.2 THERMAL INSULATION

A. After all work has been tested and approved, insulate as follows:
   1. INSULATION SHALL BE INSTALLED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS AND INSTRUCTIONS.

2.3 HVAC CONDENSATE DRAIN PIPING

A. Insulate with 1/2" Aerotube or Armaflex pipe insulation applied in accordance with manufacturer's recommendations and instructions.

2.3 HVAC DUCTWORK INSULATION:

A. All indoor and concealed ductwork shall be wrapped on outside with 2” thick, 1-1/2# density fiberglass insulation with aluminum foil (FSK) vapor barrier with a minimum R-Value of R-6. Insulation shall be taped at all seams/joints with matching reinforced tape and installed per the manufacturer's recommendations. Insulation shall meet ASTM C1290, Type III.

B. All interior and exposed ductwork shall be wrapped on outside with 2” thick 3# density rigid fiberglass insulation with aluminum foil (FSK) vapor barrier with a minimum R-Value of R-6. Insulation shall be taped at all seams /joints with matching reinforced tape and installed per the manufacturer's recommendations. Insulation shall meet ASTM C 612, Type IA and IB.

C. All tops of supply diffusers shall be insulated same as ductwork exposed within spaces. All exposed edges of insulation shall be taped to match insulation.

D. Refer to air distribution section of mechanical specifications for duct insulation supplied by the sheet metal sub-contractor.

2.4 HVAC FLEX-CONNECTIONS:

NIH Comment #66

A. Shall be wrapped on outside with 1-1/2# density fiberglass insulation with aluminum foil (FSK) vapor barrier with a minimum R-value of R-6. Insulation shall be taped at all seams/joints with matching reinforced tape and installed per the manufacturer's recommendations.

2.5 CHILLED WATER SUPPLY AND RETURN PIPING

A. Insulate lines above slab with foamglass or approved equivalent pipe covering with factory applied Flame Bar Jacket to pipe with all joints firmly butted together. Seal all laps and butt joint strips with vapor barrier adhesive. Fittings to be insulated with pre-fabricated fitting covers and finished with an envelope coverage of vapor barrier mastic reinforced with Glassfab.

B. Thickness for indoor piping to be 1" for pipe sizes up to and including 3/4", 1-1/2" thick for pipe sizes 1” to 1-1/4”, and 2” for pipe sizes 1-1/2" and above. Thickness for outdoor piping to be 1" for pipe sizes up to and including 3/4", 3" thick for pipe sizes 1” and above.

C. All voids around valves, fittings, housings and other devices installed in the piping system shall be filled with loose fiberglass insulation. Insulation vapor barrier shall be maintained to prevent moisture penetration through outer cover.

D. In addition, finish entire installation with a white 0.020 PVC pipe and fitting covering with clear solvent weld joints and seams suitable for installation in return air plenum.

E. Lines on the exterior of the building shall be covered with smooth 0.160 aluminum jacket and elbows.

2.6 CHILLED PUMPS

A. Insulate pump housing with 1-1/2" thick foamglass block or ceramic foam insulation and arrange so that it can be removed without destroying the insulation. Finish with a vapor barrier mastic and glassfab BF30-35, Insulacoustic 501-C or equal.

B. Pump housings installed outdoors exterior of the building shall be additionally covered with 3M Venture Clad insulation jacketing system.

2.7 CHILLED WATER EXPANSION TANKS

A. Shall be insulated with 3/4" armaflex or equal sheets of closed cell insulation, adhered to tank with contact adhesive and sealed at all joints. Finish with white vapor barrier mastic and glassfab BF30-35, insulacoustic 501-C or equal.

B. Expansion tanks installed outdoors, exterior of the building shall be additionally covered with smooth 0.160 aluminum jacket.

2.8 CHILLED WATER AIR SEPARATORS and BUFFER TANKS

A. Shall be insulated with 1" thick armaflex or equal sheets of closed cell insulation, adhered to tank with contact adhesive and sealed at all joints. Finish with white vapor barrier and glassfab BF30-35, insulacoustic 501-C or equal.

B. Air separators and buffer tanks installed outdoors exterior of the building shall be additionally covered with smooth 0.160 aluminum jacket.

2.9 CALIBRATED BALANCING VALVES

A. Insulate calibrated balancing valves with molded insulated furnished with the unit and provide strap bands for access.

2.10 INSULATION THROUGH HANGERS AND SLEEVES

A. The insulation shall be continuous through pipe hangers and pipe sleeves. At hangers where the pipe is supported by insulation, provide a galvanized iron protection shield. Provide pipes 2-inch i.p.s. and larger in insulation inserts at points of hanger supports. The inserts shall be of calcium silicate, cellular glass, prestressed molded glass fiber of minimum 13-pound density, or other approval material of the same thickness as adjacent insulation and not less than 13-pound density. The inserts shall have sufficient compression strength to adequately support the pipe without compressing the inserts to a thickness less than the adjacent insulation. Inserts shall be 180 degrees and not less than the length of the protection shield. Vapor barrier facing of the insert shall be the same as the facing on the adjacent insulation. Where copper clad hangers are used on domestic copper pipe, insulation may cover pipe and hanger. Provide 18-gauge metal saddles between all hangers and insulation.

END OF SECTION 230713

SECTION 230800
COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 COMMISSIONING PROCESS

A. Section includes commissioning process requirements for MECHANICAL systems, assemblies, and equipment.

B. The commissioning agent (CxA) is a subcontractor directly to the general contractor for this project. The CxA has overall responsibility for planning and coordinating the commissioning process. However, commissioning involves all parties to the design and construction process, including the contractor and their subcontractors.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including general and supplementary conditions, general electrical provisions and applicable Divisions 01, Specification sections, apply to work of this section.

1.3 DEFINITIONS

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

B. CxA: Commissioning Authority.

C. 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 DESCRIPTION OF WORK

A. The purpose of the commissioning process is to provide the owner/operator of the facility with assurance that the Mechanical Systems have been installed according to the contract documents and operate within the performance guidelines set out in the specifications. The CxA will provide the owner with an unbiased, objective view of the system's installation, operation, and performance. The commissioning process does not take away or reduce the responsibility of the installing contractors to provide a finished product, installed and fully functional in accordance with the contract documents.

B. Commissioning is intended to enhance the quality of system start-up and aid in the orderly completion and transfer of systems for beneficial use by the owner. The CxA will be the leader of the commissioning team, planning and coordinating all commissioning activities in conjunction with the design professionals, construction manager, subcontractors, manufacturers, and equipment suppliers.

C. The General Contractor, Mechanical Contractor, and all Division 23 sub-contractors shall be responsible for cooperating, and coordinating their work, with the CxA. They shall also be responsible for carrying out all the physical activities required for installation of components and systems and operating them during the commissioning process as required in this Section.

1.5 REFERENCES

A. ASHE Commissioning Guideline-2010

B. ASHRAE Guideline 1-2007 The HVAC Commissioning Process

C. ASHRAE Guideline 0-2005 The Commissioning Process

PART 2 - PRODUCTS

2.1 MECHANICAL - SYSTEMS TO BE COMMISSIONED

A. Mechanical systems installed under this contract are to be inspected, tested, signed off as complete and operational, and operated for commissioning agency verification as described in Part 3 of this Section. This includes but is not necessarily limited to the work listed for each system. The foregoing includes all the following:
1. Air Terminal Units
2. Air Handling Units
3. Exhaust systems
4. Lab Exhaust System
5. Duct Leakage
6. Chilled Water System
7. Fire and Smoke Dampers
8. Test & Balance Verification
9. Verified Room & Building Pressure Requirements
10. Building Pressure Controls
11. Automatic Temperature Control - Building Automation System
12. Humidifiers
13. Domestic Hot Water & Re-circulation System

B. The contractor shall be responsible for carrying out all work required for commissioning these systems that is defined as a contractor responsibility in Part 3 of this Section.

2.2 PRE-FUNCTIONAL CHECKLISTS

A. The CxA will develop pre-functional checklists for every piece of equipment within the scope of the commissioning project, and those checklists shall include all items included in the specific design that require checking. Pre-functional testing of the systems is performed by the contractors.

2.3 FUNCTIONAL PERFORMANCE TEST CHECKLISTS

A. Commissioning authority will develop functional performance test checklists for every system included within the scope of the commissioning project. Start-up of major equipment will be performed by the contractor or manufactures representative and witnessed by the CxA.

2.4 MEMBERS OF THE COMMISSIONING TEAM

A. The commissioning team will be comprised of representatives from each discipline involved in the commissioning process. The core members of the team will be required to attend all meetings.

B. Team Members Appointed by Contractor(s):
1. Representatives of each contractor, including project superintendent and subcontractors, installers, vendor, suppliers, and specialists deemed appropriate by the CxA. The individuals shall each have authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated actions.
2. The commissioning team will meet on a regular basis as defined by the CxA in the "kick-off" meeting. The frequency of the meetings will be determined by the activity of the construction and the nearness to completion of each specialty.
3. Non-core team members will be required to attend meetings as scheduled by the team in order to provide seamless continuity to the commissioning progress schedule.

PART 3 - EXECUTION

3.1 COMMISSIONING RESPONSIBILITIES - CONTRACTOR TEAM MEMBERS

A. Provide the following information to the CxA for inclusion in the commissioning process:
1. Deliver submittals, systems manuals, and other documents and reports as needed.
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 Mechanical systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of readiness, signed by the Contractor, certifying that Mechanical systems, assemblies, equipment, components, and associated controls are ready for testing.
5. Test and inspection reports and certificates.
6. Corrective action documents.
7. Verification of testing, adjusting, and balancing reports.

3.2 CONTRACTOR/SUBCONTRACTOR RESPONSIBILITIES

A. This Section of the specifications defines the contractor's responsibilities with respect to the commissioning process. Each contractor and sub-contractor shall review this Section and carry out the work described, as it applies to each Division and Section of these specifications both individually and collectively.
B. Each Contractor and their subcontractors at a minimum shall assign representatives with expertise and authority to act on their behalf and shall schedule them to participate on the Commissioning Team and perform commissioning process activities including, but not limited to the following:
1. Evaluate performance deficiencies identified in test reports, and with approval of the design authority and the entity responsible for system and equipment installation, implement corrective action.
2. Cooperate with CxA for resolution of issues recorded in Issues Log
3. Attend and participate in commissioning team meetings.
4. Integrate and coordinate commissioning process activities into the construction schedule.
5. Review and accept construction checklists provided by the commissioning authority.
6. Complete manufacturer and commissioning checklists as work is completed and provide to the commissioning authority on a regular basis.

7. Review and accept commissioning process test procedures provided by the commissioning authority.
8. Complete commissioning process test procedures.

C. Construction manager
1. Participate in construction coordination.
2. Participate in the commission process and attend all meetings.
3. Develop the project schedule.
4. Work with the CxA to incorporate the commissioning schedule into the project schedule.
5. Ensure that subcontractors perform assigned responsibilities in a timely manner to meet the schedule.
6. Submit to CxA pre-functional test forms that meet the specifications and are typically used for the start-up of major equipment and systems.
7. Participate in maintenance orientation and inspection.
8. Participate in O&M training.
9. Certify work is complete and systems are operational.

D. Subcontractors
1. Participate in commissioning team meetings.
2. Cooperate with all commissioning team members and work in a cohesive manner to accomplish the commissioning process objectives.
3. Provide schedules for O&M data submittals and equipment start-up and testing to the CxA for incorporation into the commissioning plan. Update the schedule on a regular basis throughout the construction phase.
4. Provide information to the CxA for developing the construction phase commissioning plan.
5. Ensure participation of major equipment manufacturing in appropriate start-up, testing and training activities.
6. Provide sufficient personnel to assist the CxA as required during equipment start-up, system verification and functional performance testing.

3.3 PREFUNCTIONAL EQUIPMENT AND SYSTEMS STARTUP

A. Complete the pre-functional (PF) checklist and manufacturer checklists prior to scheduling functional testing.
B. Prior to start-up, inspect, check and confirm the correct and complete installation of all equipment and systems for which pre-functional checklists are included in the commissioning plan.
C. Document the results of all inspections and checks on the checklists and sign them. If deficient or incomplete work is discovered, ensure corrective action is taken and re-check until the results are satisfactory and the system is ready for safe startup.
D. Notify the CxA a minimum of two weeks in advance of scheduled equipment and system start-ups, so that the CxA may witness system verifications, and equipment and system start-ups.
E. Provide equipment and systems start-up resources as specified and required. If during an attempted equipment or system start-up, deficient or incomplete work is discovered that would preclude safe operation, the start-up shall be aborted until corrective action has been taken. Ensure such action is taken and verified before re-scheduling a new start-up.

3.4 FUNCTIONAL PERFORMANCE TESTING

A. Carry out performance checks to ensure that all equipment and systems fully functional and ready for the CxA to witness formal functional performance tests (FTs).

B. Operate equipment and systems for FTs in accordance with the commissioning plan and as directed by the commissioning agency. If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FTs will be stopped by the CxA.

C. Ensure that all corrections necessary for full and complete system operation as specified are completed; then with applicable sub-contractors, carry out functional performance checks to confirm correct operation before applying to the CxA to reschedule the FTs for the system in question.

D. Assign technicians who are familiar with the construction and operation of the installed systems to operate and participate in the testing of the systems, assemblies, equipment, and components.

E. Assure that all subordinate contractors (sub-sub contractors, etc.) meet the requirements of this section.

F. Assure that vendors and suppliers required for the commissioning process are properly coordinated, scheduled, and participate as required.

G. Certify that Mechanical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

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

I. 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.

J. 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).

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

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

3.5 TESTING AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least 10 days in advance of testing and balancing work, and provide access for the Cx to witness testing and balancing work

C. Provide technicians, instrumentation, and tools to verify testing and balancing of Mechanical systems at the direction of the CxA.

D. The CxA will notify testing and balancing Contractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.

E. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.

F. Failure of an item includes a deviation of more than the criteria as set forth in project specifications. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report.

1. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.6 GENERAL TESTING REQUIREMENTS

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

B. Scope of Mechanical testing shall include entire Mechanical installation, from central equipment 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 CxA shall prepare detailed testing plans, procedures, and checklists for Mechanical systems, subsystems, and equipment.

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

F. The CxA may direct that set points be altered when simulating conditions is not practical.

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

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

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

J. Participate in specified training sessions for owner's O & M personnel.

K. Gather and submit O & M data, coordination drawings and as-built drawings to the CxA.

END OF SECTION 230800

SECTION 230900
HVAC FACILITY MANAGEMENT SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control equipment and installation for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-furnished controls.

B. See "Sequences of Operation" for requirements that relate to this Section.

1.2 WORK INCLUDED

A. Provide Building Management and Control System (BMCS), including industrial instrumentation necessary to obtain functions and results specified. Integrate all components to provide a complete and functioning system. The system shall be a Niagara Framework (or “Niagara”), a Java-based framework developed by Tridium. The system shall be an extension of the Owner’s existing Siemens Building Automation System, and all controllers and software shall match existing or be the latest version of existing.

B. The Temperature controls components, equipment, etc. installed as part of this project shall be integrated to be tied back into the existing frontend located on the campus.

C. The BAS Contractor shall provide a complete and operational system that will perform the sequences of operation as described herein.

D. Furnish a complete distributed direct digital control system in accordance with this specification section. This includes all system controllers, logic controllers, and all input/output devices. Items of work included are as follows:
1. Provide a submittal that meets the requirements below for approval.
2. Coordinate installation schedule with the mechanical contractor and general contractor.
3. Provide installation of all panels and devices unless otherwise stated.
4. Provide power for panels and control devices unless otherwise stated.
5. Provide all low voltage control wiring for the DDC system.
6. Provide miscellaneous control wiring for HVAC and related systems regardless of voltage.
7. Provide engineering and technician labor to program and commission software for each system and operator interface. Submit commissioning reports for approval.
8. Provide testing, demonstration and training as specified below.

E. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation, or identification number and sequence of operation all bearing the name of the manufacturer.

1.3 SUBMITTALS

A. Provide submittals for fast track items that need to be approved and released to meet the schedule of the project. Provide submittals for the following items separately upon request:
1. Valve schedule and product data
2. Damper schedule and product data
3. Mounting and wiring diagrams for factory-installed control components
4. Thermostat locations

B. Provide a complete submittal with all controls system information for approval before construction starts. Include the following:
1. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
2. Wiring Diagrams: Power, signal, and control wiring.Detail the wiring of the control devices and the panels. Show point-to-point wiring from field devices to the control panel. Show point-to-point wiring of hardwired interlocks. Show a ladder diagram or schematic of wiring internal to the panels, including numbered terminals. Clearly designate wiring that is done at a factory, at a panel shop or in the field.
3. Details of control panel faces, including sizes, controls, instruments, and labeling.
4. Schedule of dampers and actuators including size, leakage, and flow characteristics. If dampers are furnished by other, submit a damper actuator schedule coordinating actuator sizes with the damper schedule.
5. Schedule of valves including leakage and flow characteristics.
6. Written description of the Sequence of Operations.
7. Network riser diagram showing wiring types, network protocols, locations of floor penetrations and number of control panels. Label control panels with network addresses and BACnet device instance numbers. Show all routers, switches, hubs and repeaters.
8. Point list for each system controller including both inputs and outputs (I/O), point numbers, controlled device associated with each I/O point, and location of I/O device.
9. Starter and variable frequency drive wiring details of all automatically controlled motors.
10. Reduced size floor plan drawings showing locations of control panels, thermostats and any devices mounted in occupied space.
11. Product Data: Include manufacturer's technical literature for each control device indicated, labeled with setting or adjustable range of control. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Submit a write-up of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.
12. Submit BACnet Protocol Implementation Conformance Statements (PICS) for all direct digital controllers, software and other system components that will communicate on the BAS utilizing BACnet.

C. Submit a description of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.

D. Submit blank field check-out and commissioning test reports, customized for each panel or system, which will be filled out by the technician during start-up.

E. Variance letter: Submit a letter detailing each item in the submission that varies from the contract specification or sequence of operation in any way.

F. After the BAS system is approved for construction, submit sample operator workstation graphics for typical systems for approval. Print and submit the graphics that the operator will use to view the systems, change setpoints, modify parameters and issue manual commands. Programming shall not commence until typical graphics are approved.

G. Operation and Maintenance Data: In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
1. Product data with installation details, maintenance instructions and lists of spare parts for each type of control device.
2. Keyboard illustrations and step-by-step procedures indexed for each operator function.
3. Inspection period, cleaning methods, cleaning materials recommended and calibration tolerances.
4. Calibration records and list of set points.

1.4 QUALITY ASSURANCE

A. Codes
1. Perform all wiring in accordance with Division 26, NEC, local codes and Owner’s requirements.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."
4. Comply with ASHRAE 135-2010 BACnet: A Data Communication Protocol for Building Automation and Control Networks.
5. Comply with ASHRAE 90.1-2013 Energy Standard for Buildings Except Low-Rise Residential Buildings.
6. All equipment shall be UL listed and approved and shall meet with all applicable NFPA standards, including UL 916 - PAZX Energy Management Systems,
7. Provide written approvals and certifications after installation has been completed.
8. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
9. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-140001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

B. Qualifications
1. Installing contractor shall be in the business of installing and servicing DDC controls for mechanical systems, temperature and ventilation control, environmental control, lighting control, access and security, life safety and energy management as their primary business.

2. Installer Qualifications: An experienced installer who is the authorized representative of the automatic control system manufacturer for both installation and maintenance of controls required for this Project.
3. Engineering, drafting, programming, and graphics generation shall be performed by BAS qualified engineers and technicians directly employed by the Building Automation System Contractor.
4. Supervision, checkout and commissioning of the system shall be by the local branch engineers and technicians directly employed by the Building Automation System Contractor. They shall perform commissioning and complete testing of the BAS system.

C. The BAS contractor shall maintain a service organization consisting of factory trained service personnel and provide a list of ten (10) projects, similar in size and scope to this project, completed within the last five years.

D. Final determination of compliance with these specifications shall rest solely with the Engineers and Owner who will require proof of prior satisfactory performance.

E. For any BAS system and equipment submitted for approval, the BAS contractor shall state what, if any, specific points of system operation differ from these specifications.

F. All portions of the system must be designed, furnished, installed, commissioned and serviced by manufacturer approved, factory trained employees.

G. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability for any existing control system component including but not limited to building controllers, advanced application controllers, application specific, personal operator workstations and portable operator's terminals, to be connected and directly communicate with any new BAS system equipment without bridges, routers or protocol converters.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

B. Deliver, store, protect, and handle products to site under provisions of the contract Documents. Coordinate all site delivers with Construction project Manager.

C. Protect products from construction operations, dust, and debris, by storing materials inside, protected from weather in a conditioned space.

1.6 COORDINATION

A. Coordinate IP drops, network connections, user interfaces, firewall, etc with Owner’s IT representative.

B. Coordinate location of thermostats, humidistats, panels, and other exposed control components with plans and room details before installation.

C. Coordinate equipment with Division 28 "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate power for control units and operator workstation with electrical contractor.

E. Coordinate equipment with provider of starters and drives to achieve compatibility with motor starter control coils and VFD control wiring.

F. Coordinate scheduling with the mechanical contractor and general contractor. Submit a schedule for approval based upon the installation schedule of the mechanical equipment.

G. Coordinate installation of taps, valves, airflow stations, etc. with the mechanical contractor.

H. Products Furnished but Not Installed Under This Section
   1. Hydronic and Refrigerant Piping accessories:
      a. Control Valves
      b. Temperature Sensor Wells and Sockets
      c. Pressure Sensor Wells and Sockets
      d. Flow Switches
      e. Flow Meters
      f. Differential Pressure Transmitters
   2. Sheetmetal accessories
      a. Dampers
      b. Airflow Stations
      c. Terminal Unit Controls

I. Products Installed but Not Furnished Under This Section
   1. Refrigeration Equipment:
      a. Refrigerant Leak Detection System
      b. Proof of flow pressure switches
   2. Rooftop Air Handling Equipment:
      a. Thermostats
      b. Duct Static Pressure Sensors
   3. Products Integrated To but Not Furnished or Installed Under This Section
      a. Laboratory Airflow Controls

1.7 WARRANTY

A. Provide warranty per Division 23 Section “General Mechanical Requirements” and as supplemented in this section.

B. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of 12 months from completion of system demonstration.

C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours.

D. During normal building occupied hours, failure of items that are critical for system operation shall be provided within 4 hours of notification from the Owner’s Representative.

E. This warranty shall apply equally to both hardware and software.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. The new controls system shall integrate with the existing BAS shall be based on the Niagara Framework by Tridium. Niagara provides an automation infrastructure that integrates diverse systems and devices (regardless of manufacturer, communication standard or software) into a unified platform that can be managed in real time over the Internet using a standard Web browser.

B. The BAS shall be comprised of Network Area Controller or Controllers (NAC) within each facility. The NAC shall connect to the owner's local or wide area network, depending on configuration. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard Web browsers, via the Internet and/or local area network. Each NAC shall communicate to BACnet Building Controllers and other open and legacy protocol systems/devices.

C. Provide networking to new DDC equipment using industry accepted communication standards. System shall utilize BACnet communication according to ANSI/ASHRAE standard 135-2010 for interoperability with smart equipment, for the main IP communication trunk to the BAS Server and for peer-to-peer communication between DDC panels and devices. The system shall not be limited to only standard protocols, but shall also be able to integrate to a wide variety of third-party devices and applications via drivers and gateways.

D. Approved bidders / providers of the Siemens Talon system (extension of current system) are;
1. Powers of Louisiana
2. Select Building controls
3. Any qualified Siemens distributor

2.2 BUILDING AUTOMATION SYSTEM NETWORK

A. All networked control products provided for this project shall be comprised of an industry standard open protocol internetwork. Communication involving control components (i.e. all types of controllers and operator interfaces) shall conform to ASHRAE 135-2010 BACnet standard. Networks and protocols proprietary to one company or distributed by one company are prohibited.

B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.
1. Software applications, features, and functionality, including administrative configurations, shall not be separated into several network control engines working together.

C. Provide at a minimum 1 operator interface to be designated as the BAS Server with server application software. Additional operator interfaces shall use operator workstation licenses or connect via a thick or thin-client application.

D. BAS Server shall be capable of simultaneous direct connection and communication with BACnet/IP, OPC and TCP/IP corporate level networks without the use of interposing devices.

E. Any break in Ethernet communication from the server to the controllers on the Primary Network shall result in a notification at the server.

F. Any break in Ethernet communication between the server and standard client workstations on the Primary Network shall result in a notification at each workstation.

G. The network architecture shall consist of three levels of networks:
1. The Management Level Network (MLN) shall utilize BACnet/IP over Ethernet along with other standardized protocol, such as web services, html, JAVA, SOAP, XML, etc., to transmit data to non-BAS software applications and databases. The BAS Server and Operator Workstations shall reside on this level of the network architecture.
2. The Automation Level Network (ALN) shall utilize BACnet/IP over Ethernet. It shall connect BACnet Building Controllers to the BAS Server and Operator Workstations. Controllers for central plant equipment and large infrastructure air handlers shall reside on the ALN backbone BACnet/IP network. Provide network media converters, routers and switches as necessary for a complete network.
3. The Floor Level Network shall utilize BACnet/IP over Ethernet or BACnet MS/TP over RS-485 to connect all of the DDC-controlled terminal heating and cooling equipment on a floor or in a system that are controlled with BACnet Advanced Application Controllers or BACnet Application Specific Controllers. FLN devices are networked to a router that connects to the Automaton Level Network backbone.

H. The primary backbone network between the building level controllers, BAS Server and Operator Workstations shall be based upon BACnet/IP. Ethernet Network switches shall be strategically placed through the building to cover several floors or several mechanical rooms that are within 300 ft wiring-feet of each other.

I. Use fiber optic cabling for all Ethernet runs longer than 300 ft.

J. Provide a router for each RS-485 subnetwork to connect them to the base building backbone level network. The router shall connect BACnet MS/TP subnetworks to BACnet over Ethernet. Routers shall be capable of handling all of the BACnet BIBBs that are listed for the controller that reside on the subnetwork.

K. The Building Level Controllers shall be able to support subnetwork protocols that may be needed depending on the type of equipment or application. Subnetworks shall be limited to:
1. BACnet MS/TP
2. Modbus

L. BACnet MSTP Setup rules
1. Addressing for the MSTP devices shall start at 00 and continue sequentially for the number of devices on the subnetwork.
2. No gaps shall be allowed in the addresses.
3. Set the MaxMaster property to the highest address of the connected device.
4. MaxMaster property shall be adjusted when devices are added to the subnetwork.

M. Provide all communication media, connectors, repeaters, bridges, switches, and routers necessary for the internetwork.

N. Controllers and software shall be BTL listed at the time of installation.

O. The system shall meet peer-to-peer communication services such that the values in any one BACnet Building Controller or BACnet Advanced Application Controller can be read or changed from all other controllers without the need for intermediary devices. The software shall provide transparent transfer of all data, control programs, schedules, trends, and alarms from any one controller through the internetwork to any other controller, regardless of subnetwork routers.

P. Systems that use variations of BACnet using Point-to-Point (PTP) between controllers, gateways, bridges or networks that are not peer-to-peer are not allowed.

Q. Remote Communications: Provide a TCP/IP compatible communication port for connection to the Owner's network for remote communications. Provide coordination with the Owner for addressing and router configuration on both ends of the remote network.

R. The system shall be installed with a 10% spare capacity on each subnetwork for the addition of future controllers.

S. On each floor, wing or major mechanical room provide an Ethernet RJ45 connection that allows connection to the BACnet network. An open port shall always be available and shall not require any part of the network to be disconnected. The location shall be accessible to the base building personnel and not in a location where the tenant can restrict the access.

T. Distributed Control Requirements:
   1. The loss of any one DDC controller shall not affect the operation of other HVAC systems, only for the points connected to the DDC controller.
   2. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.
   3. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.
   4. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller on the network without dependence upon a central processing device. DDC Controllers shall also be able to send alarms to multiple operator workstations without dependence upon a central or intermediate processing device.
   5. Operators shall have the ability to make database changes at the central system server while operator workstations are on-line without disrupting other system operations.
   6. The DDC control panel shall be mounted in the same mechanical room as the equipment being controlled, or an adjacent utility room.
   7. Multiple systems can be programmed on the same controller as long as they are in the same room. Systems on separate floors shall have separate controllers.
   8. VAV boxes subnetworks shall be connected to the AHU controller that feeds those boxes. If multiple subnetworks are needed, then the VAV shall be grouped into subnetworks in an orderly method, such as per floor, per wing, etc.
   9. Remote sensors shall be wired to the control panel of the equipment it is controlling, not across the network.

10. Signals to remote motor control centers shall be hard wired to the control panel, not across the network.
11. Terminal units shall each have their own controller. Only exceptions are:
    a. Groups of reheat coils
    b. Groups of exhaust fans

2.3 BACNET ADVANCED WORKSTATION SOFTWARE

A. The Graphical User Interface (GUI) shall include navigation with logical grouping of the equipment into equipment summary screens such that all the VAV boxes being fed air from a particular AHU can be displayed together for comparison.

B. The GUI shall include Air Handler unit roll up screens showing the min/max and average airflow devices in the family of equipment and provide for a means to quickly reset static discharge set point for more efficient controls.

C. The Custom Equipment graphics for VAV boxes shall allow the user to initiate the creation of trend storage and collection of a system point through a simple drag and drop.

D. Each custom VAV equipment graphic shall have the ability to display the detailed sequence of operations controlling the space from within each unique device and/or application.

E. The GUI shall provide a completely interactive user interface and must offer the following features as a minimum:
1. Operating System:
    a. The GUI shall run on Microsoft Windows Operating Systems and/or standard Internet browsers including Internet Explorer, Firefox, and Chrome.
2. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.
3. Real-Time Displays. The GUI, shall at a minimum, support the following graphical features and functions:
    a. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.
    b. Graphics shall support layering and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.
    c. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
    d. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
    e. Holidays shall be set by using a graphical calendar without requiring any keyboard entry from the operator.

f. Commands to start and stop binary objects shall be done by selecting the appropriate object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
g. Adjustments to analog objects, such as set points, shall be done by right-clicking the selected object and using a graphical slider to adjust the value. No entry of text shall be required.

4. System Configuration. At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:
   a. Create, delete or modify control strategies.
   b. Add/delete objects to the system.
   c. Tune control loops through the adjustment of control loop parameters.
   d. Enable or disable control strategies.
   e. Generate hard copy records or control strategies on a printer.
   f. Select points to be alarmable and define the alarm state.
   g. Select points to be trended over a period of time and initiate the recording of values automatically.
5. On-Line Help. 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. All system documentation and help files shall be in HTML format.
6. Security. Each operator shall be required to log on to that 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 administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' 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 log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.
7. 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.
8. Alarm Console:
   a. The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.
   b. When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

F. 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™ or Chrome.
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 System, 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:
      i. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
         1) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
         2) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
      ii. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
      iii. View logs and charts
      iv. View and acknowledge alarms
      v. Setup and execute SQL queries on log and archive information
   g. 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.
   h. 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.

G. System Programming
1. The Graphical User Interface software (GUI) shall provide the ability to perform system programming and graphic display engineering as part of a complete

software package. Access to the programming functions and features of the GUI shall be through password access as assigned by the system administrator.

2. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.
3. Programming Methods:
   a. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
   b. All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.
   c. The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.
4. The B-ASC, and Building Controller's sequence of operations must be visible and editable from Niagara AX and via the Siemens LaunchPad Web Services application. All Building Controllers shall be available on the network for command, control and editing through the Niagara AX without the requirement of the BACnet Driver on Niagara AX.

H. BACnet:
1. The BAS server and Operator Workstations shall meet the BACnet device profile of an Advanced Workstation Server (B-AWS) and Operator Workstation (B-OWS) and shall support the following BACnet BIBBs:
   a. Data Sharing
      i. Data Sharing-Read Property-Initiate, Execute (DS-RP-A,B)
      ii. Data Sharing-Read Property Multiple-Initiate, Execute (DS-RPM-A,B)
      iii. Data Sharing-Write Property-Initiate, Execute (DS-WP-A,B)
      iv. Data Sharing-Write Property Multiple-Initiate (DS-WPM-A)
      v. Data Sharing-COV-Initiate (DS-COV-A)
   b. Scheduling
      i. Scheduling-Initiate (SCHED-A)
   c. Trending
      i. Trending-Viewing and Modifying Trends-Initiate (T-VMT-A)
      ii. Trending-Automated Trend Retrieval-Initiate (T-ATR-A)
   d. Network Management
      i. Network Management-Connection Establishment-Initiate (NM-CE-A)

e. Alarming
   i. Alarm and Event-Notification-Initiate (AE-N-A)
   ii. Alarm and Event-ACK-Initiate (AE-ACK-A)
   iii. Alarm and Event –Alarm Summary-Initiate (AE-ASUM-A)
   iv. Alarm and Event –Enrollment Summary-Initiate (AE-ESUM-A)
   v. Alarm and Event –Information-Initiate (AE-INFO-A)
f. Device Management
   i. Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A, B)
   ii. Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A,B)
   iii. Device Management-Device Communication Control- Initiate (DM-DCC-A)
   iv. Device Management-Private Transfer- Initiate, Execute (DM-PT-A,B)
   v. Device Management-Text Message-Execute (DM-TM-B)
   vi. Device Management-Time Synchronization- Initiate (DM-TS-A)
   vii. Device Management-UTC Time Synchronization- Initiate (DM-UTC-A)
   viii. Device Management-Reinitialize Device- Initiate (DM-RD-A)
   ix. Device Management-Backup and Restore- Initiate (DM-BR-A)
   x. Device Management-List Manipulation- Initiate, Execute (DM-LM-A,B)
   xi. Device Management-Object Creation and Deletion- Initiate (DM-OCD-A)

2. The BAS Server and Workstations shall support the following Data Link Layers:
   a. BACnet IP Annex J
   b. BACnet IP Annex J Foreign Device
   c. ISO 8802-3, Ethernet (Clause 7)
3. The BAS Server and Workstations shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
   a. Calendar – Creatable, Deletable
   b. Command – Creatable, Deletable
   c. Event Enrollment – Creatable, Deletable
   d. Notification Class – Creatable, Deletable
   e. Schedule - Creatable, Deletable
4. The BAS Server and Workstations shall support transmitting and receiving segmented messages.
5. The BAS Server and Workstation shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.

2.4 WEB BASED CONTROLLER SOFTWARE FOR CONFIGURATION, PROGRAMMING AND OPERATORS

A. The purpose of this specification is to allow the Owner/Operator to have the same controller programming capabilities as the Controls Contractor Technician without additional software, tools, or licenses.
   1. The controller programming shall be accessible to any user via a Web Services application over an IP or Internet connection through port 80.
B. The following types of controllers shall have this feature:
   1. All BACnet BC level controllers

2. Network Engine Controllers
3. Controllers on equipment or sequences customized for this job

C. The controller shall come with the software built-in and delivered with the controller as part of the controller purchase. It shall not require a separate software license to enable the software capability.
   1. The software shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer or another controller for execution.

D. The software application shall be accessible from a PC using Web Services, but shall use all of its own services and data files so as to not be susceptible to Microsoft Windows operating systems based viruses.

E. Access to the controller software shall be username and password protected. User shall be authenticated by the controller.

F. The embedded Web Services shall provide the following functionality to users, based on their access and privilege rights:
   1. Point Navigation – Provide a screen that allows users to see all of the points that are active in the system. The points shall include hardwired, software, schedules, trends, alarms and network setup.
      a. The point navigation shall display the point name, descriptor, command priority, alarm status, and current value.
      b. The user shall be able to run and print a pre-configured point log report through a web interface client that shows the point name, descriptor, command priority, alarm status, and current value.
      c. The interface and report shall allow selection filter such that the operator can select or deselect the types of point that are visible.
   2. Alarm Display –displays current BAS alarms to which the user has access will be displayed. Users will be able to acknowledge active alarms, erase resolved alarms, and directly link to the Point Commanding feature.
      a. The alarm display must provide a filter that displays all alarms whether acknowledged or not.
      b. The alarm display must provide a filter that displays only alarms that have not yet been acknowledged.
      c. The alarm display must provide a persistent indication whenever there is one or more unacknowledged alarm in any connected field panel.
   3. Point details – users will have access to point detail information including operational status, operational priority, physical address, and alarm limits, for point objects to which they have access rights.
   4. Point Commanding – users will be able to override and command points they have access to via the Web browser interface.
   5. Scheduling – allows operators, depending on their current user privileges, to override schedules selected by date, and to modify the properties of a selected schedule.
      a. The scheduler display must be able to represent facility mode schedules in a graphical format.
   6. Trend Data Report – allows users to run and print a pre-configured trend data report for historical data reporting, including a representation of the alarm status of the each point for each Trend sample. The report shall allow selection of individual points or wildcard selection of points.
      a. Trend data shall be exportable to a data file, such as .csv or other comparable.

7. Network navigation - Provide a screen that allows users to navigate to the panels and terminal units via the network architecture.

G. The web server shall be able to send SMTP text messages to notify users of alarm status. The owners shall provide a mail server and a connection port. SSL shall not be required.

H. The operator shall be able to add modify and delete controller database program, including points, schedules, alarms, and trends.
1. The operator shall be able to edit the custom program in the field panel that executes the sequences of operations, control loops and logic for the systems controlled.
2. The operator shall be able to add terminal unit controllers that reside on field panel subnetworks.

I. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the Owner as required to support the Web access feature.

J. Coordinate with the Owner/Operator’s IT representatives to setup and allow access to controllers via IP connections and Web Services through port 80.
1. It shall be the responsibility of the Owner/IT to setup and maintain security for user access to the private networks.
2. Coordinate IP addressing scheme.

2.5 NETWORK AREA CONTROLLERS (NAC)

A. The Network Area Controller (NAC) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NAC. It shall be capable of executing application control programs to provide:
1. Calendar functions
2. Scheduling
3. Trending
4. Alarm monitoring and routing
5. Time synchronization
6. Integration of controller data through NiagaraAX drivers installed in the NAC.
7. Network Management functions for all controllers

B. The Network Area Controller must provide the following hardware features as a minimum:
1. One Ethernet Port – 10/100 Mbps
2. One RS-232 port
3. One RS-485 ports
4. Battery Backup
5. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
6. The NAC must be capable of operation over a temperature range of 32 to 122°F
7. The NAC must be capable of withstanding storage temperatures of between 0 and 158°F
8. The NAC must be capable of operation over a humidity range of 5 to 95% RH, non-condensing.

C. The NAC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the NAC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.

D. The NAC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 32 simultaneous users.

E. Provide a “query” feature to allow review of specific alarms by user defined parameters.

F. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

G. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

H. Network Access
   1. Remote Access:
      a. For Local Area Network installations, provide access to the LAN from a remote location, via the Internet. The Owner shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer’s Intranet to a corporate server providing access to an Internet Service Provider (ISP). Customer agrees to pay monthly access charges for connection and ISP.
   2. Event Alarm Notification and actions
      a. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
      b. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.
      c. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
         i. To alarm
         ii. Return to normal
         iii. To fault
      d. Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
      e. Provide timed (schedule) routing of alarms by class, object, group, or node.
      f. Provide alarm generation from binary object “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
   3. Control equipment and network failures shall be treated as alarms and annunciated.
   4. Alarms shall be annunciated in any of the following manners as defined by the user:
      a. Screen message text
      b. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
         i. Day of week
         ii. Time of day
         iii. Recipient
      c. Pagers via paging services that initiate a page on receipt of email message

d. Graphic with flashing alarm object(s)
e. Printed message, routed directly to a dedicated alarm printer
5. The following shall be recorded by the NAC for each alarm (at a minimum):
a. Time and date
b. Location (building, floor, zone, office number, etc.)
c. Equipment (air handler #, accessway, etc.)
d. Acknowledge time, date, and user who issued acknowledgement.
e. Number of occurrences since last acknowledgement.
6. Alarm actions may be initiated by user defined programmable objects created for that purpose.
7. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
8. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.
9. Provide a “query” feature to allow review of specific alarms by user defined parameters.
10. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
11. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

I. Data Collection and Storage
1. The NAC shall have the ability to collect data for any property of any object and store this data for future use.
2. The data collection shall be performed by log objects, resident in the NAC that shall have, at a minimum, the following configurable properties:
a. Designating the log as interval or deviation.
b. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
c. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
d. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
e. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
3. All log data shall be stored in a relational database in the NAC and the data shall be accessed from a server (if the system is so configured) or a standard Web browser.
4. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.
5. All log data shall be available to the user in the following data formats:
a. HTML
b. XML
c. Plain Text
d. Comma or tab separated values
6. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.
7. The NAC shall have the ability to archive its log data either locally (to itself), or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties, at a minimum:

a. Archive on time of day
b. Archive on user-defined number of data stores in the log (buffer size)
c. Archive when log has reached its user-defined capacity of data stores
d. Provide ability to clear logs once archived

J. Audit Log
1. Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:
a. Time and date
b. User ID
c. Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

K. Database Backup and Storage
1. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
2. Copies of the current database and, at the most recently saved database shall be stored in the NAC. The age of the most recently saved database is dependent on the user-defined database save interval.
3. The NAC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

2.6 DIRECT DIGITAL CONTROLLER SOFTWARE

A. Provide a full capability user license to the owner for the operator to be able to see, modify, create, upload, download and save control programs to the DDC controllers.

B. The software program shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer or another controller for execution.

C. The software application shall be accessible from a PC using the Windows environment, but shall use all of its own services and data files so as to not be susceptible to Microsoft Windows operating systems based viruses.

D. The software shall be provided with an interactive HELP function to assist operators with syntax, abbreviations, commands and saving programs.

E. Point naming and communication format:
1. All points, panels, and programs shall be identified by a 30-character name. All points shall also be identified by a 16-character point descriptor. The same names shall be displayed at both Building Controller and the Operator Interface.
2. All digital points shall have a consistent, user-defined, two-state status indication with 8 characters minimum (e.g., Summer, Enabled, Disabled, Abnormal).
3. The Building Controller Software shall be capable of BACnet communications. The BACnet Building Controller (B-BC) shall have demonstrated interoperability during at least one BTL Interoperability Workshop, have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, Annex L.

F. System Security
1. User access shall be secured using individual security passwords and user names.
2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
3. Building Controllers shall be able to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any Operator Interface or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the Operator Interface or portable terminal. Passwords and priorities for every point shall be fully programmable and adjustable.
4. User Log On/Log Off attempts shall be recorded.
5. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
6. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the DDC controller software.

G. User Defined Control Applications: The applications software shall program DDC routines to meet the sequences of operations.
1. Building Controllers shall have the ability to perform energy management routines including but not limited to time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating/cooling interlock, supply temperature reset, priority load shedding, and power failure restart.
2. The Building Controllers shall have the ability to perform the following pre tested control algorithms:
   a. Two position with differential control and time delays
   b. Floating control
   c. Proportional control
   d. Proportional plus integral control
   e. Proportional, integral, plus derivative control
   f. Automatic tuning of control loops
   g. Start Stop Time Optimization
3. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
4. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.

H. Peer-to-peer access to other DDC controllers
1. It shall be possible to use any actual or virtual point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system.
2. Any process shall be able to issue commands to points in any and all other controllers in the system.
3. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of an advanced annunciation feature, such as:

a. Generate a report
b. Annunciate an alarm
c. Issue a text message or email

I. Alarm Management
1. Alarm management shall be provided within the controller software to monitor and direct alarm information to operator devices.
2. Each Building Controller shall perform distributed, independent alarm analysis, minimize network traffic and prevent alarms from being lost. At no time shall the Building Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
3. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.
4. An Alarm “shelving” feature shall be provided to disable alarms during testing. (Pull the Plug, etc.).
5. Binary Alarms. Each binary alarm object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
6. Analog Alarms. Each analog alarm object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.
7. All alarm shall include the point's user-defined language description and the time and date of occurrence.
8. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print reports, be logged in the event log, generate custom messages, and display graphics.
9. The user shall be able to add a 200-character alarm message to each alarm point to more fully describe the alarm condition or direct operator response. Each Building Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assigned to any number of points in the Controller.
10. Operator-selected alarms shall be capable of initiating a trigger to an advanced annunciation, such as text, email, etc.
11. An alarm history log shall report the start of the alarm condition, acknowledgement by a user and return of the alarm to normal condition.

J. Scheduling:
1. Provide a comprehensive menu driven program to automatically start and stop designated multiple objects or events in the system according to a stored time.
2. Schedules shall reside in the building controller and shall not rely on external processing or network.
3. It shall be possible to define a group of objects as a custom event (i.e., meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.
4. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and/or stop within that group.
5. The operator shall be able to define the following information:
   a. Time, day
   b. Commands such as on, off, auto, etc.
   c. Time delays between successive commands.

d. There shall be provisions for manual overriding of each schedule by an authorized operator.

6. It shall be possible to schedule calendar-based events up to one year in advance based on the following:
   a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.
   b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. 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.

K. Peak Demand Limiting (PDL):
1. The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.
2. PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.
3. PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.
4. If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.
5. Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.

L. Temperature-compensated duty cycling
1. User defined conditions shall be able to initiate a Duty Cycle Control Program.
2. The Duty Cycle Control Program (DCCP) shall be configured to periodically stop and start loads according to various patterns.
3. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.

M. Automatic Daylight Savings Time Switchover. The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

N. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

O. Enthalpy switchover (economizer). The Building Controller Software (BCS) shall control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover setpoint the BCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly change over to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.

P. Control Loop Algorithm
1. Provide a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup. The algorithm shall calculate a time-

varying analog value that is used to position an output or stage a series of outputs. The controlled variable, setpoint, and weighting parameters shall be accessible from the operator workstation.

Q. Adaptive Loop Tuning
1. Building Controllers shall also provide high resolution sampling capability for verification of DDC control loop performance. Documented evidence of tuned control loop performance shall be provided on a monthly, seasonal, quarterly, annual period.
2. For PID control loops, operator-initiated automatic and manual loop tuning algorithms shall be provided for all operator-selected PID control loops. Evidence of tuned control loop performance shall be provided via graphical plots or trended data logs for all loops.
   a. In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.
   b. Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

R. Logic programming: Provide a software routine that can build ladder logic to control using many conditional statements.
1. The logic programming syntax shall be able to combine ladder logic with other software features, such as combining status, scheduling, PDL and alarm conditions into one conditional decision.
2. Logic programming shall be able to reference conditions in any other controller in the system.

S. Staggered Start:
1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable in an application and shall not require written scripts or ladder logic.
2. Upon the resumption of power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

T. Totalization Features:
1. Run-Time Totalization. Building Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.
2. Consumption totalization. Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.
3. Event totalization. Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

U. Data Collection:

1. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for all points.
2. Building Controllers shall store point history data for selected analog and digital inputs and outputs:
3. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controllers point group.
4. Two methods of collection shall be allowed: either by up to four pre-defined time intervals or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided.
5. Each Building Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.
6. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in third-party personal computer applications.

2.7 BACNET BUILDING CONTROLLERS

A. Provide all necessary hardware for a complete operating system as required. The Building Controller shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

B. This controller shall have the BTL listing and meet the BACnet device profile of a Building Controller (B-BC) and shall support the following BACnet BIBBs:
1. Data Sharing
    a. Data Sharing-Read Property-Initiate, Execute (DS-RP-A,B)
    b. Data Sharing-Read Property Multiple- Initiate, Execute (DS-RPM-A,B)
    c. Data Sharing-Write Property- Initiate, Execute (DS-WP-A,B)
    d. Data Sharing-Write Property Multiple- Execute (DS-WPM-B)
    e. Data Sharing-COV- Initiate, Execute (DS-COV-A,B)
    f. Data Sharing-COV-Unsolicited- Initiate, Execute (DS-COVU-A,B)
2. Scheduling
    a. Scheduling-Internal- Execute (SCHED-I-B)
    b. Scheduling-External- Execute (SCHED-E-B)
3. Trending
    a. Trending-Viewing and Modifying Trends - Initiate (T-VMT-A)
    b. Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)
    c. Trending-Viewing and Modifying Trends-External- Execute (T-VMT-E-B)
    d. Trending-Automated Trend Retrieval- Execute (T-ATR-B)
4. Network Management
    a. Network Management-Connection Establishment- Initiate (NM-CE-A)
5. Alarming
    a. Alarm and Event-Notification- Initiate (AE-N-A)
    b. Alarm and Event-Notification Internal- Execute (AE-N-E-B)
    c. Alarm and Event-Notification External- Execute (AE-N-E-B)
    d. Alarm and Event-ACK- Initiate, Execute (AE-ACK-A,B)
    e. Alarm and Event –Alarm Summary- Execute (AE-ASUM-B)
    f. Alarm and Event –Enrollment Summary- Execute (AE-ESUM-A,B)
    g. Alarm and Event –Information- Initiate, Execute (AE-ESUM-A,B)
6. Device Management

a. Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A,B)
b. Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A,B)
c. Device Management-Device Communication Control- Execute (DM-DCC-B)
d. Device Management-Private Transfer- Initiate, Execute (DM-PT-A,B)
e. Device Management-Text Message- Initiate, Execute (DM-TM-A,B)
f. Device Management-Time Synchronization- Execute (DM-TS-B)
g. Device Management-Reinitialize Device- Execute (DM-RD-B)
h. Device Management-Backup and Restore- Execute (DM-RD-B)
i. Device Management-List Manipulation- Execute (DM-RD-B)
j. Device Management-Object Creation and Deletion- Execute (DM-OCD-B)

7. The Building Level Controller shall support the following Data Link Layers:
   a. BACnet IP Annex J
   b. BACnet IP Annex J Foreign Device
   c. MS/TP Master (Claus 9)
8. The Building Level Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
   a. Calendar – Creatable, Deletable
   b. Command – Creatable, Deletable
   c. Event Enrollment – Creatable, Deletable
   d. Notification Class – Creatable, Deletable
   e. Schedule - Creatable, Deletable
9. The Building Level Controller shall support transmitting and receiving segmented messages.
10. The Building Level Controller shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.
11. The Building Level Controller shall have the capability to act as a BACnet router between MS/TP subnetworks and BACnet/IP.

C. This level of controller shall be used for the following types of systems:
   1. Chiller plant systems
   2. Pumping systems
   3. VAV air handlers
   4. Systems with over 24 input/output points
   5. Rooftop systems

D. Computing power and memory minimum:
   1. A 32 bit, stand alone, multi tasking, multi user, real-time 100MHz digital control microprocessor module.
   2. Inputs shall be 16-bit minimum analog-to-digital resolution
   3. Outputs shall be 10-bit minimum digital-to-analog resolution
   4. Memory module (24 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases (see Controllers Software section), including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial up communications.
   5. Real time clock and battery
   6. Data collection/ Data Trend module sized for 10,000 data samples.

7. Flash Memory Firmware: Each Building Level Control Panel shall support firmware upgrades without the need to replace hardware.

E. Onboard or Modular hardware and connections:
1. Primary Network communication module, if needed for primary network communications.
2. Secondary Network communication module, if needed for secondary network communications.
3. RJ45 port 10/100Mbaud
4. RS485 ports for subnetworks and point expansion
5. Man to Machine Interface port (MMI)
6. USB Port

F. Input and Output Points Hardware
1. Input/output point modules as required including spare capacity.
2. Input/output point modules shall have removable terminal blocks.
3. Monitoring of the status of all hand off auto switches.
4. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
5. Local status indication for each digital input and output for constant, up to date verification of all point conditions without the need for an operator I/O device. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
6. Graduated intensity LEDs or analog indication of value for each analog output.
7. Optional HOA (hand-off-auto module) with software configurability and LED status indicators.

G. Code compliance
1. Approvals and standards: UL916; CE; FCC
2. Provide UL864-UUKL where called for in the sequences of operations.

H. Accessories:
1. Appropriate NEMA rated metal enclosure.
2. Power supplies as required for all associated modules, sensors, actuators, etc.

I. The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. Provide hand/off/auto switch for each digital output, including spares.

J. Each Building Level Control Panel shall continuously perform self diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

K. Panel setup, point definitions and sequencing diagrams shall be backed up on EEPROM memory.

L. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 30 days.

M. Building Level control panels shall provide at least two serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal communications, operation of permanently connected modems, printers or terminals.

N. Building Level Controllers shall have the capability to serve as a gateway between Modus subnetworks and BACnet objects. Provide software, drives and programming.

O. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587 1980.

P. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be “future” on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

Q. Environment.
   1. Controller hardware shall be suitable for the anticipated ambient conditions.
   2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
   3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
   4. Controller hardware shall be optionally suitable for rooftop environments.

R. Immunity to power and noise.
   1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
   2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
   3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
      a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
      b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
      c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
      d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
   4. Isolation shall be provided at all Building Controller’s AC input terminals to suppress induced voltage transients consistent with:
      a. IEEE Standard 587 1980
      b. UL 864 Supply Line Transients
      c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

2.8 BACNET ADVANCED APPLICATION CONTROLLERS

A. Provide all necessary hardware for a complete operating system as required. The Advanced Application level control panel shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

B. The Advanced Application Controller Software shall be capable of BACnet communications. The BACnet Advanced Application Controller (B-AAC) shall have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2004 or ANSI/ASHRAE 135-2008. Supported BIBBS shall include:
1. Data Sharing
   a. Data Sharing-Read Property-Initiate, Execute (DS-RP-A,B)
   b. Data Sharing-Read Property Multiple- Initiate, Execute (DS-RPM-A,B)
   c. Data Sharing-Write Property- Initiate, Execute (DS-WP-A,B)
   d. Data Sharing-Write Property Multiple- Execute (DS-WPM-B)
   e. Data Sharing-COV- Initiate, Execute (DS-COV-A,B)
2. Scheduling
   a. Scheduling-Internal- Execute (SCHED-I-B)
3. Trending
   a. Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)
   b. Trending-Automated Trend Retrieval- Execute (T-ATR-B)
4. Network Management
   a. Network Management-Connection Establishment- Initiate (NM-CE-A)
5. Alarming
   a. Alarm and Event-Notification Internal- Execute (AE-N-I-B)
   b. Alarm and Event-ACK- Initiate, Execute (AE-ACK-A,B)
   c. Alarm and Event –Enrollment Summary- Execute (AE-ESUM-B)
   d. Alarm and Event –Information- Execute (AE-INFO-B)
6. Device Management
   a. Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A,B)
   b. Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A,B)
   c. Device Management-Device Communication Control- Execute (DM-DCC-B)
   d. Device Management-Time Synchronization- Execute (DM-TS-B)
   e. Device Management-Reinitialize Device- Execute (DM-RD-B)
   f. Device Management-Backup and Restore- Execute (DM-BR-B)
   g. Device Management-List Manipulation- Execute (DM-LM-B)
   h. Device Management-Object Creation and Deletion- Execute (DM-OCD-B)
7. The Advanced Application Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
   a. Calendar – Creatable, Deletable
   b. Command – Creatable, Deletable
   c. Event Enrollment – Creatable, Deletable
   d. Notification Class – Creatable, Deletable
   e. Schedule - Creatable, Deletable
8. The Advanced Application Controller shall support transmitting and receiving segmented messages.

C. Communication:

1. BAS Network: The Advanced Application Controller shall support the following Data Link Layers:
   a. MS/TP Master
2. Serial Communication: Temporary use of portable devices shall not interrupt the BAS communication, nor the normal operation of permanently connected printers or terminals.
   a. Provide at least one EIA-232C serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals.
   b. A USB port shall alternatively be available to support local HMI tools connection.

D. Software
1. The software programs specified in this section shall be provided as an integral part of Advanced Application Controllers and shall not be dependent upon any higher level computer or another controller for execution.
2. Advanced Application Controllers shall have the ability to perform energy management routines including but not limited to
   a. scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides
   b. automatic daylight savings time switch over
   c. night setback control
   d. economizer switch over using enthalpy, dry bulb or a combination
   e. peak demand limiting,
   f. temperature-compensated duty cycling
   g. heating/cooling interlock
   h. supply temperature reset
   i. priority load shedding
   j. power failure restart
3. The software shall have a routine for automatic tuning of control loops
4. System Security in the Field Panel
   a. User access shall be secured using individual security passwords and user names.
   b. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
   c. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
   d. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.
5. User Defined Control Applications:
   a. Controllers shall be fully-programmable. Controllers shall execute custom, job-specific sequences to automatically perform calculations and special control routines. Factory installed or pre-configured sequences shall only be allowed if they exactly match the sequence specified herein.
   b. Programs shall combine control logic, control loop algorithms, and energy management routines
   c. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.

d. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task oriented information from the user manual.

E. Adaptive Loop Control.
1. Each AAC controller shall come standard with an Adaptive Control Loop Algorithm
   a. Tuning parameter shall automatically adjust for non-linear applications
2. Model-Free Adaptive (MFA) algorithm
   a. The algorithm shall not require modeling of the non-linear system in order to maintain control at all points of the non-linear load.
   b. The controlled variable, setpoint, and weighting parameters shall be user-selectable.
3. Output shall be analog or shall stage a series of outputs.
4. Adaptive Control shall take the place of Proportional, Proportional + Integral, and PID type algorithms for non-linear applications. Adaptive Control routines shall :
   a. Improve response time
   b. Improve System efficiency
   c. Improve Stability
   d. Result in Consistent outputs
   e. Reduce cycling and repositioning
   f. Reduce wear and tear on actuators
5. Adaptive control shall auto-adjust to compensate for
   a. mode changes
   b. load changes
   c. seasonal changes
   d. Heating and cooling changeover
   e. Heating or cooling capacity changes on the primary side
   f. Flow changes on the primary or secondary side
   g. Airflow changes across coil
   h. Flow across a heat exchanger
6. Adaptive control shall auto-adjust to compensate for
   a. Non-linear coils and heat exchangers
   b. Hot water and chilled water reset routines
   c. Water flow reset routines
   d. Duct Static reset routines
7. Auto-Tune PID loops are not acceptable substitutions.
8. If Adaptive Loop Control is not available, then the BAS contractor shall provide re-tuning of the control loops for coils and heat exchangers for each of the following conditions:
   a. Low heating supply water, high heating supply water
   b. Low load on steam coil, high load on steam coil
   c. Chilled water coil, non dehumidification and condensing
   d. Chilled water coil, low airflow, high airflow, economizer
   e. Dual temperature systems tune for heating and cooling modes
   f. Each of 4 seasons

F. This level of controller shall be used for the following types of systems:
1. Systems with custom sequences that meet all of the criteria below:
2. No primary pumping systems
3. Secondary Pumping systems that are remote from Central Plants
4. Air handlers up to 15,000 cfm
5. Systems up to 20 input/output points

6. Room control sequences that cannot be achieved with an application specific controller
7. BAS Network or Architecture or Sequences do not require the system to be on an IP network
8. No systems that require integration to meters, VFDs or other smart equipment
9. Integration to smart thermostats is allowed

G. Input/Outputs
1. Inputs shall be 16-bit minimum digital resolution
2. Outputs shall be 10-bit minimum digital resolution
3. The following I/O port types shall be available on the controller
    a. Universal Input (software configurable):
        i. Digital Input choices:
            1) Pulse Accumulator
            2) Contact Closure Sensing
            3) Dry Contact/Potential Free inputs only
            4) Digital Input (10 ms settling time)
            5) Counter inputs up to 20 Hz, minimum pulse duration 20 ms (open or closed)
        ii. Analog Input Choices:
            1) 0-10 Vdc
            2) 4-20 mA
            3) 1K Ni RTD @ 32°F (Siemens, JCI, DIN Ni 1K)
            4) 1K Pt RTD (375 or 385 alpha) @ 32°F
            5) 10K NTC Type 2 or Type 3 Thermistor
            6) 100K NTC Type 2 Thermistor
    b. Universal Input or Output (software configurable):
        i. All of the above input types
        ii. Analog Output Types:
            1) 0 to 10 Vdc @ 1 mA max
    c. Super Universal Input or Output (software configurable):
        i. All of the above input types
        ii. All of the above output types
        iii. Super digital output type:
            1) 0 to 24 Vdc, 22 mA max. (for controlling pilot relay)
        iv. Super Analog Output Choices:
            1) 0 to 20 mA @ 650 Ω max.
4. Provide software configurable I/O ports such that a programmer make a port either an input or an output

H. Each System Level Control Panel shall, at a minimum, be provided with:
1. Appropriate NEMA rated metal enclosure.
2. A 32 bit,multi tasking, real-time 100 MHz digital control microprocessor with plug-in, enclosed processors.
3. Each Advanced Application Controller shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, and operator I/O.
4. Real time clock and battery
5. Data collection/ Data Trend module sized for 10,000 data samples.
6. Power supplies as required for all associated modules, sensors, actuators, etc.

7. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
8. Local status indication for each digital input and output for constant, up to date verification of all point conditions without the need for an operator I/O device.
9. Each control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
10. Graduated intensity LEDs or analog indication of value for each analog output.

I. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for the operating system software and firmware.
   1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
   2. Brownout protection and power recovery circuitry protect the controller board from power fluctuations.
   3. Battery backup shall be provided to support the real-time clock for 10 years
   4. The program and database information stored SDRAM memory shall be battery backed for a minimum of 30 days and up to 60 days. This eliminates the need for time consuming program and database re-entry in the event of an extended power failure.

J. Database Restore: Each AAC controller shall automatically save the latest programmed database. The controller shall be able to automatically restore a lost or corrupt database without involvement from the operator.

K. Each System Level Control Panel shall continuously perform self diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

L. Each Control Panel shall support firmware upgrades without the need to replace hardware.

M. System Level control panels shall provide at least two RS 232C serial data communication ports for operation of operator I/O devices such as operator terminals, and additional memory. Control panels shall allow temporary use of portable operator interface devices without interrupting the normal communications.

N. Immunity to noise.
   1. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
   2. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
      a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
      b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
      c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
      d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
   3. Isolation shall be provided at all Advanced Application Controller's AC input terminals to suppress induced voltage transients consistent with:
      a. IEEE Standard 587 1980

b. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

O. Agency Compliance
1. UL UL916 PAZX (all models)
2. UL916 PAZX7 (all models)
3. FCC Compliance CFR47 Part 15, Subpart B, Class B

P. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be “future” on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

2.9 CONTROL PANELS

A. Controllers in mechanical rooms shall be mounted in NEMA 1 enclosures.

B. Controllers in areas where moisture is a concern shall be mounted in NEMA 12 enclosures.

C. Controllers installed outdoors shall be mounted in NEMA 4X enclosures. Provide heaters where freezing temperatures are normally experienced.

D. Mount on walls at an approved location or provide a free standing rack.

E. Panels shall be constructed of 16 gauge, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with ANSI 61 gray polyester-powder painted finish, UL listed. Provide common keying for all panels.

F. Provide power supplies for control voltage power.

G. Dedicate 1 power supply to the DDC controller. Other devices shall be on a separate power supply, unless the power for the control device is derived from the controller terminations.

H. Power supplies for controllers shall be a transformer with a fuse or circuit breaker. Power supplies for other devices can be plain transformers.

I. All power supplies for 24V low voltage wiring shall be class 2 rated and less than 100VA. If low voltage devices require more amps, then provide multiple power supplies. If a single device requires more amps, then provide a dedicated power supply in a separate enclosure and run a separate, non-class 2 conduit to the device.

J. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator’s workstations.

K. All devices in a panel shall be permanently mounted, including network switches, modems, media converters, etc.

L. Provide a pocket to hold documentation.

2.10 UNINTERRUPTIBLE POWER SUPPLY

A. Provide an UPS for each of the following:
   1. BAS Server

B. Each UPS shall power the device for a minimum of 30 minutes, in the case of power interruption.

C. The UPS shall be DIN rail mounted within the associated control panel and consist of a battery power source, charger, AC output inverter system and automatic load transfer circuits for a full automatic operation. The UPS shall be an on-line type. When normal AC power returns, the UPS shall transfer the load to the rectifier output. At this time, the charger shall turn on to its 'high' charge rate until the batteries are charged approximately 80% of their rated capacity and then automatically shall switch to its maintenance 'sensing' position to keep the batteries in their best full-charge condition. Battery recharge time shall not be more than 3 hours.

D. Each UPS shall be provided, as a minimum, with pilot lights for the following conditions: "Incoming AC Power is Available", "UPS Ready Mode" and "UPS in Standby Mode". The UPS shall have the capability to hot-swap batteries without interrupting the supply of power to its users.

E. The batteries shall be of the totally enclosed nickel-cadmium type or equal. Batteries that can leak gas shall not be acceptable. There shall not be any damages should the emergency outage of line power exceed the maximum operation time of the UPS. Automatic shutdown shall occur when the UPS' maximum duty cycle is exceeded.

F. Provide APC, Liebert, or pre-approved equal.

2.11 SENSORS

A. General
   1. Provide mounting hardware for all devices, including actuator linkages, wells, installation kits for insertion devices, wall boxes and fudge plates, brackets, etc.
   2. If a special tool is required to mount a device, provide that tool.

B. Terminal Unit Space Thermostats
   1. Each controller performing space temperature control shall be provided with a matching room temperature sensor.
      a. Plain Space Temperature Sensors – Wired: Where called for in the sequences or on the drawings, provide sensors with plain covers.
      b. The sensing element for the space temperature sensor shall be thermistor type providing the following.
         i. Element Accuracy: + /- 1.0°F
         ii. Operating Range: 55 to 95°F
         iii. Set Point Adjustment Range: 55 to 95°F
         iv. Calibration Adjustments: None required
         v. Installation: Up to 100 ft. from controller
         vi. Auxiliary Communications Port: as required
         vii. Local LCD Temperature Display: as required
         viii. Setpoint Adjustment Dial as required
         ix. Occupancy Override Switch as required

c. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator’s terminal.

2. Digital Display temperature sensor specifications – Wired:
   a. As called for in the sequences of operations or on the drawings, provide temperature sensors with digital displays.
   b. The sensing element for the space temperature sensor must be IC-based and provide the following.
      i. Digitally communicating with the Application Specific Controller.
      ii. Mountable to and fully covering a 2 x 4 electrical junction box without the need for an adapter wall plate.
      iii. IC Element Accuracy: +/- 0.9°F
      iv. Operating Range: 55 to 95°F
      v. Setpoint Adjustment Range: User limiting, selectable range between 55 and 95°F
      vi. Display of temperature setpoint with numerical temperature values
      vii. Display of temperature setpoint graphically, with a visual Hotter/Colder setpoint indication
      viii. Calibration: Single point, field adjustable at the space sensor to +/- 5°F
      ix. Installation: Up to 100 ft. from controller
      x. Auxiliary Communications Port: included
      xi. Local OLED Temperature Display: included
      xii. Display of Temperature to one decimal place
      xiii. Temperature Setpoint Adjustment included
      xiv. Occupancy Override Function included
   c. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator’s terminal.

3. Provide the following options as they are called for in the sequences or on the drawings:
   a. Setpoint Adjustment. The setpoint adjustment function shall allow for modification of the temperature by the building operators. Setpoint adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator's terminal.
   b. Override Switch. An override button shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator

interface, Building Controller, room sensor two-line display or via the portable operator's terminal.

c. Space Combination Temperature and Humidity Sensors. Each controller performing space temperature control shall be provided with a matching room temperature sensor, which also includes the ability to measure humidity for either monitoring or control purposes. The combination temperature and humidity sensors shall have the same appearance as the space temperature sensors. Humidity elements shall measure relative humidity with a +/- 2% accuracy over the range of 10 to 90% relative humidity. Humidity element shall be an IC (integrated circuit) sensing element. Humidity sensing elements shall be removable and field replaceable if needed.

C. Temperature Sensors
1. All temperature sensors shall meet the following specifications:
   a. Accuracy: Plus or minus 0.2 percent at calibration point.
   b. Wire: Twisted, shielded-pair cable.
   c. Vibration and corrosion resistant
2. Space temperature sensors shall meet the following specifications:
   a. 10k ohm type 2 thermisters
3. Insertion Elements in Ducts shall meet the following specifications:
   a. Single point 10k ohm thermister
   b. Use where not affected by temperature stratification
   c. The sensor shall reach more that 1/3 the distance from the duct wall
   d. Junction box for wire splices
4. Averaging Elements in Ducts shall meet the following specifications:
   a. 72 inches (183 cm) long
   b. Flexible
   c. Use where prone to temperature stratification, in front of coils, or where ducts are larger than 9 sq. ft.
   d. Junction box for wire splices
5. Insertion Elements for Liquids shall meet the following specifications:
   a. Platinum RTD with 4-20mA transmitter
   b. Threaded mounting with matching well
   c. Brass well with minimum insertion length of 2-1/2 inches for pipes up to 4” diameter
   d. Brass well with insertion length of 6 inches for pipes up to 10” diameter
   e. Junction box for wire splices
6. Outside-Air Sensors Platinum RTD with 4-20mA transmitter:
   a. Watertight enclosure, shielded from direct sunlight
   b. Circulation fan
   c. Watertight conduit fitting

D. Where called for in the sequences of operations, provide the following feature on space sensors and thermostats:
1. Security Sensors: Stainless-steel cover plate with insulated back and security screws
2. Space sensors with setpoint adjust: Plain white plastic cover with slide potentiometer to signal a setpoint adjustment to the DDC
3. Space Sensors with LCD display:
   a. Operator buttons for adjusting setpoints, setting fans speeds and overriding unit to on/off

b. Graphical LCD icons for signaling heating/cooling mode, fans speed, schedule mode, actual temperature and current setpoint

E. Humidity Sensors shall meet the following specifications:
1. Bulk polymer sensor element
2. Accuracy: 2 percent full range with linear output
3. Room Sensors: With locking cover matching room thermostats, span of 0 to 100 percent relative humidity
4. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity

F. Air Static Pressure Transmitter shall meet the following specifications:
1. Non-directional sensor with suitable range for expected input, and temperature compensated.
2. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
3. Output: 4 to 20 mA.
4. Building Static-Pressure Range: 0 to 0.25 inches wg.
5. Duct Static-Pressure Range: 0 to 5 inches wg.

G. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.

H. Equipment operation sensors as follows:
1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg.
2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig.
3. Status Inputs for direct drive electric motors: Current-sensing relay with current transformers, adjustable and sized for 175 percent of rated motor current.
4. Status inputs for belt drive electric motors: Current sensing transmitter with linear 4-20mA output

I. Electronic Valve/Damper Position indication: Visual scale indicating percent of travel and 0 to 10 V dc, feedback signal.

J. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless-steel or bronze paddle. For chilled-water applications, provide vapor proof type.

K. Air Differential Pressure Switches: Diaphragm type air differential pressure switches with die cast aluminum housing, adjustable setpoint, minimum 5 amp switch rating at 120VAC, SPDT switches, and the switch pressure range shall be suited for the application. Provide Dwyer or equal. These switches shall be utilized for filter status.

L. Leak detectors: Provide spot leak detectors that can be secured to the floor or secured to a drain pan. The detection shall used a microchip controlled energized probes. The detector shall operate on 24Vor less. Provide a way to adjust the height of the leak probes. The SPDT contacts shall be inside a watertight enclosure.

2.12 ELECTRO-MECHANICAL THERMOSTATS

A. Fire-Protection Thermostats: UL listed with fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature, with the following:
   1. Reset: Automatic with control circuit arranged to require manual reset at central control panel, with pilot light and reset switch on panel labeled to indicate operation.

B. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point. Setpoint shall be adjustable.
   1. Bulb Length: Minimum 20 feet.
   2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

C. Electric space thermostats: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V.

D. Aquastat: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V.

2.13 AUTOMATIC CONTROL VALVES

A. General:
   1. All automatic control valves shall be fully proportioning, un¬less specified otherwise. The valves shall be quiet in opera¬tion and fail safe in either normally open or normally closed position in the event of control air failure. All valves shall be capable of operating at varying rates of speed to correspond to the exact dictates of the controllers and variable load re¬quirements. The valves shall be capable of operating in se¬quence with other valves and/or dampers when required by the se-quence of operation. All control valves shall be sized by the control vendor and shall be guaranteed to accommodate the flow rates as scheduled. All control valves shall be suitable for the pressure conditions and shall close against the differential pressures involved. Body pressure rating and connec¬tion type construction shall conform to fitting and valve sched¬ules. Control valve operators shall be sized to close against a differential pressure equal to the design pump heads plus 10 percent.
   2. Cold water, hot water and steam valves, throttling type, and bypass valves shall have equal percentage flow characteristics.
   3. Unless otherwise specified, control valves 2 inches and smaller shall have cast iron or bronze bodies with screwed NPT connections.
   4. Valves between 2 1/2 inch and 4 inch shall have cast iron bodies with flanged connections.
   5. All automatic control valves installed exposed to the elements shall be provided with electric actuators with operating characteristics and accessories as described in herein. Coordinate with electrical contractor for power availability and point of connection.
   6. All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless noted otherwise in these documents.
   7. All automatic control valves shall be installed by the mechanical trade.
   8. The controls contractor shall provide wiring as follows:

a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
b. All wiring between the central control system (ATC/BMS) and the valve actuator shall be wired by the controls contractor.
c. All wiring between the valve actuator and their associated thermostats, pressure switches, control devices, etc. shall be wired by the controls contractor.
d. All wiring shall comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (BMS) terminals.

B. Characterized Ball Valves
1. All control valves shall be sized by the control vendor. All control valve bodies shall be suitable for the static and dynamic pressures of the system. Control valve operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent.
2. Body pressure rating and connection type construction shall conform to fitting and valve schedules.
a. Design body pressure shall be determined by the adding the static pressure due to the height of the system plus the compression tank charge plus the maximum head of the system pump at cut off. Provide 10% design factor.
3. The valve seat differential pressure rating shall exceed the pump dynamic head design pressure.
4. All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless otherwise noted in these documents.
5. All automatic control valves shall be installed by the mechanical trade.
6. The controls contractor shall provide wiring as follows:
a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
b. All low voltage wiring between the controller and the valve actuator shall be wired by the controls contractor.
c. All wiring between safeties and the valve actuator shall be wired by the controls contractor.
d. All wiring shall comply with code requirements. Segregate high and low voltage wiring and circuits and segregate the Fire Alarm (FACS) and BAS controls wiring.

C. Threaded Valves, line size ½” to 2”
1. Controlled Media Specific Items
a. The control valve shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 250°F (121°C). 3-way 1-1/2 inch and 2 inch valves shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 230°F (110°C).
b. The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 250°F (121°C). 3-way 1-1/2 inch and 2 inch valves shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions

to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 230°F (110°C).

2. General Construction Materials/Applicable Standards
   a. Control valve bodies shall be constructed of forged brass according to ASTM B283 and shall meet requirements of ANSI 250 and 600WOG pressure classes.
   b. Inlets and outlets shall be clearly marked on the valve bodies.
   c. Valve ball shall consist of nickel-plated brass, chrome-plated brass or stainless steel.
   d. End connections shall be NPT internally threaded according to ANSI B1.20.1.
   e. The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.
   f. The control valve shall have an equal percentage flow characteristic, according to ANSI/ISA S75.11. A single glass filled PTFE V port insert shall provide both the ball seal and shall establish the flow coefficient of the valve. The V port insert shall be retained by the valve body itself, not requiring additional retaining components. Flow coefficient adapters requiring a retainer clip, or installed after final assembly of the valve or as inserts in the ball shall not be allowed.
   g. 2-way valves and the A-AB path on 3-way valves shall meet the requirements of ANSI Class IV (0.01% of rated Cv) seat leakage, or better, according to ANSI/FCI 70.2, at the specified close-off pressure. Bypass path (B-AB) on 3-way valves shall meet the requirements of ANSI Class III (0.1% of rated Cv) seat leakage, or better, according to ANSI/FCI 70.2.
   h. Chilled and Hot water valve shall have a blow-out proof stem with two EPDM (peroxide cured) O-rings. External stem retainers will not be allowed.
   i. Valve stem shall be made of brass or stainless steel.
   j. Valve shall have the ability to be manually operated in the event of a power failure.

D. Actuators - Electric
1. The valves shall be provided with an actuator by the same manufacturer, factory installed.
2. All actuators shall have visual position indication.
3. No external programming device shall be required.
4. Actuator shall be electric motor driving, microprocessor signal controlled.
5. Modulating valves shall be positive positioning, responding to a 0-10VDC, 2-10VDC or 4-20mA signal. Floating modulating signals are acceptable for modulation on terminal units and radiation units. There shall be a visual valve position indicator.
6. Power: All actuators shall be 24VAC power and less than 100VA draw. Power shall be via Class 2 wiring. Actuators requiring more than 100VA shall have a dedicated conduit for power wiring, not mixed with the signal wiring.
7. Fail Safe: Valves actuators shall position the valve in a fail safe position when the power supply is disrupted or the signal goes to 0. Fail-safe according to the following guidelines unless otherwise stated in the sequence of operations
   a. Power fail safe shall be via spring loaded mechanical means
   b. Any AHU hot water exposed to ventilation air shall fail open
   c. AHU Chilled water coils exposed to ventilation air in possible freezing conditions shall be fail open

d. AHU Chilled water coils that are drained in winter months or are in climate zones without freezing conditions shall be fail-in-place
e. Terminal unit valves shall fail-in-place

8. Fail in Safe valves on primary equipment such as chilled water systems, hot water systems and condenser water systems shall have a means to manually open the valve when power is not available, such as a hand wheel or a geared crank with a clutch.
9. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).
10. Actuator shall provide minimum torque required for proper valve close-off. The close-off differential pressure rating of the valve shall exceed the highest possible head pressure available at the pump plus 10%, and still be rated for a Class IV leakage.
11. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.
12. All automatic control valves installed in locations exposed to the elements shall be provided with weather resistant housings and heaters for climates that reach below freezing.
13. Actuators shall be UL and CSA listed.

E. Hot Water / Condenser Water / Control Valves
1. Single-seated.
2. Fully proportioning with modulating plug or V-port inner valves.
3. Body pressure rating and connection type construction shall conform to fitting and valve schedules. The ANSI rating of the valve shall match the ANSI rating of the piping in which the valve is installed. Minimum ANSI rating shall be ANSI 125.
4. Stainless steel stems and trim.
5. Spring loaded Teflon packing
6. Quiet in operation.
7. Fail-safe in either normally open or normally closed position in the event of power failure.
8. Capable of operating in sequence with other valves and/or dampers when required by the sequence of operation.
9. Capable of operating at varying rates of speed to correspond to the exact dictates of the controller and variable load requirements.

F. Differential Pressure Control Valves :
1. Provide for all water systems where modulating water flow conditions are required to prevent excessive pump pressure build-up. Provide a valve for each closed loop water system. Valve to be globe type. Provide valves 2" and smaller with screwed end bodies and provide valves 2-1/2" and larger with flanged ends.

G. Butterfly Valves
1. All valve body connections shall be full lugged type flange connections. Wafer valves shall not be used.
2. Valves specified herein shall apply to cold water, glycol solutions and hot water up to 200F. This valve spec shall not apply to superheated water or steam systems.
3. Applications
a. Butterfly valves shall be used for 2 position isolation.
b. Butterfly valves shall not be used for modulation control of closed water systems, for coils, or for heat exchanger control.

c. Butterfly valves can be used for temperature control bypass on open cooling towers.
d. Butterfly valves can be used for temperature control of water injection into secondary water systems.
e. For valves that switchover between heating and cooling supply, see requirements for actuator speed under actuator specification.

4. Butterfly valves shall have body ratings in accordance with the piping specifications.
   a. Design body pressure shall be determined by the adding the static pressure due to the height of the system plus the compression tank charge plus the maximum head of the system pump at cut off. Provide 10% design factor.
   b. Valves that are in high static locations or where flanges are ANSI300 per the piping design shall be high performance, ANSI 300 as required by pipe specifications.
   c. Valves that are in locations where ANSI150 flanges are allowed shall be ANSI 150 valves.
   d. Undercut discs shall only be used on systems where the maximum pump total head pressure is below 50psi. Otherwise, the valve seats shall be bubble tight at a pressure higher than the maximum pump total head pressure. Maximum total pump head shall be taken from the pump curve at full speed and 0 flow.
   e. Bubble tight rating shall apply when the system is under operation and at full pressure. Bubble tight rating shall also apply when the system is not operating and under low or no pressure. Valves that require system pressure to remain bubble tight are not acceptable.
   f. Disc edge and hub on metal discs shall be spherically machined and hand polished for minimum torque and maximum sealing capability.
   g. The seat shall totally encapsulate the body isolating it from the line media and no flange gaskets shall be required.
5. Materials for ANSI 125 Bubble tight Resilient Seat Valves 2” to 12”
   a. Materials that vary from what is specified herein shall be evaluated by the Engineer.
   b. Stem 416 stainless steel
   c. Body Cast iron
   d. Packing NBR
   e. Stem Bearing Bronze
   f. Disc 304 Stainless steel
   g. Seat EPDM
6. Materials for ANSI 125 Undercut Resilient Seat Valve 4” to 20” and Bubble tight valves 14” to 20”
   a. Materials that vary from what is specified herein shall be evaluated by the Engineer.
   b. Stem 316 stainless steel or 18-8 stainless steel
   c. Body Cast iron
   d. Packing NBR
   e. Stem Bearing Sintered Metal
   f. Disc Aluminum bronze
   g. Seat EPDM
7. Materials for ANSI 300 High Performance Valves 2” to 12”
   a. Materials that vary from what is specified herein shall be evaluated by the Engineer.

b. Stem 17-4 PH stainless steel
c. Body Carbon steel or stainless steel
d. Packing PTFE or Graphite
e. Stem Bearing 316 stainless steel, PTFE Bronze, or PTFE Bronze
f. Disc 316 Stainless steel or Monel (corrosive media)
g. Seat RTFE or Monel (corrosive media)

H. Butterfly Valve Actuators - Electric
1. Provide 120V or 24V powered actuators. Actuators shall be UL and CSA listed.
2. Actuator shall be fully modulating, floating, or two position, and/or spring return as indicated in the control sequences.
3. Where called for in the sequences of operations, provide a fail to a position actuators.
   a. Power Fail
      i. Valves up to 4” provide spring return power fail actuators
      ii. Valves 5” to 20” provide battery or capacitor driven fail-to-position option
   b. System fail bias position with power
      i. For valves up to 4” the control signal shall determine the fail bias position
      ii. For valves above 4”, the control signal shall determine the fail bias position. If the control signal is lost, the actuator shall have a signal fail bias position.
4. Modulating valves shall be positive positioning, responding to a 0-10VDC or 4-20mA signal. There shall be a visual valve position indicator.
5. For all modulating valves provide a 0-100% position feedback signal.
6. For all 2 position valves provide a 0-100% position feedback or open and closed status end switches.
7. Actuator shall provide minimum torque required for proper valve close-off. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).
8. Valve rotation speed:
   a. In applications where the speed of the valve rotation matters, the controls contractor shall provide a means to adjust the valve rotation speed during setup and commissioning.
   b. Applications where adjustable valve rotation is required are:
      i. Switchover valves for 2- pipe heating and cooling systems
      ii. Chiller condenser water isolation valves
      iii. As called for in the sequences of operations
   c. Where needed, the valve rotation speed shall be adjustable in the controller program or set at the actuator electronic board. If the speed is adjustable at the controller, then the valve signal shall be a modulating signal and not a drive open/drive closed signal.
9. Provide waterproof enclosure and crankcase heater for actuator and accessories mounted outside.
10. The controls contractor shall provide wiring as follows:
   a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
   b. All low voltage wiring between the controller and the valve actuator shall be wired by the controls contractor.

c. All wiring between safeties and the valve actuator shall be wired by the controls contractor.
d. All wiring shall comply with local code requirements.
e. Total valve power draw on a circuit shall not exceed 75% of the total rated circuit at the power source. For example on a 20A circuit, valves shall not exceed 15A draw.
f. Total valve low voltage power on a circuit shall not exceed 75% of the transformer VA it is connected to. For example on a 100VA transformer, valves shall not exceed 75VA draw.
g. Segregate non-class 2 and class 2 low voltage wiring in separate conduits. Class 2 wiring shall not exceed 100VA draw. Connections to transformers with greater than 100VA draw shall be run in separate conduits from low voltage control signal wiring.

11. Provide high performance or industrial actuators on all butterfly valves. Commercial grade, direct-mount rotary style (or direct mount damper style) actuators shall only be allowed if approved by the Engineer or allowed in these specifications and meets the torque performance.
12. High performance or industrial actuators shall have the following features:
    a. Wiring terminals in a separate compartment from the valve electronics
    b. Nema 4 enclosures. (Provide Nema 4x or 6 in locations that require those specifications.)
    c. Adjustable torque settings at the actuator.
    d. Manual override always engaged – no clutching necessary.
    e. Anti-rust and anti-corrosive cover with anodized epoxy coating.
    f. Visual mechanical position indicator.
    g. Direct mount on valve stem – no linkages
    h. Permanently lubricated self-locking gear train eliminating the need for motor brakes.
    i. Mechanical travel stops to prevent over turning during automatic or manual wheel operation.
    j. Over temperature motor protection.
    k. Speed control on open and close rotations.
    l. Operating temperature range: -40F to 140F

I. Steam Valves:

1. Steam control valves shall be of linear flow characteristics for modulating service.
2. Sizing Criteria:
    a. 15 psig or less; pressure drop 80% of inlet psig.
    b. 16 to 50 psig; pressure drop 50% of inlet psig.
    c. Over 50 psig; pressure drop as scheduled on plans.
    d. Steam valves shall fail normally open or closed, as scheduled on plans, or as follows:
        i. Heating coils in air handlers: normally open.
        ii. Steam to hot water heat exchanger: normally closed.
        iii. Other applications: as required by sequences of operation.

2.14 PRESSURE INDEPENDENT CONTROL VALVES (PICV)

A. General
1. All control valves shall be sized by the control vendor. All control valve bodies shall be suitable for the static and dynamic pressures of the system. Control valve

operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent.

a. Body pressure rating and connection type construction shall conform to fitting and valve schedules. Design body pressure shall be determined by the adding the static pressure due to the height of the system plus the compression tank charge plus the maximum head of the system pump at cut off. Provide 10% design factor.

2. The valve seat differential pressure rating shall exceed the pump dynamic head design pressure.
3. All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless otherwise noted in these documents.
4. All automatic control valves shall be installed by the mechanical trade.
5. The controls contractor shall provide wiring as follows:
   a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
   b. All low voltage wiring between the controller and the valve actuator shall be wired by the controls contractor.
   c. All wiring between safeties and the valve actuator shall be wired by the controls contractor.
   d. All wiring shall comply with code requirements. Segregate high and low voltage wiring and circuits and segregate the Fire Alarm (FACS) and BAS controls wiring.

B. Where to use PICVs
1. Provide PICVs where called for in the specifications, sequences of operations, or on the drawings.
2. If it is not stated elsewhere, PICV valves should be provided to meet the following guidelines:
   a. Provide in direct return, constant speed pumping systems.
   b. Provide in direct return, variable flow water systems where with the system at full flow the pressure differential between the supply connection and the return connection is more than double the pressure drop of the circuit or loop at design flow (including piping, fittings, devices, control valve and coil).
   c. Provide in reverse return, constant speed pumping systems where the circuits and loop pressure drops differ by more than 50%.
   d. Provide in reverse return, variable speed pumping systems where the differential pressure between the systems will vary more than the pressure drop of the circuit or loop.
   e. Provide in systems that have direct return headers and reverse return branch lines where with the system at full flow the pressure differential between the supply connection and the return connection is more than double the pressure drop of the branch at design flow (including piping, fittings, devices, control valve and coil).

C. Piping for circuits with PICVs
1. Systems installed with PICVs shall not require balancing valves.
2. Calibrated balancing valves shall not be required in branches or loops where PICV are installed.
3. Automatic flow control valves are strictly prohibited in branches or loops where PICVs are installed.

4. Circuit setters may be required for coils with multiple sections. Follow the piping details.
5. Install pressure ports on either side of the coil for the balancer to test the flow across the coil at different system flows.

D. Sizing Criteria (Pressure Independent):
1. Two-way modulating service:
   a. Determine the design GPM of the actual coil that is selected be used (may be different than the coil and GPM on the design coil schedule).
   b. Select the PICV valve with a GPM rating higher than the GPM required.
   c. If more than one valve fits the GPM rating, then pick the valve that matches or is closest to the line size of the circuit piping.
   d. If the maximum GPM of the valve exceeds the design GPM required, then adjust the Flow Limiter setting on the valve to the GPM required.
   e. Traditional flow coefficient and pressure drop sizing is not applicable to PICV valves.

E. Flanged Valves, line size 2 ½” and larger
1. Controlled Media Specific Items
   a. The control valve shall be suitable for chilled water to a minimum of 34°F (1°C) and hot water to a maximum temperature of 248°F (120°C).
   b. The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 34°F (1°C) and hot glycol/water solutions to a maximum temperature of 248°F (120°C).
2. General Construction Materials/Applicable
   a. Control valve bodies shall be constructed of cast iron and shall meet requirements of ANSI 125 or ANSI 250 pressure classes.
   b. Inlets and outlets shall be clearly marked on the valve bodies.
   c. Valves shall be constructed with a single chamber and multiple seats to provide flow limiting, pressure compensation and flow control.
   d. Valves shall contain a mechanical, spring-loaded pressure independent regulator to maintain a consistent differential pressure across the control port of the valve.
   e. Valves shall contain an actuated flow control portion that responds to the modulating signal from the controller. This control valve portion shall have a linear flow characteristic.
   f. Valves shall contain a field adjustable flow limiter. The flow limiter shall be easily adjustable in the field without the use of special tools. The adjustment dial shall be set for and indicate maximum flow. It shall be possible to manually limit the flow to the required value with the flow limiter and then modulate the flow with the control valve and actuator.
      i. A table shall be attached to each valve indicating GPM corresponding to each setting on the dial.
      ii. No mechanical devices besides the valve and actuator shall be permitted to adjust the maximum flow setting. Flow limiting port shall be integrated into the valve body.
      iii. The valve shall always maintain full nominal stroke regardless of the maximum flow setting of the flow limiter.
      iv. The flow limiter shall be lockable and tamper resistant when the actuator is installed correctly.

g. At any given actuator setting the flow accuracy across the entire pressure independent operating range of the automatic differential pressure regulator shall be ±10% or less.
h. Pressure ports shall be standard in the body of the valve for all flanged valves. Pressure ports shall provide a means for a balancer to test the differential pressure across the valve control port to ensure the PICV is operating within the pressure independent range.
i. Valves 2-1/2 inch and larger shall be provided with ANSI 125 or ANSI 250 flanged connections.
j. Valves 2-1/2 inch and larger line size shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 100 psi close off.
k. The differential pressure range for effective pressure independent operation shall be 3.6 – 90 psi or 8 – 90 psi for 2-½ and 3 inch flanged valves and 5 – 90 psi or ≤ 10 – 90 psi for 4 to 6 inch flanged valves, depending on the maximum gpm flow range of the valve.
l. Valve materials shall meet or exceed the following:
   i. Valve body: Cast iron
   ii. Stem, spring: Stainless steel
   iii. Seat: Stainless steel
   iv. Plug: Brass and EPDM
   v. Seals: EPDM (peroxide cured)

F. Threaded Valves, line size ½” to 2”
1. Controlled Media Specific Items
   a. The control valve shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 250°F (121°C).
   b. The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 250°F (121°C).
2. General Construction Materials/Applicable Standards
   a. Control valve bodies shall be constructed of forged DZR brass or ductile iron and shall meet requirements of ANSI 250 pressure class.
   b. Inlets and outlets shall be clearly marked on the valve bodies.
   c. Valves shall be constructed with a single chamber and multiple seats to provide flow limiting, pressure compensation and flow control.
   d. Valves shall contain a mechanical, spring-loaded pressure independent regulator to maintain a consistent differential pressure across the control port of the valve.
   e. Valves shall contain an actuated flow control portion that responds to the modulating signal from the controller. This control valve portion shall have a linear flow characteristic.
   f. Valves shall contain a field adjustable flow limiter. The flow limiter shall be easily adjustable in the field without the use of special tools. The adjustment dial shall be set for and indicate maximum flow. It shall be possible to manually limit the flow to the required value with the flow limiter and then modulate the flow with the control valve and actuator.
      i. The dial shall show settings in GPM.
      ii. No mechanical devices besides the valve and actuator shall be permitted to adjust the maximum flow setting. Flow limiting port shall be integrated into the valve body.

iii. The valve shall always maintain full nominal stroke regardless of the maximum flow setting of the flow limiter.
iv. The flow limiter shall be lockable and tamper resistant when the actuator is installed correctly.

g. At any given actuator setting the flow accuracy across the entire pressure independent operating range of the automatic differential pressure regulator shall be +/- 5% from 5 to 58psi and ≤-10% from Δp min. to 5 psi.

h. Pressure ports shall be an optional accessory that can be added to threaded valves. Pressure ports shall provide a means for a balancer to test the differential pressure across the valve control port to ensure the PICV is operating within the pressure independent range.

i. Valves 2 inch and smaller shall be provided female NPT piping connections.

j. Close-off and leakage
i. Normally open valves 1-1/4 inch and smaller line size shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 200 psi close off.
ii. Normally closed valves 1-1/4 inch and smaller line size shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 45 psi close off.
iii. Valves 1-1/2 and 2 inch line sizes shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 100 psi close off.Differential pressure ranges:
iv. The start-up differential pressure of the automatic differential pressure regulator shall be between 2.3 and 5 psi, depending on valve size and flow rate for ½ to 2 inch valves.
v. The maximum operating differential pressure of the automatic differential pressure regulator shall be 58 psi for ½ to 2 inch valves.
vi. In no instance shall the minimum effective pressure differential for effective pressure independent operation exceed 5 psi for valves less than or equal to 2 inch line size.

k. Valve materials shall meet or exceed the following:
i. Valve body: DZR brass or ductile iron
ii. Stem, spring: Stainless steel
iii. Seat: brass
iv. Plug: Brass and EPDM
v. Seals: EPDM (peroxide cured)

2.15 ELECTRONIC ACTUATOR SPECIFICATION

A. ELECTRONIC VALVE ACTUATORS
1. Actuator shall be fully modulating, floating (tri-state), two position, and/or spring return as indicated in the control sequences. Specified fail safe actuators shall require mechanical spring return.
2. Modulating valves shall be positive positioning, responding to a 2-10VDC or 4-20mA signal. There shall be a visual valve position indicator.
3. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.

4. Actuator shall provide minimum torque required for proper valve close-off. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).
5. Actuators shall be UL listed.

B. ELECTRONIC DAMPER ACTUATORS
1. Actuator shall be direct coupled (over the shaft), enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The actuator-to-shaft clamp shall use a "V" bolt and "V" shaped, toothed cradle to attach to the damper shaft for maximum holding strength. Single bolt or set screw type fasteners are not acceptable.
2. Actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. End switches to deactivate the actuator at the end of rotation or magnetic clutch are not acceptable.
3. For power-failure/safety applications, a mechanical, spring return mechanism shall be used.
4. Actuators with spring return mechanisms shall be capable of either clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
5. Proportional actuators shall accept a 2-10VDC, 4-20mA signal, or be of the 2 point floating type and provide a 2-10VDC actuator position feedback signal.
6. All actuators shall have an external manual gear release (clutch) or manual crank to aid in installation and for allowing manual positioning when the actuator is not powered.
7. All actuators shall have an external direction of rotation switch to aid in installation and to allow proper control response.
8. Actuators shall be provided with a factory-mounted 3-foot electrical cable and conduit fitting to provide easy hook-up to an electrical junction box.
9. Actuators shall be listed under Underwriters Laboratories Standard 873 and Canadian Standards Association. They must be manufactured under ISO 9001.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

C. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor’s work and the plans and the work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor’s work with the work of others.

3.2 INSTALLATION

A. Provide all relays, switches, sources of emergency and UPS battery back-up electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified. All field wiring shall be by this contractor.

B. Install controls so that adjustments and calibrations can be readily made. Controls are to be installed by the control equipment manufacturer.

C. Mount surface-mounted control devices on brackets to clear the final finished surface on insulation.

D. Install equipment level and plumb.

E. Install control valves horizontally with the power unit up.

F. Unless otherwise noted, install wall mounted thermostats and humidistat 60” above the floor measured to the center line of the instrument, or as otherwise directed by the Architect.

G. Install averaging elements in ducts and plenums in horizontal crossing or zigzag pattern.

H. Install outdoor sensors in perforated tube and sunshield.

I. Install damper motors on outside of duct in protected areas, not in locations exposed to outdoor temperatures.

J. Install labels and nameplates on each control panel listing the name of the panel referenced in the graphics and a list of equipment numbers served by that panel.

K. Furnish hydronic instrument wells, valves, and other accessories to the mechanical contractor for installation.

L. Furnish automatic dampers to mechanical contractor for installation.

3.3 GRAPHIC DISPLAY GENERATION

A. All workstation(s) shall be provided with color graphics. All workstation(s) software shall include a graphical viewing and control environment and definition and construction of dynamic color graphic displays.

B. Provide a main default screen showing the basic layout of the building. Each color graphic screen shall have transfer links to allow the building operator to transfer between system associated screens (both forward and backward), as well as a transfer link back to the main default screen.

C. Basic CAD floor plans with layers for walls, windows, low pressure ductwork only, supply diffusers and room numbers shall be provided for all CV, VAV, and FPVAV terminal units. Floor plans shall show the location of each space temperature sensor with a dashed line to the associated terminal unit. Display in real time the difference between the space temperature and the current setpoint.

1. Display the

a. cooling %,
b. heating % (if applicable)
c. current CFM of each terminal unit.

2. Provide a transfer link for each terminal unit to allow the operator to access the flow graphic for each individual terminal unit. Use a different color to shade the background area for each part of a floor plan graphic served by a different air handling unit.

D. Thermal floor plan graphics:
1. Show heating and cooling zones throughout the building in a range of colors (minimum 5) that provide a visual display of temperatures relative to their respective setpoints. The colors shall be updated dynamically as zones' comfort conditions change. Locations of space sensors shall also be shown for each zone. Floor plan humidity's shall be represented similarly to zone temperatures. Setpoint adjustment and color band displays shall be provided as a tool for user adjustment.
2. These full screen plans shall be accessible by rolling over the floor on the building elevation rendering. This will provide the viewer a quick and accurate overview of which zones are at setpoint, near setpoint, or need attention.
3. The viewer may then click on any zone to be brought to the terminal unit that is related to that zone. Rolling over any zone will bring up the zone description and temperature in a pop-up flag. Flags are used to keep the zone information legible regardless of how small the zone is depicted on the plan
4. All floor plans shall be vector based to allow for zooming in and out of floor plans without pixelization.
5. If zone lighting controls are tied into the BAS, then produce the same floor viewing and control for lights.
6. If a Web-based graphical interface is specified, then the floor plan graphics shall be accessible through the Web Browser Interfaces.

E. All control set points shall be easily adjustable from the system's color graphic screen by operators with the proper access level. Each controlled point on the BAS operator workstation color graphic screens shall have the set point indicated along with the actual controlled variable reading (preferred set point on top and actual reading on bottom). All points shall indicate the associated engineering unit. All analog outputs points shall indicate engineering units such as "%-open" or "%-closed" as required by the application. All normally-closed or normally-open points shall indicate the normal position (such as "N.C." or "N.O." next to the controlled device).

F. Provide system color graphics for each HVAC system and for each electrical, plumbing and/or piping system that is monitored and/or controlled by the BMS. Provide scaled floor plans indicating equipment location, service, and system data as required.

G. Provide color graphic floor plan displays and system schematics for each piece of mechanical equipment, including but not limited to air handling units, chilled water systems and hot water systems to optimize system performance analysis and speed alarm recognition.

H. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.

I. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.

J. The windowing environment of the PC operator workstation(s) shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
   1. Provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.
   2. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points which aids the operator in the analysis of the facility.

K. Provide an automatically updated, dynamic display of the site-specific BMS architecture indicating the status of primary and secondary controllers, PC workstation(s)and networks.

L. Provide a separate dynamic display page of each HVAC (AHU, AC, chiller, cooling tower, fuel oil, etc.), electrical, and/or plumbing system connected to the BMS.

M. Provide a separate dynamic display page of each piece of terminal equipment (VAV box, fan coil unit, etc.) connected to the BMS.

N. Provide an additional (10) separate dynamic, graphic display pages at each workstation as required by the operating staff to further assist in daily system operations.

O. Graphics shall incorporate all system integration points communicated via hardware or software gateways and/or interfaces. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.

P. Each graphic shall have a “BACK” button and a “HOME” or “MAIN” button located in the same location on all graphics.

Q. The operator shall be able to clearly distinguish the difference between the following types of points on a graphic either by color, shape, icon or text lable:
   1. Real-time sensor reading
   2. Setpoint
   3. Manually set vs. program set Setpoint
   4. Real-time output reading
   5. Manually Overridden or commanded output vs program set output
   6. Status feedback from a piece of equipment vs the output command

R. When the operator selects a graphic from a menu or a hyperlink, the system shall also make the following adjustments for the operator:
   1. Highlight the system name on the system tree
   2. Highlight the controller name on the network tree
   3. Make appear links to additional information associated with the data on the graphic, such as:
      a. Adjustable modes of operation
      b. Setpoints
      c. Alarm statuses

d. Trend logs

4. Make appear links to additional information associated with the system on the graphic, such as:
   a. Controls as-built schematics and wiring diagrams
   b. As-built Sequence of Operation
   c. Mechanical drawings
   d. Electrical drawings

S. For control loops that have a 4-point setpoint reset schedule, the operator shall have access to adjust the 4 points in the graphics. Provide a separate graphic with the 4 adjustable data points and a line graph with labels vertices showing the scale of the reset ramp. Display the current calculated output setpoint.

T. Integration graphics shall be representative of personnel standing in front of equipment. The graphics for equipment specified in the Building Systems Integration paragraph shall be representative of the manufacturers' local display panel and each shall be completely operable from the computer workstation.

3.4 ELECTRICAL WIRING SCOPE

A. This contractor shall be responsible for power that is not shown on the electrical drawings, to controls furnished by this contractor. If power circuits are shown on the electrical drawings, this contractor shall continue the power run to the control device. If power circuits are not shown, this contractor shall coordinate with the electrical contractor to provide breakers at distribution panels for power to controls. This contractor is then responsible for power from the distribution panel.
   1. Coordinate panel locations. If enclosures for panels are shown on the electrical drawings, furnish the enclosures according to the electrician's installation schedule.

B. This contractor shall not be responsible for power to control panels and control devices that are furnished by others, unless it is part of the control interlock wiring.

C. Refer to Coordination section for what devices this contractor is responsible to mount and which are turned over to others to mount.

D. This contractor shall be responsible for wiring of any control device that is furnished as part of this section of specification.

E. Interlock wiring shall be run in separate conduits from BAS associated wiring.

F. Provide network wiring for equipment that is called to be integrated to the BAS.

3.5 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. All low voltage control wiring shall be class 2. Control wiring that is not class 2 shall be run in separate conduits from class 2 wiring.

B. Floor level network wiring between terminal units can be combined with thermostat and other low voltage wiring in the same conduit. All other network wiring shall be in dedicated conduits.

C. Install raceways, boxes, and cabinets according to Division 26 Section "Raceways and Boxes."

D. Install building wire and cable according to Division 26 Section "Conductors and Cables."

E. Installation shall meet the following requirements:
1. Conceal cable and conduit, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway or conduit.
3. Install concealed cable using plenum rated cable.
4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. All wiring in lab areas shall be in conduit.
8. All unsupported risers shall be rigid steel conduit. Supported risers shall be EMT.

F. Rigid conduit shall be steel, hot dip galvanized, threaded with couplings, ¾ inch minimum size, manufactured in accordance with ANSI C-80-1. Electrical metallic tubing (EMT) with compression fittings or intermediate metallic conduit (IMC) may be used as conduit or raceway where permitted by the NEC.

G. Concealed control conduit and wiring shall be provided in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90 degree angles.

H. Install conduit adjacent to machine to allow service and maintenance.

I. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

J. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

K. Ground equipment.

3.6 COMMUNICATION WIRING

A. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer’s installation recommendations for all communication cabling.

B. Do not install communication wiring in raceway and enclosures containing Class 1 wiring.

C. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

D. Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

E. Cable bundling:

1. RS485 cabling run open air in accessible areas can be bundled with other class 2 low voltage cabling.
2. RS485 cabling run between terminal units in conduits above ceilings or under floors or in inaccessible areas can be bundled with other class 2 low voltage cabling.
3. RS485 cabling run between floors shall be in a communication only conduit.
4. RS485 conduit run long distances between utility rooms or between buildings shall be in a communication only conduit.
5. Ethernet cabling shall be in a communication only conduit.
6. Ethernet and RS485 can be run together.
7. Fiber optics can be run with Ethernet and RS485 cabling as long as the conduit is bent to fiber optic standards and junction boxes are sized for fiber optic use.

F. RS485 Cabling
1. RS485 cabling shall be used for BACnet MS/TP networks.
2. RS485 shall use low capacitance, 20-24 gauge, twisted shielded pair.
3. The shields shall be tied together at each device.
4. The shield shall be grounded at one end only and capped at the other end.
5. Provide end of line (EOL) termination devices at each end of the RS485 network or subnetwork run, to match the impedance of the cable, 100 to 120ohm.

G. Ethernet Cabling
1. Ethernet shall not be run with any Class 1 or low voltage Class 2 wiring.
2. CAT6, unshielded twisted pair (UTP) cable shall be used for BAS Ethernet.
3. Solid wire shall be used for long runs, between mechanical rooms and between floors. Stranded cable can be used for patch cables and between panels in the same mechanical room up to 50 feet away.
4. When the BAS Ethernet connects to an Owner’s network switch, document the port number on the BAS As-builts.

H. Fiber-Optic Cabling
1. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer’s specifications.
2. All cabling and associated components shall be installed in accordance with manufacturers’ instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.
3. All terminations shall to be made into a patch panel, designed for such use. Free air terminations with patch panels are prohibited.

I. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to the manufacturer’s instructions.

J. All runs of communication wiring shall be unspliced length when that length is commercially available.

K. All communication wiring shall be labeled to indicate origination and destination data.

L. Grounding of coaxial cable shall be in accordance with NEC regulations article on “Communications Circuits, Cable, and Protector Grounding.”

3.7 IDENTIFICATION

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.
   1. Labels shall use white lettering (12-point type or larger) on a red background.
   2. Warning labels shall read as follows: C A U T I O N This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to “Off” position before servicing.

B. Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.
   1. Labels shall use white lettering (12-point type or larger) on a red background.
   2. Warning labels shall read as follows: C A U T I O N This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

C. Control Equipment and Device labeling:
   1. Labels and tags shall match the unique identifiers shown on the as-built drawings.
   2. All Enclosures shall be labeled to match the as-built drawing by either control panel name or the names of the DDC controllers inside.
   3. All sensors and actuators not in occupied areas shall be tagged.
   4. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMS flow coefficient.
   5. Duct static pressure taps shall be tagged at the location of the pressure tap.
   6. Each device inside enclosures shall be tagged.
   7. Terminal equipment need only have a tag for the unique terminal number, not for each device. Match the unique number on:
      a. First, the design drawings, or
      b. Second, the control as-builts, or
      c. Third, the DDC addressing scheme
   8. Tags on the terminal units shall be displayed on the Operator Workstation Graphics.

D. Tags shall be mechanically printed on permanent adhesivebacked labeling strips, 12 point height minimum.

E. Manufacturers’ nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

F. Identification of Wires
   1. Tag each wire with a common identifier on each end of the wire, such as in the control panel and at the device termination.
   2. Tag each network wire with a common identifier on each end.
   3. Tag each 120V power source with the panel and breaker number it is fed by.

G. Identification of Conduits:
   1. Identify the low voltage conduit runs as BAS conduit, power feeds not included.
   2. Identify each electric box, junction box, utility box and wiring tray with a blue paint mark or blue permanent adhesive sticker.
   3. For conduit runs that run more than 8 ft between junction boxes in 1 room, place a blue identifier at least every 8 feet.

4. Place a blue identifier on each side of where a conduit passed through a wall or other inaccessible path.
5. Identify all BAS communication conduits the same as above.

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
3. Calibration test controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

B. Engage a factory-authorized service representative to perform startup service.

C. Replace damaged or malfunctioning controls and equipment.
1. Start, test, and adjust control systems.
2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

3.9 SYSTEM CHECKOUT AND STARTUP

A. Inspect each termination in the MER control panels and devices to make sure all wires are connected according to the wiring diagrams and all termination are tight.

B. After the controls devices and panels are installed and power is available to the controls, perform a static checkout of all the points, including the following:
1. Inspect the setup and reading on each temperature sensor against a thermometer to verify its accuracy.
2. Inspect the setup and reading on each humidity sensor against a hygrometer to verify its accuracy.
3. Inspect the reading on each CO2 sensor using a calibration kit to verify the sensor range accuracy matches the DDC setup.
4. Inspect the reading of each status switch to verify the DDC reads the open and close correctly.
5. Command each relay to open and close to verify its operation.
6. Command each 2-position damper actuator to open and close to verify operation.
7. Command each 2-position valve to open and close to verify operation.
8. Ramp each modulating actuator to 0%, 25%, 50%, 75% and 100% to verify its operation.
9. Ramp each modulating output signal, such as a VFD speed, to verify its operation.
10. Test each safety device with a real life simulation, for instance check freezestats with ice water, water detectors with water, etc.

C. Document that each point was verified and operating correctly. Correct each failed point before proceeding to the dynamic startup.

D. Verify that each DDC controller communicates on its respective network correctly.

E. After all of the points are verified, and power is available to the mechanical system, coordinate a startup of each system with the mechanical contractor. Include the following tests:
1. Start systems from DDC.
2. Verify that each setpoint can be met by the system.
3. Change setpoints and verify system response.
4. Change sensor readings to verify system response.
5. Test safety shutdowns.
6. Verify time delays.
7. Verify mode changes.
8. Adjust filter switches and current switches for proper reactions.
9. Adjust proportional bands and integration times to stabilize control loops.

F. Perform all program changes and debugging of the system for a fully operational system.

G. Verify that all graphics at the operator workstations correspond to the systems as installed. Verify that the points on the screens appear and react properly. Verify that all adjustable setpoints and manual commands operate from the operator workstations.

H. After the sequence of operation is verified, setup the trends that are listed in the sequence of operations for logging and archiving for the commissioning procedure.

3.10 SYSTEM COMMISSIONING, DEMONSTRATION AND TURNOVER

A. The BAS Contractor shall prepare and submit for approval a complete acceptance test procedure including submittal data relevant to point index, functions, sequence, inter-locks, and associated parameters, and other pertinent information for the operating system. Prior to acceptance of the BAS by the Owner and Engineer, the BAS contractor shall completely test the BAS using the approved test procedure.

B. After the BAS contractor has completed the tests and certified the BAS is 100% complete, the Engineer shall be requested, in writing, to approve the satisfactory operation of the system, sub-systems and accessories. The BAS contractor shall submit Maintenance and Operating manuals at this time for approval. An acceptance test in the presence of the Engineer and Owner's representative shall be performed. The Owner will then shake down the system for a fixed period of time (30 days).

C. The BAS contractor shall fix punch list items within 30 days of acceptance.

D. When the system performance is deemed satisfactory in whole or in part by these observers, the system parts will be accepted for beneficial use and placed under warranty.

3.11 TRAINING

A. During System commissioning and at such time as acceptable performance of the Building Automation System hardware and software has been established, the BAS contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction during normal working hours shall be performed by a competent building automation contractor representative familiar with the Building Automation System's software, hardware and accessories.

B. At a time mutually agreed upon, during System commissioning as stated above, the BAS contractor shall give 16-hours of onsite training on the operation of all BAS equipment. Describe its intended use with respect to the programmed functions specified. Operator orientation of the automation system shall include, but not be limited to:
1. Explanation of drawings and operator's maintenance manuals.
2. Walk through of the job to locate all control components.
3. Operator workstation and peripherals.
4. DDC Controller and ASC operation/sequence.
5. Operator control functions including scheduling, alarming, and trending.
6. Explanation of adjustment, calibration and replacement procedures.

C. Additional 8-hours of training shall be given after the 30 day shakedown period.

D. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off site classroom facility and detail what is included in the manufacturer's standard pricing such as transportation, meals, etc.

PART 4 - SEQUENCE OF OPERATION

4.1 SEQUENCE SUMMARY

A. The BSL-2 laboratory HVAC system shall operate continuously unless specifically directed otherwise by the Owner. System operation shall prioritize:
1. Laboratory ventilation
2. Directional airflow / pressurization
3. Humidity control
4. Space temperature control
5. Energy optimization, only to the extent it does not compromise the above

4.2 MODE OF OPERATION

A. The system shall operate in the following modes:
1. Occupied / Normal Operating Mode
2. Unoccupied / Setback Mode
3. Emergency / Power Loss Recovery Mode
4. Smoke / Fire Alarm Shutdown Mode
5. Freeze Protection Mode
6. Failure / Degraded Redundancy Mode

4.3 VARIABLE AIR VOLUME AIR HANDLING UNIT

A. The variable volume air handling unit consists of a 100% outside air section with motorized dampers, pre-filter, emergency electric preheat coil, secondary electric preheat coil, redundant chilled water-cooling coils (N+1), UV light sections, fan array supply fans (4), and final filter. Unit fan array supply fans shall be arranged from the factory for service from four (4) variable frequency drives. The unit is DDC controlled using electronic actuation. The DOAS shall provide conditioned outdoor air for ventilation, space pressurization, and latent load control. The BAS shall continuously monitor unit operation and coordinate with associated exhaust systems, room pressure controls, terminal units, standby equipment, and emergency power as applicable.

B. Enable / Start Sequence
1. Upon BAS enable command for laboratory operation, the BAS shall:
a. Verify no active fire alarm shutdown is present.
b. Verify no manual lockout is active.
c. Open the outdoor air damper to operating position.
d. Start lead fan array members as required.
e. Prove fan operation.
f. Enable the lead chilled water pump/chiller sequence through the plant controls.
g. Enable electric preheat coil control.
h. Enable chilled water coil control.
i. Enable humidifier control when airflow is proven and humidity demand exists.
j. Enable supply airflow reset logic as required to support laboratory and terminal unit demand.
k. Enable exhaust fan sequence.
l. Enable room pressure control coordination.
2. The BAS shall not enable the humidifier unless:
a. Supply airflow is proven,
b. The fan array is operating,
c. High limit humidistat is normal,
d. The duct smoke detector is normal,
e. The humidifier safeties are normal.

C. Supply Fan Array Control
1. The DOAS supply fan section shall consist of a fan array arranged for N+1 redundancy.
2. The BAS shall:
a. Modulate operating fan speeds through VFD control to maintain the supply duct static pressure setpoint or supply airflow setpoint, as applicable.
3. Fan Failure Response
a. If any operating fan fails:
i. BAS shall alarm the failed fan.
ii. BAS shall remove the failed fan from service.
iii. Remaining operating fans shall modulate as required to maintain setpoint.
iv. BAS shall generate a degraded redundancy alarm.
v. Failure of one fan shall not shut the DOAS down provided remaining fans can satisfy required airflow.

D. Electric Preheat Coil Control
1. Two electric preheat coils shall be controlled in sequence to prevent low leaving air temperature and protect downstream chilled water coils from low-temperature conditions.
2. The BAS shall:
a. Energize preheat coil stages as required to maintain the preheat leaving air temperature setpoint (50°F adjustable) during low outdoor air temperature conditions.
b. Stage the electric preheat coils as required to achieve leaving air temperature setpoint.

c. Limit preheat output to the minimum required to maintain stable downstream conditions.
d. Preheat control shall be active whenever entering air temperature falls below the preheat enable setpoint (45°F adjustable).

3. Low Temperature Protection
   a. If low temperature is detected downstream of the preheat section before the cooling coil, the BAS shall energize preheat as required to achieve setpoint. If Temperatures are unable to be achieve with preheat at full capacity.
      i. BAS shall alarm low temperature condition.
      ii. If temperature continues to fall to freezestat trip point, BAS shall execute freeze protection shutdown sequence.

E. Chilled Water Coil Control
1. The DOAS shall include two chilled water cooling coils arranged as N+1 redundancy.
2. The BAS shall control the chilled water coils to maintain the active supply air temperature setpoint and/or dehumidification requirements.
3. Space humidity overrides control of chilled water control valve to maintain 55% (adjustable) relative humidity. When the space relative humidity exceeds 55%, the supply air temperature shall drop to 52F (adjustable) until the relative humidity is below set point.
   a. Control priority shall be:
      i. Supply air dew point / humidity control
      ii. Supply air dry-bulb temperature control
   b. The BAS shall:
      i. Enable lead chilled water coil first.
      ii. Modulate the lead coil control valve to maintain the discharge air temperature setpoint (54°F adjustable).
      iii. Enable the lag/standby chilled water coil when:
         1) the lead coil is unable to achieve the discharge temperature setpoint
         2) additional capacity is needed to maintain humidity or temperature setpoint,
         3) the lead coil is unavailable/faulted.
      iv. Rotate lead/lag coil assignment on adjustable schedule or runtime.
   c. Coil Failure Response
      i. Upon loss of one chilled water coil, valve actuator failure, low water flow indication, or otherwise confirmed loss of coil function:
         1) BAS shall alarm the failed coil.
         2) BAS shall isolate or disable the failed coil as applicable.
         3) BAS shall enable the standby coil.
         4) BAS shall continue operation in degraded mode.
         5) BAS shall issue an alarm that unit redundancy has been reduced.

F. Humidity Control / Humidifier Control
1. A duct-mounted electric steam generating humidifier shall be installed in the supply air duct and controlled by laboratory humidistat input.
2. The BAS shall enable humidification when:

a. Supply airflow is proven,
b. Supply fan array is operating,
c. Humidifier safeties are normal,
d. Lab humidistat indicates humidity below setpoint,
e. There is no high duct humidity shutdown,
f. There is no smoke shutdown.
g. The humidifier shall modulate to maintain the active laboratory relative humidity setpoint.
h. Where multiple lab humidistats are associated with one unit, the BAS shall enable the humidifier upon any of the humidistats indicating humidity below setpoint

3. A duct-mounted high limit humidistat shall disable humidification upon high duct humidity.
4. Upon humidifier shutdown, the BAS shall:
   a. Close humidifier control output,
   b. Maintain fan operation,
   c. Alarm humidifier fault if shutdown is due to safety trip.

G. Supply Airflow Control
1. The DOAS shall vary airflow to satisfy terminal unit demand while maintaining required minimum ventilation to all served BSL-2 spaces.
2. In labs and spaces requiring specific pressure relationships, the VAV boxes shall maintain a constant airflow rate to achieve required air change rates and constant offset from exhaust VAV to achieve required pressurization. Electric reheat shall energize in stages or modulate as required to maintain space temperature setpoint.
   a. If exhaust airflow increases, DOAS airflow shall increase as required to maintain room offsets and terminal performance.
3. In non-pressure dependent spaces, The VAV damper shall modulate to maintain room temperature until airflow reaches programmed minimum or maximum. Electric reheat shall energize in stages or modulate as required once the terminal airflow has reached minimum and space temperature remains below setpoint.
4. The BAS shall monitor:
   a. Room temperature
   b. Room temperature setpoint
   c. Terminal airflow
   d. Reheat status/output
   e. Terminal damper position
   f. Terminal alarm/fault condition

H. Safety:
1. Discharge high duct static cutout, fire alarm shutdown (provided by the FAS contractor) and supply fan array VFD fault alarms de-energize the supply fan upon activation. Dampers and valves modulate to their normal position after the fans are de-energized.
2. A low temperature detector before the cooling coil de-energizes the supply fan when temperatures below 38 degrees F (3 degrees C) are sensed. The cooling coil valves open and the motorized outside air damper closes.
3. Current switches are installed on the load side of each fan array fan. The DDC system uses the switches to confirm the fans are in the desired state (i.e. on or off) and generates an alarm if status deviates from DDC start/stop control. The DDC system generates a VFD trouble alarm independent from the fan status.
4. Prefilter and final filter differential pressure sensors shall the measure pressure

across each prefilter and final filter. When the differential pressure exceeds the filter rating for a dirty filter, an alarm in the BAS shall occur indicating a dirty filter.

4.4 LAB EXHAUST FAN SEQUENCE

A. Laboratory exhaust shall be provided by lead/lag VAV exhaust fans. Exhaust fans are induced flow high plume fan which contains multiple fan blowers with by-pass dampers. One (1) fan blower shall act as standby should one of the lead fan blowers fail.

B. The exhaust fans shall operate continuously whenever the laboratory HVAC system is enabled unless otherwise required by emergency shutdown sequence.

C. The BAS shall:
1. Start the lead exhaust fan upon DOAS enable.
2. Modulate lead exhaust fan speed to maintain the required exhaust static pressure setpoint as sensed at least two- thirds of the way downstream of the exhaust of the longest or most critical duct. Upon reaching the plume fans minimum speed (as determined by fan manufacturer), the fans by-pass dampers shall modulate open as not to over pressure the exhaust duct system while also maintain duct static pressure setpoint.
3. Coordinate exhaust airflow with room pressure control requirements.
4. Automatically rotate lead/lag fan status to equalize runtime. Selection of the lead fans is evaluated on a weekly basis. The fans with the least amount of runtime are the lead fans

D. Exhaust Fan Failure Response
1. If the lead exhaust fan fails:
a. BAS shall alarm the failure.
b. BAS shall automatically start the lag exhaust fan.
c. BAS shall transfer control to the lag fan without manual intervention.
d. BAS shall continue modulation to maintain required exhaust flow.
e. BAS shall issue degraded redundancy alarm.
2. If exhaust capacity cannot be maintained:
a. BAS shall alarm critical exhaust failure.
b. BAS shall command associated supply airflow reduction as required to preserve safe room pressure relationships and avoid overpressurization.

4.5 ROOM PRESSURE MONITORING SEQUENCE

A. Pressure monitors shall be located at the entrance to each laboratory and where indicated on the drawings.

B. Each pressure monitor shall continuously display and transmit room differential pressure status to the BAS.

C. The BAS shall:
1. Monitor pressure status for each lab.
2. Alarm loss of required directional airflow when room pressure is no longer negative to adjacent spaces for an adjustable time delay.
3. Provide local annunciation at the pressure monitor and remote BAS alarm.
4. Trend room pressure for each lab.

4.6 CHILLED WATER PLANT SEQUENCE

A. The chilled water system shall consist of:
   1. Two air cooled chillers arranged N+1
   2. Three variable primary chilled water pumps arranged N+1

B. The chilled water plant shall operate in a lead/lag configuration and shall automatically respond to load and equipment failure.

C. Pump Sequence
   1. Upon call for cooling from the DOAS:
      a. BAS shall start the two lead chilled water pumps.
      b. Prove pump status.
      c. Enable the lead chiller.
      d. Maintain chilled water flow through active cooling coil(s).
      e. Additional pump(s) shall start when:
         i. required by plant design,
         ii. lead pump fails,
         iii. minimum flow cannot be maintained,
      f. Pump lead/lag assignment shall alternate to equalize equipment runtime; Selection of the lead pump is evaluated on a weekly basis. The pumps with the least amount of runtime are the lead pumps.

D. Pump Failure Response
   1. If an operating pump fails:
      a. BAS shall alarm the failed pump.
      b. BAS shall start the next available standby pump.
      c. BAS shall continue operation in degraded mode.
      d. BAS shall issue N+1 redundancy alarm.

E. Chiller Sequence
   1. The BAS shall enable the lead chiller upon cooling demand from the DOAS.
   2. The chilled water supply temperature setpoint is set to the chiller plant design temperature and can be manually adjusted by the operator.
   3. After any chiller(s) are commanded, the program waits 15 minutes before issuing any other commands.
   4. The chiller stop sequence first stops the chiller. After a delay, the associated chilled water pumps are stopped.
   5. The chilled water system continues to operate until either the chiller water system enable point is off or cooling is no longer required. When the chilled water system shuts down, all operating chillers and pumps go through a chiller stop sequence.
   6. The DDC system uses current switches to confirm the pumps are in a state (i.e., on or off) and generates an alarm if status deviates from DDC start/stop control.
   7. The lag chiller shall start when:
      a. lead chiller cannot maintain chilled water supply temperature for an adjustable amount of time
      b. lead chiller fails
      c. load exceeds the capacity of one chiller

8. Chiller lead/lag assignment shall rotate to equalize equipment runtime; Selection of the lead chiller is evaluated on a weekly basis. The chiller with the least amount of runtime is the lead chiller.

F. Chiller Failure Response
1. If the operating chiller fails:
a. BAS shall alarm the failed chiller.
b. BAS shall start the standby chiller.
c. BAS shall continue plant operation to maintain chilled water supply.
d. BAS shall issue degraded redundancy alarm.
e. The plant shall automatically restart after power restoration if cooling demand still exists.

G. Chilled Water By-Pass – The chilled water by-pass shall consist of an interconnecting pipe between the chilled water supply and return piing., an electronically actuated modulating 2-way chilled water control valve in this interconnecting piping and chilled water flow measuring flow meter placed in the return chilled water piping. The chilled water flow meter shall measure GPM provided by the chilled water system and shall verify the minimum flow rate is acceptable when one chiller is operating. This minimum flow value shall be determined by the chiller manufacturer and programmed into the BMS. As the VFD on the primary pump controls reduces speed due to reduced cooling loads on zones and the chilled water flow rate approaches the minimum evaporator flow rate of one chiller, the 2-way modulating valve shall open and allow chilled water supply to bypass the building circulation loop. The modulating 2-way valve shall increase its open position until minimum flow rate determined by the BMS is satisfied.

4.7 FREEZER ROOM OXYGEN MONITOR

A. The oxygen monitor in the freezer room shall be monitored by the BAS.

B. The BAS shall:
1. Annunciate normal, low oxygen alarm, sensor fault, and trouble status.
2. Generate local and BAS alarm upon low oxygen condition.

4.8 MECHANICAL ROOM LEAK DETECTION

A. The mechanical room leak detection system shall be monitored by the BAS.

B. Upon leak detection alarm:
1. BAS shall generate immediate alarm.
2. BAS shall identify the affected zone or sensor where available.
3. BAS shall trend event time and status.
4. BAS shall notify operators through BAS alarm routing.

4.9 SAFETIES

A. Fire Alarm / Smoke Shutdown
1. Upon receipt of smoke shutdown command, duct smoke detector trip, or fire alarm shutdown signal affecting the system:
a. DOAS supply fan array shall shut down.

b. Humidifier shall shut down.
c. Outdoor air damper shall close.
d. Chilled water valves shall close.
e. Electric preheat coils shall de-energize unless required for protection sequence.
f. Exhaust fan response shall be as required by the life safety sequence of operation.
g. BAS shall alarm the shutdown condition.

B. Freeze Protection Sequence

1. If low temperature is detected that threatens coil freezing or unsafe low leaving temperature:
   a. BAS shall energize preheat coil capacity as required.
   b. BAS shall alarm low temperature warning.
2. If low temperature continues to fall to the critical protection threshold:
   a. BAS shall shut down supply fan array
   b. close outdoor air dampers,
   c. open chilled water valve to full position.
   d. de-energize humidifier,
   e. maintain preheat as required for protection,
   f. alarm freeze protection trip.
3. If ambient air temperature drops below 32°F and the chilled water system is not in operation due to no cooling needs, the BAS shall:
   a. Open the chilled water bypass valve and both chiller isolation valves
   b. Energize two lead chilled water pumps
   c. Set pump speed for all three pumps to 50% (adjustable) to maintain continuous flow through the chilled water system.
   d. Lead/lag the pumps on a daily basis while this sequence is maintained

C. Power Loss / Restart Sequence

1. Upon loss of power:
   a. All controlled equipment shall stop unless served by emergency/standby power.
   b. BAS shall retain mode and alarm history where possible.
2. Upon restoration of power:
   a. BAS shall restart the chilled water plant as required by demand and equipment availability.
   b. BAS shall restart DOAS supply fan array.
   c. BAS shall restart exhaust fans.
   d. BAS shall restore terminal unit control.
   e. BAS shall restore humidifier control when safeties are normal.
   f. BAS shall restore normal room pressure control sequence.
   g. BAS shall generate a power restoration event log.
3. All systems shall automatically restart without manual intervention unless prevented by a manual-reset safety or fire alarm lockout.

PART 5 - POINT LIST:

5.1 VAV AIR HANDLING UNIT (AHU-1)

A. DO FAN START/STOP (FOR EACH INDIVIDUAL FAN)
B. DI FAN STATUS (FOR EACH INDIVIDUAL FAN)
C. AO VFD SPEED (FOR EACH INDIVIDUAL FAN)
D. DI VFD FAULT INDICATION (FOR EACH INDIVIDUAL FAN)
E. AI DUCT STATIC PRESSURE
F. AI SPACE HUMIDITY
G. AI SUPPLY AIR TEMP
H. AI OUTSIDE AIR TEMP
I. AO OUTSIDE AIR DAMPER
J. AO CHILLED WATER COIL 1 CONTROL VALVE
K. AO CHILLED WATER COIL 2 CONTROL VALVE
L. AI PREHEAT SUPPLY AIR TEMP
M. AO EMERGENCY PRE-HEAT OUTPUT
N. AO SECONDARY PRE-HEAT OUTPUT
O. DI PRE-FILTER DIFF PRESSURE
P. DI FINAL FILTER DIFF PRESSURE
Q. DI HIGH STATIC LIMIT
R. DI LOW TEMP LIMIT
S. DI CONDENSATE OVERFLOW
T. DI DUCT SMOKE DETECTORS
U. ALARMS:
 1. SUPPLY FAN FAILURE, EACH FAN
 2. FAN ARRAY OPERATING IN DEGRADED MODE
 3. HIGH DUCT STATIC PRESSURE
 4. DIRTY FILTER
 5. CHILLED WATER COIL FAILURE
 6. LOW SUPPLY AIR TEMPERATURE
 7. HIGH SUPPLY AIR TEMPERATURE
 8. SMOKE SHUTDOWN
 9. FREEZE PROTECTION ACTIVE/TRIP

** BACNET INTERFACE INTEGRATION WITH VFD's

5.2 SUPPLY VAV BOXES

A. AI SPACE TEMP
B. AO SPACE TEMP SETPOINT
C. AO ELECTRIC REHEAT CONTROL
D. AI DISCHARGE AIR TEMP
E. AO SUPPLY CFM
F. AI VALVE POSITION
G. ALARMS:
 1. VAV COMMUNICATION FAILURE
 2. ELECTRIC REHEAT FAULT
 3. SPACE TEMPERATURE OUT OF RANGE
 4. TERMINAL AIRFLOW OUT OF RANGE

5.3 DUCT-MOUNTED ELECTRIC STEAM HUMIDIFIER

A. AI SPACE HUMIDITY
B. DO HUMIDIFIER START/STOP
C. DI HUMIDIFIER STATUS

D. ALARMS:
1. DUCT HIGH HUMIDITY SAFETY TRIP

5.4 LAB EXHAUST FANS
A. DO FAN START/STOP
B. DI FAN STATUS
C. AO FAN VFD SPEED
D. AI DUCT STATIC PRESS
E. AO FAN BYPASS DAMPER
F. ALARMS:
1. LEAD EXHAUST FAN FAILURE
2. LAG EXHAUST FAN FAILURE
3. LOW EXHAUST AIRFLOW
4. EXHAUST SYSTEM DEGRADED MODE
** BACNET INTERFACE INTEGRATION WITH VFD's

5.5 EXHAUST VAV BOXES
A. AO EXHAUST CFM
B. AI VALVE POSITION
C. ALARMS:
1. VAV COMMUNICATION FAILURE
2. TERMINAL AIRFLOW OUT OF RANGE

5.6 CHILLERS
A. DO CHILLER START/STOP
B. DI CHILLER STATUS
C. AI CHILLED WATER SUPPLY TEMP
D. AI CHILLED WATER RETURN TEMP
E. AO CHILLED WATER MINIMUM FLOW BYPASS VALVE
F. AI CHILLED WATER FLOW METER
G. AI EVAPORATOR DIFF PRESSURE
H. ALARMS:
1. CHILLER FAILURE
2. PLANT DEGRADED REDUNDANCY
3. CHILLED WATER SUPPLY TEMPERATURE OUT OF RANGE
** BACNET INTERFACE INTEGRATION WITH CHILLERS

5.7 PRIMARY CHILLED WATER PUMPS
A. DO PUMP START/STOP
B. DI PUMP STATUS
C. AO PUMP VFD SPEED
D. AI PRIMARY CHILLED WATER DIFF PRESSURE
E. ALARMS:
1. PUMP FAILURE
2. PLANT DEGRADED REDUNDANCY
** BACNET INTERFACE INTEGRATION WITH VFD'S

5.8 GENERAL
A. AI PRESSURE MONITORS AT ENTRANCE TO EACH LABORATORY
B. DI FREEZER ROOM OXYGEN MONITOR
C. DI MECHANICAL ROOM WATER LEAK DETECTION SYSTEM
D. DI EMERGENCY POWER STATUS

E. ALARMS:
1. LAB ROOM PRESSURE ALARM, EACH LAB
2. FREEZER ROOM LOW OXYGEN ALARM
3. O2 MONITOR FAULT
4. MECHANICAL ROOM LEAK DETECTION ALARM

END OF SECTION 23 09 00

SECTION 231321
HYDRONIC PIPING

STATE OF LOUISIANA
R. CRAIG CAMPBELL, II
License No. 29380
3/10/26
PROFESSIONAL ENGINEER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. This Section includes piping systems for the chilled water system. Piping materials and equipment specified in this Section include:
1. Pipes, fittings, and specialties;
2. Special duty valves;
3. Hydronic specialties.

1.3 SYSTEM DESCRIPTION

A. General: The hydronic piping systems are the "water-side" of an air-and-water or all-water heating and air conditioning system. Hydronic piping system as specified in this Section include 4-pipe, chilled water and heating water piping system.

1.4 SUBMITTALS

A. Product Data, including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties and accessories, and installation instructions for each hydronic specialty and special duty valve specified.
1. Furnish flow and pressure drop curves for diverting fittings and calibrated plug valves, based on manufacturer's testing.

B. Maintenance Data for hydronic specialties and special duty valves, for inclusion in operating and maintenance manual specified in Division 01 and Division-23 "Basic Mechanical Requirement."

C. Welders' certificates certifying that welders comply meet the quality requirements specified in Quality Assurance below.

D. Certification of compliance with ASTM and ANSI manufacturing requirements for pipe, fittings, and specialties.

E. Reports specified in Part 3 of this Section.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the provisions of the following:
1. ASME B 31.9 "Building Services Piping" for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.

2. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 01.
3. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators.
4. IMC International Mechanical Code.
5. IBC International Building Code.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate the installation of pipe sleeves for foundation wall penetrations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering hydronic piping system products which may be incorporated in the work include, but are not limited to, the following:

B. Manufacturer: Subject to compliance with requirements, provide hydronic piping system products from one of the following:
1. Calibrated Plug Valves:
   a. Bell & Gossett ITT; Fluid Handling Div.
   b. Taco, Inc.
2. Air Vents (manual and automatic):
   a. Armstrong Machine Works
   b. Bell & Gossett ITT; Fluid Handling Div.
   c. Hoffman Specialty ITT; Fluid Handling Div.
   d. Spirax Sarco
3. Dielectric Unions:
   a. Perfection Corp.
   b. Watts Regulator Co.

2.2 PIPE AND TUBING MATERIALS

A. PIPING APPLICATIONS
1. Chilled water piping aboveground, NPS 2 and smaller, shall be any of the following:
   a. Type L, ASTM B88, hard drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
   b. Schedule 40, ASTM A20 seamless black steel pipe; Class 125, cast-iron fittings; malleable screw fittings; and threaded joints.
2. Chilled water piping aboveground, NPS 2-1/2 and larger, shall be any of the following:
   a. Schedule 40 ASTM A120 seamless black steel pipe, wrought-steel fittings or forged-steel flanges and flange fittings, and welded and flanged joints.
   b. Makeup-water piping installed aboveground shall be the following:
   c. Type L, ASTM B88, hard drawn-temper copper tubing, wrought-copper fittings, and soldered joints

3. Chilled Water Piping (below grade/slab):
    a. Shall be ductile iron pipe with factory-applied, 40 mils coal-tar free abrasion resistant ceramapure epoxy interior lining; ceramapure also applied to bells and pipe ends (including field cuts); ANSI/AWWA C150, C151, AWWA 210; asphalt or fusion bonded epoxy exterior coating. AWWA C105 8-mil polyethylene encasement. Piping shall be manufacturer prepared prior to lining/coating in accordance with lining manufacturer recommendation.
    b. All fitting shall be ductile iron ANSI/AWWA C110/A21.10; minimum pressure class 350; with factory applied, 40-mils coal-tar free abrasion resistant ceramapure epoxy interior lining. ANSI/AWWA C150, C151, AWWA 210; asphalt or fusion bonded epoxy exterior coating. AWWA C105 8-mil polyethylene encasement. Piping shall be manufacturer prepared prior to lining/coating in accordance with lining manufacturer recommendation.
    c. All pipe joints shall be AWWA/ANSI C111/A21.11 compression gasketed joints or AWWA/ANSI C110/A21.10 Type MJ mechanical joint. Where restraint is required, provide corrosion resistant epoxy coated ductile iron wedge action gland restraint except that restraining gasket my be used in place of wedge action gland restraint where each piping joint is fully extended to engage the thrust restraint, and following manufacturer requirements.
    d. All underground piping and fittings shall be bedded in a 6” layer of sand surrounding piping on all sides, The minimum depth of horizontal piping below grade shall be 5 feet to the top of pipe.
4. Air-Vent Piping:
    a. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
    b. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

2.3 FITTINGS

A. Cast-Iron Threaded Fittings: ANSI B16.4, Class 125, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

B. Malleable-Iron Threaded Fittings: ANSI B16.3, Class 150, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

C. Steel Fittings: ASTM A 234, seamless or welded, for welded joints.

D. Cast-Iron Threaded Flanges: ANSI B16.1, Class 125; raised ground face, bolt holes spot faced.

E. Steel Flanges and Flanged Fittings: ANSI B16.5, including bolts, nuts, and gaskets of the following material group, end connection and facing:
1. Material Group: 1.1.
2. End Connections: Butt Welding.
3. Facings: Raised face.

F. Unions: ANSI B16.39 malleable-iron, Class 150, hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; female threaded ends. Threads shall conform to ANSI B1.20.1.

G. Dielectric Unions: Threaded or soldered end connections for the pipe materials in which installed; constructed to isolate dissimilar metals, prevent galvanic action, and prevent corrosion.

H. Flexible Connectors: Stainless steel bellows with woven flexible bronze wire reinforcing protective jacket; minimum 150 psig working pressure, maximum 250 deg F operating temperature. Connectors shall have flanged or threaded end connections to match equipment connected; and shall be capable of 3/4 - inch misalignment.

2.4 JOINING MATERIALS

A. Solder Filler Metals: ASTM B 32, 95-5 Tin-Antimony, for heating hot water.
   1. Warning: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes. Provide adequate ventilation.

B. Welding Materials: Comply, with Section II, Part C. ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.

C. Gasket Material: Thickness, material, and type suitable for fluid to be handled, and design temperatures and pressures.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Division 23 Section "HVAC Valves."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Identify piping as specified in 23 Section "Mechanical Identification."

3.3 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23 Section "HVAC Hangers and Supports" Comply with the following requirements for maximum spacing of supports.

B. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for steel piping and copper tubing with the following maximum spacing and minimum rod sizes as per section 305.4 of the 2009 IMC (or latest revision).

3.4 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.

3.6 EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gauges"

3.7 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

   1. Leave joints, including welds, uninsulated and exposed for examination during test.
   2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:
1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, i.e. chillers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 231321

SECTION 232100
HYDRONIC PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Provide pumps and required system trim for heating, and chilled water, water systems including all related appurtenances for a complete and operating systems.

1.2 SECTION INCLUDES

A. End Suction, Base Mounted Pump

1.3 RELATED SECTIONS

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

1.4 REFERENCES

A. HI - Hydraulic Institute.
B. ANSI - American National Standards Institute.
C. OSHA - Occupational Safety & Health Administration.
D. ASHRAE – American Society of Heating, Refrigeration and Air-Conditioning Engineers.
E. NEMA - National Electrical Manufacturers Association.
F. UL - Underwriters Laboratories.
G. ETL - Electrical Testing Laboratories.
H. CSA - Canadian Standards Association.
I. NEC - National Electric Codes.
J. ISO - International Standards Organization.
K. IEC - International Electrotechnical Commission.
L. ASME – American Society of Mechanical Engineers.
M. NIH DRM – Nation Institutes of Health Design Requirements Manual

1.5 SUBMITTAL

A. Submit each item in this article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Submit manufacturer’s installation instructions under provisions of General Conditions and Division 1.
   1. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts lists.
   2. Under provisions of commissioning documentation, testing of pumps, as well as training of owner’s operation and maintenance personnel may be required in cooperation with the commissioning consultant.

C. Product Data including certified performance curves and rated capacities of selected model, weights (shipping, installed, and operating), furnished specialties, and accessories. Indicate pump’s operating point on curves.

D. Complete Package information Product Data including:
   1. System summary sheet (where applicable)
   2. Sequence of Operation
   3. Shop drawing indicating dimensions, required clearances and location and size of each field connection
   4. Power and control wiring diagram
   5. System profile analysis including pump curves, system curve, and variable speed pump curves (where applicable)
   6. Pump data sheets - Rated capacities of selected models and indication of pump’s operating point on curves.
   7. Submittals on furnished specialties and accessories
   8. Submittals must be specific to this project. Generic submittals will not be accepted

E. Hanging and support requirements should follow the recommendations in the manufacturer’s installation instructions.

1.6 QUALITY ASSURANCE

A. All equipment or components of this specification section shall meet or exceed the requirements and quality of the items herein specified, or as denoted on the drawings.

B. Ensure pump operation at specified system fluid temperatures without vapor binding and cavitation, is non-overloading in parallel or individual operation, and operates to ANSI/HI 9.6.3.1 standard for Preferred Operating Region (POR) unless otherwise approved by the engineer.

C. Ensure pump pressure ratings are at least equal to system’s maximum operating pressure at point where installed but not less than specified.

D. Equipment provider shall be responsible for providing certified equipment start-up and, when noted, an in the field certified training session. New pump start-up shall be for the purpose of determining pump alignment, lubrication, voltage, and amperage readings. All proper electrical connections, pump’s balance, discharge and suction gauge readings, and adjustment of head, if required. A copy of the start-up report shall be made and sent to both the contractor and to the Engineer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the site in such a matter as to protect the materials from shipping and handling damage. Provide materials on factory provided shipping skids and lifting lugs if required for handling. Materials damaged by the elements should be packaged in such a matter that they could withstand short-term exposure to the elements during transportation.

B. Store materials in clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage.

C. Use all means necessary to protect equipment before, during, and after installation.

D. All scratched, dented, and otherwise damaged units shall be repaired or replaced as directed by the Architect Engineer.

1.8 WARRANTY:

A. Provide a minimum One (1) year warranty on materials and installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Contractor shall furnish and install new base mounted end suction pumps for chilled water system as indicated on the drawings. Pumps shall be as manufactured by Bell & Gossett, Armstrong or Taco. Pumps shall meet types, sizes, capacities, and characteristics as scheduled on the Equipment Schedule drawings.

2.2 BASE MOUNTED END SUCTION PUMPS

A. The pumps shall be base mounted, single stage, end suction, vertical split case design, in cast iron stainless steel fitted, specifically designed for quiet operation. Suitable standard operations at 225°F and 175 PSIG working pressure. Working pressures shall not be de-rated at temperatures up to 250F. The pump internals shall be capable of being serviced without disturbing piping connections, electrical motor connections or pump to motor alignment.
B. The pumps shall be composed of three separable components a motor, bearing assembly, and pump end (wet end). The motor shaft shall be connected to the pump shaft via a replaceable flexible coupling.
C. A bearing assembly shall support the shaft via two heavy-duty regreaseable ball bearings. Bearing assembly shall be replaceable without disturbing the system piping and shall have foot support at the coupling end. Pump bearings shall be regreaseable without removal of the bearings from the bearing assembly. Thermal expansion of the shaft toward the impeller shall be prevented via an inboard thrust bearing.
D. The bearing assembly shall have a solid SAE1144 steel shaft. A stainless steel shaft sleeve shall be employed to completely cover the wetted area under the seal.
E. Pump shall be equipped with an internally-flushed mechanical seal assembly installed in an enlarged tapered seal chamber. Application of an internally flushed mechanical seal shall be adequate for seal flushing without requiring external flushing lines. Seal assembly shall have Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.
F. Bearing assembly shaft shall connect to a bronze or stainless steel impeller. Impeller shall be both hydraulically and dynamically balanced to ANSI/HI 9.6.4-2009, balance grade G6.3 and secured by a stainless steel locking cap screw or nut.
G. Pump should be designed to allow for true back pull-out allowing access to the pump's working components, without disturbing motor or piping, for ease of maintenance.
H. A center drop-out type coupling, capable of absorbing torsional vibration, shall be employed between the pump and motor. Pumps for variable speed application shall be provided with a suitable coupling sleeve. Coupling shall allow for removal of pump's wetted end without disturbing pump volute or movement of the pump's motor and electrical connections. On variable speed applications the coupling sleeve should be constructed of a neoprene material to maximize performance life.
I. An ANSI and OSHA rated coupling guard shall shield the coupling during operation. Coupling guard shall be dual rated ANSI B15.1 and OSHA 1910.219 compliant coupling guard and contain viewing windows for inspection of the coupling. No more than .25 inches of either rotating assembly shall be visible beyond the coupling guard.

J. Pump volute shall be of a cast iron design with integrally cast pedestal volute support, rated for 175 PSIG with integral cast iron flanges drilled for 125# ANSI companion flanges. Volute shall include gauge ports at nozzles, and vent and drain ports.
K. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Pump and motors shall be factory aligned, and shall be realigned after installation. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications and conform to standards outlined in EISA 2007.
L. Base plate shall be of structural steel or fabricated steel channel configuration fully enclosed at sides and ends, with securely welded cross members and fully open grouting area (for field grouting). The minimum base plate stiffness shall conform to ANSI/HI 1.3.8.2.1-2009 for grouted Horizontal Baseplate Design standards.
M. Pump shall be of a maintainable design and, for ease of maintenance, should use machine fit parts and not press fit components.
N. The pump(s) vibration limits shall conform to Hydraulic Institute ANSI/HI 9.6.4-2009 for recommended acceptable unfiltered field vibration limits (as measured per ANSI/HI 9.6.4-2009 Figure 9.6.4.2.3.1) for pumps with rolling contact bearings.
O. Pump manufacturer shall be ISO-9001 certified.
P. Each pump shall be hydrostatically tested 1.5 times the maximum rated working pressure and name-plated before shipment.
Q. Pump shall conform to ANSI/HI 9.6.3.1-2012 standard for Preferred Operating Region (POR) unless otherwise approved by the engineer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All components shall be installed in accordance with manufacturer's installation instructions.
B. Reduction from line size to pump connection size shall be made with eccentric reducers attached to the pump with tops flat to allow continuity of flow.
C. Furnish and install triple duty valves on the discharge side of all pumps and furnish and install a line size shut-off valve on the suction side of all pumps. Provide on the inlet side of each pump a suction diffuser which shall be used to provide appropriate flow distribution into the eye of the pump's impeller.
D. Provide temperature and pressure gauges where and as detailed.
E. On systems where pump seals require flushing water or cooling water for a heat exchanger kit, provide cooling water supply piping and connections as well as the return piping, if required. Piping should be of adequate size to pass required flow rate.
F. Proper access space around a device should be left for servicing the component. No less than the minimum recommended by the manufacturer.
G. Provide an adequate number of isolation valves for service and maintenance of the system and its components.
H. Circulating pump shall have sufficient capacity to circulate the scheduled GPM against the scheduled external head (feet) with the horsepower and speed as scheduled and/or as denoted on the drawings. Motors shall be of electrical characteristics as scheduled, denoted and/or as indicated on the electrical plans and specifications. Pump characteristics shall be such that the head of the pump under varying conditions shall not exceed the rated horsepower of the drive motor.

I. On systems where the final balancing procedure requires the triple duty valve to be throttled more than 25% to attain design flow (on a constant speed pumping system), and no future capacity has been built into the pump, the pump impeller must be trimmed to represent actual system head resistance. The pump provider and engineer of record, based on the balancing contractor's reports, shall determine the final impeller trim diameter.

J. Install base mounted pumps on vibration isolation pad or house keeping pad, via anchor bolts. Set and level and grout in place.

K. All piping shall be brought to equipment and pump connections in such a manner so as to prevent the possibility of any loads or stresses being applied to the connections or piping. All piping shall be fitted to the pumps even though piping adjustments may be required after the pipe is installed.

L. On components that require draining, contractor must provide piping to and discharging into appropriate drains.

M. Provide drains for bases and seals, piped to and discharging into floor drains.

N. Power wiring, as required, shall be the responsibility of the electrical contractor. All wiring shall be performed per manufacturer's instruction and applicable state, federal, and local codes.

O. Control wiring for remote mounted switches and sensor / transmitters shall be the responsibility of the control's contractor. All wiring shall be performed per manufacturer's instructions and applicable state, federal, and local codes.

END OF SECTION 232100

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SECTION 232513
CHEMICAL WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes water-treatment systems for the following:
   1. Chilled-water system.

1.3 SYSTEM DESCRIPTION

A. Closed Systems: One bypass feeder for each system, with isolating and drain valves installed around balancing valve downstream of circulating pumps, unless otherwise indicated.

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data for each type of product specified. Include manufacturer's technical product data, rated capacities of selected equipment clearly indicated, water-pressure drops, weights (shipping, installed, and operating), furnished specialties, accessories, and installation and startup instructions.

C. Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

D. Wiring diagrams detailing power and control wiring and differentiating clearly between manufacturer-installed wiring and field-installed wiring.

E. Field test reports indicating and interpreting test results relative to compliance with specified requirements.

F. Maintenance data for chemical water treatment to include in the operation and maintenance manual specified in Division 1. Include detailed manufacturer's instructions and parts list for each item of equipment, control, and accessory. Include troubleshooting maintenance guide.

1.5 QUALITY ASSURANCE

A. Qualifications: A recognized chemical water treatment Testing Agency in the Project's vicinity and that is or employs an experienced consultant, available at reasonable times during the course of the Work to consult with Contractor, Architect, and Owner about water treatment.

B. Chemical Standards: Meet state and local pollution-control regulations.

C. Comply with NFPA 70 for components and installation.

D. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

E. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

F. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

1.6 MAINTENANCE

A. Service Period: Provide a service program for period of one year from startup date of equipment, including the following:
   1. Initial water analysis and recommendations.
   2. Startup assistance.
   3. Training of operating personnel.
   4. Periodic field service and consultation.
   5. Customer report charts and log sheets.
   6. Laboratory technical assistance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Chemical Water Treatment Products:
         i. Southwest Engineers, Inc.
         ii. ANCO, Inc.
         iii. Betz/Dearborn Inc.
         iv. NALCO, Inc.

2.2 CHEMICAL WATER TREATMENT SYSTEM

A. Bypass (Pot) Feeders: Cast iron or steel, for introducing chemicals into system; with funnel, shutoff valve on top, air release valve on top, drain valve on bottom, and recirculating shutoff valves on sides.

B. Working Pressure: 175 psi.

2.3 CHEMICALS

A. The Contractor will furnish chemicals recommended by water treatment system manufacturer for treating water to meet specified water quality. Only chemicals that are compatible with piping materials, seals, and accessories will be used.

B. System Cleaner: Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.

C. Closed System (Water) Chemicals: Sequestering agent to reduce deposits and adjust pH, corrosion inhibitors, and conductivity enhancers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install treatment equipment level and plumb, according to manufacturer's written instructions, rough-in drawings, the original design, and referenced standards.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. The Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

B. Install piping adjacent to equipment to allow servicing and maintenance.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: A qualified independent testing agency employed and paid by Contractor will perform field quality-control testing.
   1. Testing Agency: Provide the services of a qualified independent testing agency to perform field quality-control testing.

3.4 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris; repair damaged finishes, including chips, scratches, and abrasions.

B. Ensure that system is operational, filled, started, and vented prior to cleaning. Place terminal control valves in OPEN position during cleaning.

C. Add cleaning chemicals as recommended by manufacturer.

D. Circulate for 48 hours, then drain. Refill with clean water, circulate for 24 hours, then drain. Refill with clean water and repeat until system cleaner is removed.

3.5 COMMISSIONING

A. Startup Services: Provide the services of a factory-authorized service representative to provide startup service and to demonstrate and train Owner's maintenance personnel as specified below.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel for a minimum period of four (4) hours on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

B. Review data in the operation and maintenance manuals. Refer to Division 1 Section "Contract Closeout."

C. Schedule training with Owner, through the Architect, with at least 7 days' advance notice.

END OF SECTION 232513

SECTION 233113
METAL DUCTS

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. Section Includes:
1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible "SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical System

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.4 SUBMITTALS

A. Product Data: For each type of the following products:
1. Adhesives.
2. Sealants and gaskets.

B. Shop Drawings:
1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.

6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Delegated-Design Submittal:
1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

D. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including but are not limited to the following:
    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.
    g. F/A devices, wi-fi antennas, etc.

E. Welding certificates.

F. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.

B. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. All Lab exhaust ductwork shall be constructed of fully welded minimum 18-gauge 316L stainless steel. No exceptions. Welding requirements shall comply with SMACNA "Industrial Duct Construction Standards"

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2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Lindab Inc.
      b. McGill AirFlow, LLC.
      c. SEMCO Incorporated.
      d. Sheet Metal Connectors, Inc.
      e. Eastern Sheet Metal, Inc.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
   2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G60.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized. (Paint Grip)

C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Rolled Mastic Sealant
   1. Pressure-Sensitive rolled mastic sealant comprised of a foil facer with butyl adhesive
   2. Rolled Mastic Sealant: 2-inch minimum width.
   3. Rolled Mastic Sealant: 17-mil thickness; minimum
   4. Water Resistant
   5. Mold and Mildew Resistant
   6. Maximum Pressure Class: 16-inch W.C., positive/negative
   7. Service: Indoor and Outdoor
   8. Service Temperature: Minus 20 F to 200 F
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum

10. VOC: 0 g/l, EPA Standard Method 24
11. UL 181B-FX

C. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 16-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
10. Ul-181 Listed
11. UL 2818, Green Guard Compliance

D. Solvent-Based Joint and Seam Sealant:
1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Maximum Static-Pressure Class: 16-inch wg, positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
13. UL-181 Listed

E. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
3. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
4. Unconditioned Space, Exhaust Ducts: Seal Class C.
5. Unconditioned Space, Return-Air Ducts: Seal Class B.
6. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
7. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
8. Conditioned Space, Exhaust Ducts: Seal Class B.
9. Conditioned Space, Return-Air Ducts: Seal Class C.

C. Seal all duct penetrations through interior and exterior building walls per Joint Sealants Specification for a complete penetration seal to the satisfaction of engineer.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."

B. Building Attachments: Concrete inserts or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
   1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
   2. Test the following systems:
      a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
      b. Supply Ducts with a Pressure Class of 3-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
      c. Return Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
      d. Exhaust Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.

e. Outdoor Air Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.
1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:
1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:
1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers

and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:
1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within new duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.9 START UP

A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing."

3.10 DUCT SCHEDULE

A. Supply Ducts:

1. Ducts Connected Downstream of Terminal Units or Lab Air Control Valves:
   a. Pressure Class: Positive 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 12.
   d. SMACNA Leakage Class for Round and Flat Oval: 12
2. Ducts Connected to Variable-Air-Volume Air-Handling Units and Inlets of Terminal Units and Lab Air Control Valves
   a. Pressure Class: Positive 6-inch wg
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 3.
   d. SMACNA Leakage Class for Round and Flat Oval: 3
3. Ducts Connected to Equipment Not Listed Above:
   a. Pressure Class: Positive 2-inch wg.
   b. Minimum SMACNA Seal Class: A
   c. SMACNA Leakage Class for Rectangular: 3.
   d. SMACNA Leakage Class for Round and Flat Oval: 3.

B. Return Ducts:
- 1. Ducts Connected to Air-Handling Units
  - a. Pressure Class: Positive or negative 4-inch wg.
  - b. Minimum SMACNA Seal Class: A
  - c. SMACNA Leakage Class for Rectangular: 6
  - d. SMACNA Leakage Class for Round and Flat Oval: 6
- 2. Ducts Connected to Equipment Not Listed Above:
  - a. Pressure Class: Positive or negative 2-inch wg>.
  - b. Minimum SMACNA Seal Class: A.
  - c. SMACNA Leakage Class for Rectangular: 3.
  - d. SMACNA Leakage Class for Round and Flat Oval: 3.

C. Exhaust Ducts:
- 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
  - a. Pressure Class: Negative 1-inch wg.
  - b. Minimum SMACNA Seal Class: A
  - c. SMACNA Leakage Class for Rectangular: 12
  - d. SMACNA Leakage Class for Round and Flat Oval: 6.
- 2. Ducts Connected to Lab Exhaust Fans:
  - a. Pressure Class: Negative 6-inch wg.
  - b. Minimum SMACNA Seal Class: A
  - c. SMACNA Leakage Class for Rectangular: 3.
  - d. SMACNA Leakage Class for Round and Flat Oval: 3.

D. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
- 1. Ducts Connected to Air-Handling Units:
  - a. Pressure Class: Positive or negative 2-inch wg.
  - b. Minimum SMACNA Seal Class: A.
  - c. SMACNA Leakage Class for Rectangular: 6
  - d. SMACNA Leakage Class for Round and Flat Oval: 6.
- 2. Ducts Connected to Equipment Not Listed Above:
  - a. Pressure Class: Positive or negative 2-inch wg.
  - b. Minimum SMACNA Seal Class: A
  - c. SMACNA Leakage Class for Rectangular: 6.
  - d. SMACNA Leakage Class for Round and Flat Oval: 6

E. Intermediate Reinforcement:
- 1. Galvanized-Steel Ducts: Galvanized stee

F. Elbow Configuration:
- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
  - a. Velocity 700 fpm or Lower:
    - i. Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
    - ii. Mitered Type RE 4 without vanes.
  - b. Velocity 700 to 1500 fpm:
    - i. Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
    - ii. Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
    - iii. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:
   i. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   ii. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   iii. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      i. Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      ii. Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      iii. Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      iv. Radius-to Diameter Ratio: 1.5.
   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

G. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300
DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. This Section includes the following:
1. Manual volume control dampers
2. Motorized Dampers.
3. Spin Collars.
4. Turning vanes.
5. Duct-mounted access doors and panels.
6. Flexible connectors.
7. Flexible ducts.
8. Accessories hardware.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.

B. Product data including details for materials, dimensions of individual components, profiles, and finishes for the following items:
1. Manual volume control dampers.
2. Duct-mounted access panels and doors.
3. Flexible ducts.

C. Shop drawings from manufacturer detailing assemblies. Include dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Detail the following:
1. Special fittings, volume control damper installation (both manual and automatic), and transformers details.
2. Fire and smoke damper installations, including sleeves and duct-mounted access door and panel installations.

D. Product Certification: Submit certified test data on dynamic insertion loss; self-noise power levels; and airflow performance data, static pressure loss, and dimensions and weights.

1.4 QUALITY ASSURANCE

A. NFPA Compliance: Comply with the following NFPA Standards:
1. NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

2. NFPA 90B, "Standard for the Installation of Warm Air Heating and Air Conditioning Systems."

1.5 EXTRA MATERIALS

A. Furnish extra materials matching products installed as described below, packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Owner.
   1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MANUAL VOLUME CONTROL DAMPERS

A. General: Provide factory-fabricated volume-control dampers, complete with required hardware and accessories. Stiffen damper blades to provide stability under operating conditions. Provide locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class. Provide end bearings or other seals for ducts with pressure classifications of 3 inches or higher. Extend axles full length of damper blades. Provide bearings at both ends of operating shaft.

B. Standard Volume Control Dampers: Multiple or single-blade, parallel or opposed-blade design as indicated, standard-leakage rating, with linkage outside of air stream, and suitable for horizontal or vertical applications. Greenheck MDB-15, Ruskin MD-15, Pottorff CD-10 & MD-41, or approved equal.

2.2 MOTORIZED DAMPERS

A. Mechanical Contractor shall furnish and install ultra low leakage motorized dampers as indicated on mechanical and architectural drawings. Damper shall be opposed blade motorized type equivalent to Greenheck Model VCD-23, Ruskin CD36/OB, Pottorff CD-41, or equal. Motorized dampers shall be operated by electronic actuator, coordinate requirements with BAS system contractor. Damper shall be complete with outboard support bearing, blade, and jamb seals. Dampers shall be ultra low - leakage type. Dampers shall go to closed position when units are off unless otherwise noted.

2.3 SPIN COLLARS

A. All round take-offs to round branch duct shall be made with 26-gauge spin-type collars with 26-gauge balancing dampers. These spin-collars shall be as manufactured by Flexmaster Model FLD, Dace MSD, or approved equivalent.

B. The mounting groove shall be die-formed to assure constant fit control. Balancing dampers shall be factory-installed with spring loaded, retractable bearings and a positive locking wing-nut for easy adjustment.

2.4 TURNING VANES

A. Fabricate turning vanes according to SMACNA HVAC Duct Construction Standards, Figures 2-2 through 2-7.

B. Manufactured Turning Vanes: Fabricate of 1-1/2-inch-wide, curved blades set at 3/4 inch) on center, support with bars perpendicular to blades set at 2 inches on center, and set into side strips suitable for mounting in ducts.

C. Acoustic Turning Vanes: Fabricate of airfoil-shaped aluminum extrusions with perforated faces and fiber glass fill.

2.5 DUCT-MOUNTED ACCESS DOORS AND PANELS

A. General: Provide construction and airtightness suitable for duct pressure class.

B. Frame: Galvanized sheet steel. Provide with bend-over tabs and foam gaskets.

C. Door: Double-wall, galvanized sheet metal construction with insulation fill and thickness, number of hinges and locks as indicated for duct pressure class. Provide vision panel where indicated. Provide 1-inch by 1-inch butt hinge or piano hinge and cam latches.

D. Seal around frame attachment to duct and door to frame with neoprene or foam rubber seals.

E. Insulation: 1-inch- thick fiber glass or polystyrene foam board.

F. Access doors shall be Ruskin Model ADH-22, Kees ADH, Pottorff HAD, or approved equal.

2.6 FLEXIBLE CONNECTORS

A. General: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL Standard 181, Class 1.

B. Standard Metal-Edged Connectors: Factory-fabricated with a strip of fabric 3-1/2 inches wide attached to 2 strips of 2-3/4-inch-wide, 24-gage, galvanized sheet steel or 0.032-inch (0.8-mm) aluminum sheets. Select metal compatible with connected duct system. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA HVAC Duct Standard, 1st Edition, Figure 2-19.

2.7 FLEXIBLE DUCTS

A. General: Comply with UL 181, Class 1.

B. Flexible Ducts – Insulated (2.33”, R-6): Factory-fabricated, insulated, round duct, with an outer aluminum jacket, glass fiber insulation around a continuous inner liner.
1. Reinforcement: Steel-wire helix encapsulated in the inner liner.
2. Outer Jacket: Glass-reinforced, silver mylar with a continuous hanging tab, integral fiber glass tape, and nylon hanging cord.
3. Outer Jacket: Polyethylene film.
4. Inner Liner: Polyethylene film for low pressure, woven glass fiber for high pressure.
5. Low pressure duct rated at 6" static pressure.
6. Manufacturer: Thermaflex or approved equivalent.

2.8 ACCESSORIES HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket and a flat mounting gasket. Size to allow insertion of pilot tube and other testing instruments and provide in length to suit duct insulation thickness.

B. Splitter Damper Accessories: Zinc-plated damper blade bracket, 1/4-inch, zinc-plated operating rod, and a duct-mounted, ball-joint bracket with flat rubber gasket and square-head set screw.

C. Flexible Duct Clamps: Stainless steel band with cadmium-plated hex screw to tighten band with a worm-gear action. Provide in sizes from 3 to 18 inches to suit duct size.

D. Adhesives: High strength, quick setting, neoprene based, waterproof and resistant to gasoline and grease.

E. Provide all necessary transformers, electrical components suitable for each system installation including duct damper controllers, fire dampers and smoke dampers.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of duct accessories. Do not proceed with installation until unsatisfactory conditions are corrected.

3.2 INSTALLATION

A. Install duct accessories according to manufacturer's installation instructions and applicable portions of details of construction as shown in SMACNA standards.

B. Install volume control dampers in lined duct with methods to avoid damage to liner and to avoid erosion of duct liner.

C. Provide test holes at fan inlet and outlet and elsewhere as indicated.

D. Label access doors according to Division 23 for "Mechanical Identification."

3.3 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Final positioning of manual dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing."

END OF SECTION 233300

SECTION 233423
HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Ceiling-mounted fans.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
2. Rated capacities, operating characteristics, and furnished specialties and accessories.
3. Certified fan performance curves with system operating conditions indicated.
4. Certified fan sound-power ratings.
5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
6. Material thickness and finishes, including color charts.
7. Dampers, including housings, linkages, and operators.
8. Prefabricated roof curbs.
9. Fan speed controllers.

B. Shop Drawings:
1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC power ventilators to include in normal and emergency operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
1. LOREN COOK
2. GREENHECK.
3. ACME

2.2 CEILING-MOUNTED FANS

A. Housing: Steel, lined with acoustical insulation.

B. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel removable for service.

C. Back-draft damper: Integral.

D. Grille: Painted aluminum, louvered grille with flange on intake and thumbscrew or spring retainer attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Accessories:
1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Isolation: Rubber-in-shear vibration isolators.

PART 3 - EXECUTION

3.1 INSTALLATION OF HVAC POWER VENTILATORS

A. Install power ventilators level and plumb.

B. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

C. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops having a static deflection of 1 inch.

D. Install units with clearances for service and maintenance.

E. Label units with engraved aluminum nameplate. Nameplate shall include the make, model, date of installation, design CFM and static pressure.

3.2 DUCTWORK CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.

3.3 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

3.5 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

C. Replace fan and motor pulleys as required to achieve design airflow.

D. Lubricate bearings.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain ventilator fans.

END OF SECTION 233423

SECTION 233500
LAB EXHAUST FANS

PART 1 - GENERAL

1.1 References:

A. Fans must be tested in accordance with AMCA 210 and 300 in an AMCA accredited laboratory certified for air and sound performance.

B. Fans shall be UL and CUL listed per UL 705 safety standard.

C. Fans shall meet the criteria of NFPA-45.

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

1.2 Acceptable Manufacturers

A. Strobic Air Corporation
B. Twin City
C. Loren Cook
D. Prior Approved Equals

1.3 Submittals:

A. Submit shop drawings and product data sheets including performance data, fan performance curves, vibration levels, maintenance requirements and sound power levels.

B. Fan manufacturer shall furnish a certificate of guarantee stating that the fan, mixing plenum, outlet nozzle, acoustical silencer nozzle, stack extension if any, and all related accessories specified herein have been pre-tested at the factory and that the curves supplied have been de-rated for any and all system effects created by the accessories.

1.4 Warranty

A. Fan manufacturer shall provide a min. 3 year parts warranty from date of project substantial completion to include fan, motor and drive mechanisms including pillow blocks, sheaves, shafts, couplings and belts. This warranty shall be held solely by the fan manufacturer. All warranty claims, as defined above, shall be the sole responsibility of the fan manufacturer.

PART 2 - PRODUCTS

2.1 MIXED-FLOW INDUCED DILUTION FANS:

1. Impellers shall be mounted directly to the motor shaft to provide Arrangement 4 Direct Drive. Motors shall be isolated from the primary exhaust air stream. Motor maintenance shall be limited to greasing and accessible from the fan exterior. Models that are not Arrangement #4 will be rejected.
2. Mixed flow impellers shall consist of combination axial/backward curved blades and shall be of welded steel construction unless scheduled AMCA B. The impellers shall have non-stall and non-overloading performance characteristics with aerodynamically stable operation at any point on the fan curves.

3. Fan Performance shall be as stated on the schedule. The Static Pressure stated on the schedule shall be at the inlet to the “Fan System” and does not include any losses of equipment provided by the fan manufacturer (ie: HRU, Filters, Silencers, etc…). All losses for the equipment provided by the fan manufacturer shall be detailed in the fan manufacturers technical proposal and or submittal.
4. Fan and all drive components, including motors, shall have a combined bearing life of a minimum of L10 = 150,000 hours. Belt driven fans that derate the motor bearing life to L10 = 50,000 hours are not acceptable.
5. Maintenance shall only be required on a minimum of 18-month intervals. This maintenance shall be limited to re-greasing of the motor bearings.
6. Stationary discharge guide vane sections shall be provided to increase fan efficiencies.
7. Fan dynamic balance shall not exceed 0.5 mil, peak-to-peak for nominal 900RPM, 1200RPM, and 1800RPM fans, or 0.055 in/sec -peak for 1800 RPM, 0.035 in/sec — peak for 1200 RPM, and 0.030 in/sec-peak for 900 RPM fans measured at the blade pass area when operating at fan frequency. Vibration isolation shall be limited to rubber-in-shear pad type isolators unless otherwise specified.
8. Factory test reports detailing vibration levels at the blade pass area shall be provided. Vibration levels shall be reported in both the axial and radial direction. If fan vibration is greater than 0.5 mils peak-to-peak at the blade pass area, fan manufacturer shall be responsible for providing vibration isolators on each fan and flexible connection at each duct inlet. Manufacturer shall add 0.5" additional static pressure to the fan system to compensate for losses through the flexible connection. Vibration isolators, 2” deflection seismic rated spring, must be installed on each individual fan with a minimum of four per fan. In addition, fan manufacturer shall be responsible for providing a method to repair or replace flexible connection or vibration isolators without shut down of the fan system. This includes any engineering, additional ductwork, and isolation dampers required to perform repairs while the system is still fully operational. Fan manufacturer shall also provide labor to change out or repair flexible connection and vibration isolators for a seven (7) year period from shipment.
9. Belt drive fans will not be acceptable.
10. Standard fan assemblies (4 feet or lesser above standard height) shall be designed for mounting on conventional roof curb without the need for guy wire supports.
11. Discharges shall include twin FRP nozzles with passive third central stacks that are capable of generating aspiration. The FRP shall be chemically and UV resistant.
12. Entrainment windbands shall provide secondary induction of outside air. Induction shall take place downstream of the fan impeller and shall not influence BHP or static pressure requirements. Windbands shall discharge up to 270% of the design flow rates. The manufacturer shall publish discharge volumes for all fans at specified primary exhaust flow.
13. Fan shall be constructed to AMCA “C” standards per AMCA 99 with a non-ferrous inlet bell provided in order to reduce sparking in the event of a motor bearing failure.
14. Fans shall be modular construction and capable of being assembled on the roof.
15. Chemical resistant gaskets shall be provided at all companion flanged joints.
16. Fasteners shall be 316 stainless steel.
17. A bolted access door shall be provided for impeller inspection on each fan.
18. Fans and accessories shall have internal drain systems to prevent rainwater from entering building duct system.
19. Electric motors shall be TEFC Mill & Chemical duty with a 1.15 service factor and an L10 bearing life of 150,000 hours. Premium Efficient motors shall have

regreasable bearings with grease relief fittings in every NEMA frame. Fan motors shall be C-Face and foot mounted. For motors driven by VFD's shaft grounding kits shall be installed on motor below 400 frames and insulated bearings on motors frames 400 and above.

20. Extended motor lube lines of Teflon tubing covered with braided stainless steel shall be provided. Extended lube lines shall be mounted to a bracket located on the fan housing with grease relief fittings on each line.
21. A NEMA 4x non-fused rotary disconnect switch shall be provided, mounted and wired to the motor.
22. All steel and aluminum surfaces components must be coated with a high solids epoxy with low VOC chemical resistant barrier coating epoxy. The coating system, a total thickness of up to 12 mils, is not affected by the UV component of sunlight (does not chalk), and has superior corrosion resistance to acid, alkali, and solvents. Coating system shall exceed 7000 hour ASTM B117 Salt Spray Resistance. Standard finish color to be gray. All coatings that include a zinc-rich epoxy primer are strictly prohibited. Zinc coatings react with alkalis and acids, thus causing premature failure of the coating system and should never be used for laboratory applications.
23. The fan supplied must meet the system exhaust CFM and the motor BHP shall not be larger than that shown on the fan schedule.
24. Fan and Mixing Box systems supplied by the manufacturer must have a footprint as shown on the drawings / schedule. Exhaust systems with larger footprints shall not be acceptable.
25. The static pressure shown on the schedule is based on the static pressure requirements at the inlet to the mixing box. Any system deviating from the basis of design shall include and detail in their proposal additional losses for flexible connectors, fan losses, elbows, mixing box, etc. that are not included in their fan curves.

2.2 ACCESSORIES

A. Inlet mixing plenums shall be provided by the fan manufacturer. Each plenum shall be sized to support the weight and performance requirement of the number of fans listed on the schedule. For single-thickness plenums, coatings shall be the same as specified for the fans. All plenums shall be capable of supporting the fan(s) without guy wires or supports. The plenums shall include hinged access doors. The primary air inlets shall be located on the bottom or side as noted on construction drawings. Unless otherwise specified, plenums shall be suitable for mounting on roof curbs. Safety screens shall be supplied over inlet of fan.

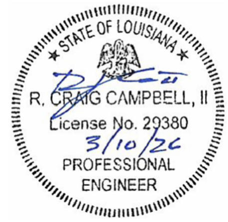
B. Bypass dampers shall be provided with all mixing plenums for outside air with primary exhaust. Bypass damper(s) shall be sized to bypass the airflow capacity of one fan at the required static pressure of the system. Dampers will be opposed blade low leakage air foil control dampers with extended shaft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

C. Low leakage isolation dampers shall be constructed of aluminum air foil extrusions and epoxy coated. Operators shall be 2 position, shall have On-off electronic or spring return damper actuators that are direct coupled type which require no crank arm and linkage and be capable of direct mounting to a jackshaft. Isolation damper actuators shall be warrantied under the original part manufacturer’s warranty term.

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

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

END OF SECTION 233500



SECTION 233600
AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. Extent of air terminals work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of air terminals specified in this section include the following:

1. Single Duct (Cooling Only)
2. Single Duct Reheat

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of air terminals with characteristics, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards: As follows:
1. Air Diffusion Council (ADC) Compliance: Provide air terminals which have been tested and rated in accordance with ADC standards, and bear ADC Seal.
2. American Refrigeration Institute (ARI) Compliance: Provide air terminals which have been tested and rated in accordance with ARI 880-94 "Industry Standard for Air Terminals" and bear ARI certification seal.
3. National Fire Protection Association (NFPA) Compliance: Construct air terminals using acoustical and thermal insulations complying with NFPA 90A "Air Conditioning and Ventilating Systems".
4. Sheet Metal & Air Conditioning Contractor's National Association, Inc. (SMACNA) Compliance: HVAC Duct Construction Standards - Metal and Flexible, Second Edition - 1995 with addendums or latest edition.

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including performance data for each size and type of air terminal furnished; schedule showing drawing designation, room location, number furnished, model number, size, and accessories furnished; and installation and start-up instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams: Submit ladder-type wiring diagrams for electric power and control components, clearly indicating required field electrical connections.

D. Maintenance Data: Submit maintenance data and parts list for each type of air terminal; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and maintenance data in maintenance manual; in accordance with requirements of Division 1.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver air terminals wrapped in factory-fabricated fiberboard type containers. Identify on outside of container type of air terminal and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in boxes.

B. Store air terminals in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

C. Air terminal(s) shall be stored and handled per manufacturer’s recommendations.

1. Deliver air terminals from the factory properly secured, crated, and protected with factory plastic shrink wrap or other protective wrap.
2. Lift and support air terminals with the manufacturer's designated lifting or supporting points.
3. Disassemble and reassemble air terminals as required for movement into the final location following manufacturer's written instructions.
4. Deliver air terminals as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.
5. Store air terminals to prevent damage to terminals. Store units out of the elements and maintain factory protective covering until ready for installation.

D. Lift and support air terminal(s) with the manufacturer's designated lifting or supporting points.

E. Disassemble and reassemble air terminal(s) as required for movement into the final location following manufacturer's written instructions.

F. Deliver air terminal unit(s) as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, provide variable air volume air terminals from one of the following:

1. Trane
2. Titus Products Div.; Philips Industries, Inc.
3. Metalaire
4. Kreuger

2.2 SINGLE DUCT (COOLING ONLY)

A. General: Provide factory-fabricated, perforated double-wall, pressure independent, VAV air terminals as indicated on plan sheets.

1. Select unit with performance characteristics which match or exceed those indicated on schedule.
2. Insulation shall be sandwiched between galvanized casing panels.
3. Air terminals shall be certified under the American Refrigeration Institute (ARI) Standard 880-94 certification program or latest edition, and shall carry the ARI seal.

B. Casings: Construct of die-cast aluminum or sheet metal of the following minimum thicknesses:

	Steel	Aluminum
Upstream Pressure Side:	22-ga	0.018 inch
Downstream Pressure Side:	22-ga	0.018 inch

1. Provide steel control enclosure housing all primary flow controls including actuators, controllers, relays, etc.
2. Provide hanger brackets for attachment of supports.
3. Linings: Line inside surfaces of casings with lining material to provide acoustic performance, thermal insulation, and to prevent condensation on outside surfaces of casing.
   a. Provide minimum thickness of 1 inch, 4.0 pcf density fiberglass insulation with an R-value of 3.5 or greater.
   b. Secure lining to prevent de-lamination, sagging, or settling.
   c. Liner shall meet NFPA 90A and UL 181 requirements.
   d. Liner shall meet bacteriological requirements of ASTM C665.
   e. Cover liner surfaces and edges with perforated metal of formed “Z” strips which enclose and seal all edges. Tape and adhesives shall not be permitted.
4. Access: Provide removable panels in casings to permit access to air dampers and other parts requiring service, adjusting, or maintenance.
   a. Provide airtight gasket and quarter-turn latches.
5. Sensor:
   a. Multi-ported of the automatic averaging type and arranged to sense velocity in each of four quadrants of the inlet. Cross type sensors utilizing single point static pressure (low side) sensing are not approved.
   b. Accuracy of the sensor shall be +/-5%.
   c. Ports shall extend through damper tube for connections to piping. Units with internal piping connections shall not be allowed.
   d. A minimum length of straight duct equal to three (3) times the inlet duct diameter shall be installed ahead of the air terminal.
6. Leakage Requirements:
   a. Casings: Construct casings such that when subjected to 2 inch w.g. pressure for low pressure units, and 3.0 inches w.g. pressure for high pressure units, total leakage does not exceed 1% of specified air flow capacity with outlets sealed and inlets wide open.
   b. Dampers: Construct air dampers such that when subjected to 4.0 inches w.g. inlet pressure with damper closed, total leakage shall not exceed 2% of specified air flow capacity.

7. Multiple Duct Connectors: For air terminals serving more than one air outlet, provide lined outlet plenum with duct collar, butterfly-type damper, and locking device in each outlet.

C. Air Dampers: Construct of materials that cannot corrode, do not require lubrication, nor require periodic servicing.

1. Dampers shall be constructed of a single round or elliptical blade composite.
2. Steel damper blade shall be mechanically attached to the shaft with either threaded fasteners, or welded. Rivets shall not be acceptable.
3. Damper shafts shall be continuous, singular axle across the full inlet diameter, and extending through the terminal casing.
4. The damper shall have a tear resistant neoprene lip seal around its perimeter to form a tight air seal for full shut-off.
5. The damper shafts shall rotate in self-lubricating bearings.
6. Provide pressure independent volume dampers that are calibrated in cfm, factory-adjusted, and marked for specified air capacities.
7. Provide mechanism to vary air volume thru damper for minimum to maximum, in response from signal from thermostat or temperature sensor/controller. The primary damper fail positions shall be easily re-configured in the field.
8. Damper shall have a seal capable of providing full shutoff against four inches (4") w.c. with leakage less than two percent (2%) of the nominal rating of the VAV box.
9. The terminal units are to be provided with an external damper position indicator embossed on the end of the damper shaft for visual indication of the damper position.

D. Controls: VAV box manufacturer to install, mount, and calibrate VAV DDC controllers provided by BAS Contractor.

1. Provide electronic controls, compatible with DDC temperature control system specified in Division 23, Section 230900 – “Building Automation System”.
2. Provide and install a 208 volt to 24-volt (coordinate and verify exact requirements with BAS Contractor) control transformer at each VAV terminal sized appropriately to handle the anticipated power requirements and consumption of each of the Terminal Equipment Controllers (TEC) and Operators.
3. Mount and carry the cost to mount the TEC, damper actuator, control transformer, and air velocity sensor at each terminal.
4. Provide and mount an averaging air velocity sensor suitable for interfacing with the TEC flow transducer.

E. Identification: Provide label on each unit indicating Plan Number, cfm range, cfm factory-setting, and calibration curve (if required). Refer to Section 230620 – “Mechanical Identification” for full requirements.

2.3 SINGLE DUCT W/ REHEAT

A. General: Provide factory-fabricated, perforated double-wall, pressure independent, VAV air terminals as indicated on plan sheets.

1. Select unit with performance characteristics which match or exceed those indicated on schedule.
2. Insulation shall be sandwiched between galvanized casing panels.

3. Air terminals shall be certified under the American Refrigeration Institute (ARI) Standard 880-94 certification program or latest edition, and shall carry the ARI seal.

B. Casings: Construct of die-cast aluminum or sheet metal of the following minimum thicknesses:

	Steel	Aluminum
Upstream Pressure Side:	22-ga	0.018 inch
Downstream Pressure Side:	22-ga	0.018 inch

1. Provide steel control enclosure housing all primary flow controls including actuators, controllers, relays, etc.
2. Provide hanger brackets for attachment of supports.
3. Linings: Line inside surfaces of casings with lining material to provide acoustic performance, thermal insulation, and to prevent condensation on outside surfaces of casing.
    a. Provide minimum thickness of 1 inch, 4.0 pcf density fiberglass insulation with an R-value of 3.5 or greater.
    b. Secure lining to prevent de-lamination, sagging, or settling.
    c. Liner shall meet NFPA 90A and UL 181 requirements.
    d. Liner shall meet bacteriological requirements of ASTM C665.
    e. Cover liner surfaces and edges with perforated metal of formed “Z” strips which enclose and seal all edges. Tape and adhesives shall not be permitted.
4. Access: Provide removable panels in casings to permit access to air dampers and other parts requiring service, adjusting, or maintenance.
    a. Provide airtight gasket and quarter-turn latches.
5. Sensor:
    a. Multi-ported of the automatic averaging type and arranged to sense velocity in each of four quadrants of the inlet. Cross type sensors utilizing single point static pressure (low side) sensing are not approved.
    b. Accuracy of the sensor shall be +/-5%.
    c. Ports shall extend through damper tube for connections to piping. Units with internal piping connections shall not be allowed.
    d. A minimum length of straight duct equal to three (3) times the inlet duct diameter shall be installed ahead of the air terminal.
6. Leakage Requirements:
    a. Casings: Construct casings such that when subjected to 2 inch w.g. pressure for low pressure units, and 3.0 inches w.g. pressure for high pressure units, total leakage does not exceed 1% of specified air flow capacity with outlets sealed and inlets wide open.
    b. Dampers: Construct air dampers such that when subjected to 4.0 inches w.g. inlet pressure with damper closed, total leakage shall not exceed 2% of specified air flow capacity.
7. Multiple Duct Connectors: For air terminals serving more than one air outlet, provide lined outlet plenum with duct collar, butterfly-type damper, and locking device in each outlet.

C. Air Dampers: Construct of materials that cannot corrode, do not require lubrication, nor require periodic servicing.

1. Dampers shall be constructed of a single round or elliptical blade composite.
2. Steel damper blade shall be mechanically attached to the shaft with either threaded fasteners, or welded. Rivets shall not be acceptable.

3. Damper shafts shall be continuous, singular axle across the full inlet diameter, and extending through the terminal casing.
4. The damper shall have a tear resistant neoprene lip seal around its perimeter to form a tight air seal for full shut-off.
5. The damper shafts shall rotate in self-lubricating bearings.
6. Provide pressure independent volume dampers that are calibrated in cfm, factory-adjusted, and marked for specified air capacities.
7. Provide mechanism to vary air volume thru damper for minimum to maximum, in response from signal from thermostat or temperature sensor/controller. The primary damper fail positions shall be easily re-configured in the field.
8. Damper shall have a seal capable of providing full shutoff against four inches (4") w.c. with leakage less than two percent (2%) of the nominal rating of the VAV box.
9. The terminal units are to be provided with an external damper position indicator embossed on the end of the damper shaft for visual indication of the damper position.

D. Electric Coils

1. Each unit terminal shall be provided with an electric reheat coil sized to supply the BTU's scheduled on the drawings with SCR Controller and controls shall be interconnected by controls contractor.

E. Controls: VAV box manufacturer to install, mount, and calibrate VAV DDC controllers provided by BAS Contractor.

1. Provide electronic controls, compatible with DDC temperature control system specified in Division 23, Section 230900 – “Building Automation System”.
2. Provide and install a 208 volt to 24-volt (coordinate and verify exact requirements with BAS Contractor) control transformer at each VAV terminal sized appropriately to handle the anticipated power requirements and consumption of each of the Terminal Equipment Controllers (TEC) and Operators.
3. Mount and carry the cost to mount the TEC, damper actuator, control transformer, and air velocity sensor at each terminal.
4. Provide and mount an averaging air velocity sensor suitable for interfacing with the TEC flow transducer.

F. Identification: Provide label on each unit indicating Plan Number, cfm range, cfm factory-setting, and calibration curve (if required). Refer to Section 230620 – “Mechanical Identification” for full requirements.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which air terminals are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF AIR TERMINALS

A. General: Install air terminals as indicated, and in accordance with manufacturer's installation instructions.

1. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.
2. Duct Connections: Connect ductwork to air terminals in accordance with Division-23 ductwork sections.

3.3 FIELD QUALITY CONTROL

A. Upon completion of installation and prior to initial operation, test and demonstrate that air terminals, and duct connections to air terminals, are leak-tight.

B. Repair or replace air terminals and duct connections as required to eliminate leaks, and retest to demonstrate compliance.

3.4 CLEANING

A. Clean exposed factory-finished surfaces. Repair any marred or scratched surfaces with manufacturers touch-up paint.

3.5 DEMONSTRATION & TESTING

A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner's maintenance personnel on the following:

1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals.
3. Provide Service Manuals for each air terminal specified.

B. Provide three (3) hours of factory authorized training.

1. Schedule training with at least seven (7) days’ notice.
2. Refer to Section 230010 – “Mechanical General Provisions” for videotaping requirements.

END OF SECTION 23 36 00

STATE OF LOUISIANA
R. CRAIG CAMPBELL, II
License No. 29380
3/10/26
PROFESSIONAL
ENGINEER

SECTION 233713
DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 SCOPE OF WORK

A. Section Includes:
1. Rectangular and square ceiling diffusers.
2. Louver face diffusers.
3. Registers and grilles

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include the following:
1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.
   a. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
i. METALAIRE, Inc.
ii. Price Industries.
iii. Titus.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Aluminum.
4. Finish: White baked enamel, unless noted otherwise.
5. Face Size: See Plans.
6. Face Style: Three cone.
7. Mounting: Surface T-bar
8. Pattern: Fixed
9. Dampers: Radial opposed blade.

B. Louver Face Diffuser
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
i. METALAIRE, Inc.
ii. Price Industries.
iii. Titus.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Aluminum.
4. Finish: Custom color selected by Architect.
5. Face Size: See Plans.
6. Mounting: Surface
7. Pattern: Four-way core style.
8. Dampers: Radial opposed blade.
9. Accessories:
a. Square to round neck adaptor.
b. Adjustable pattern vanes.
c. Throw reducing vanes.

C. Laminar Flow Diffuser
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
i. METALAIRE, Inc.
ii. Price Industries.
iii. Titus.
2. Material: Aluminum.
3. Finish: Custom color selected by Architect.
4. Diffusers shall be constructed using a maximum 6 inches tall backpan designed for optimum performance with the diffuser. The backpan shall be divided into two chambers: upper and lower. The backpan shall have integral hanger tabs for securing the unit to the overhead structure. The upper velocity dampening chamber shall be separated from the lower air dampening chamber by a pressure induction

plate. All pattern controllers shall be internal to the unit and shall be located in the lower air dampening chamber.

5. The face of the diffuser shall be 51 percent free area perforated steel with 3/16-inch diameter holes on ¼-inch staggered centers and shall match the appearance of industry standard perforated diffusers. The face shall not hang below the ceiling more than 5/8 inches and shall have 6 clips securing it in place. Quarter-turn fasteners on the face are not acceptable. The face, lower air chamber, directional blades, and the pressure induction plate shall be one assembly that can be removed from the face of the unit for sanitizing in an autoclave. The face shall be provided with two retainer cables.
6. The backpan shall be manufactured of aluminum. The diffuser must be available for full radial air diffusion (two-way) and/or ½ radial air diffusion (one-way).
7. Performance
   a. NC values shall be published. Throw for terminal velocities of 100, 75 and 50 fpm shall be published along with corresponding pressure drop.
8. Performance tests shall have been conducted in ASHRAE Standards 70-91 and 113-90.

2.2 REGISTERS AND GRILLES

A. Return Air Grille:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
         i. METALAIRE, Inc.
         ii. Price Industries.
         iii. Titus.
   2. Material: Aluminum
   3. Finish: White baked enamel, unless noted otherwise.
   4. Core Construction: ½” cubed core
   5. Frame: 1 inch wide.
   6. Mounting: Countersunk screw or Lay-in
   7. Accessories:
      a. Opposed blade damper

B. Eggcrate Grille with Filter Frames:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
         i. Anemostat Products
         ii. Krueger
         iii. METALAIRE, Inc.
         iv. Nailor Industries Inc.
         v. Price Industries
         vi. Titus
   2. Material: Aluminum Grid and border with filter frame

3. Finish: White baked enamel, unless noted otherwise. Finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes.
4. Mounting: Countersunk screw
5. Return grilles must provide a free area of at least 90%.
6. Outer borders shall be constructed of heavy extruded aluminum with a thickness of 0.040-0.050 inch and shall have countersunk screw holes for a neat appearance.
7. Border width shall be 1¼ inches on all sides and shall be interlocked at the four corners and mechanically staked to form a rigid frame.
8. Aluminum grid shall be ½ x ½ x ½ inch. Grille shall be provided with a filter frame for a standard 1-inch filter to fit the specified duct size.
9. The manufacturer shall provide published performance data for the grille.
10. The grille shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

STATE OF LOUISIANA
R. CRAIG CAMPBELL, II
License No. 29380
3/10/26
PROFESSIONAL
ENGINEER

SECTION 236423
AIR COOLED CHILLERS

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Microprocessor controlled, air-cooled liquid chiller for outdoor installation, utilizing variable speed screw compressors and low sound variable speed fans.

1.2 QUALITY ASSURANCE

A. Unit shall be rated in accordance with AHRI (Air- Conditioning, Heating and Refrigeration Institute) Standard 550/590, latest edition (U.S.A.) and all units shall be ASHRAE (American Society of Heating, Refrigeration, and Air-Conditioning Engineers) 90.1 compliant.

B. Unit construction shall comply with ASHRAE 15 Safety Code, UL latest edition, and ASME (American Society of Mechanical Engineers) applicable codes (U.S.A. codes).

C. Unit shall be manufactured in a facility registered to ISO 9001 Manufacturing Quality Standard.

D. Unit shall be full load run tested at the factory.

1.3 DELIVERY, STORAGE AND HANDLING

A. Unit controls shall be capable of withstanding 150 F (66 C) storage temperatures in the control compartment.

B. Unit shall be stored and handled per unit manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. Approved Manufacturers: Carrier, Trane, York or equivalent.

B. Factory assembled, single-piece chassis, air-cooled liquid chiller. Contained within the unit cabinet shall be all factory wiring, piping, controls, refrigerant charge (R-134A), and special features required prior to field start-up.

2.2 WARRANTY

A. Chiller shall be provided with a standard warranty including all parts and labor for one (1) year from the project’s date of substantial completion. An additional extended warranty shall also be provided for parts, labor and refrigerant covering the entire chiller for an additional two (2) years for a total warranty period of three (3) years.

2.3 UNIT CABINET:

A. The base rail is industrial-quality, 7ga, zinc-dipped, galvanized frame (with Magni-coated screws).

B. Cabinet shall be galvanized steel casing with a baked enamel powder or pre-painted finish.

C. Painted parts shall withstand 1000 hours in constant neutral salt spray under ASTM B117 conditions with a 1 mm scribe per ASTM D1654. After test, painted parts shall show no signs of wrinkling or cracking, no loss of adhesion, no evidence of blistering, and the mean creepage shall not exceed 1/4 in. (Rating = 4 per ASTM D1654) on either side of the scribe line.

2.4 FANS:

A. Condenser fans shall be variable speed, VFD [variable frequency drive] controlled, 9-blade airfoil cross-section, reinforced polymer construction, shrouded-axial type, and shall be statically and dynamically balanced with inherent corrosion resistance. The variable speed drives shall include a DC link reactor

B. Air shall be discharged vertically upward.

C. Fans shall be protected by coated steel wire safety guards.

2.5 COMPRESSOR/COMPRESSOR ASSEMBLY:

A. Semi-hermetic twin screw type compressors.

B. Direct drive, VFD (variable frequency drive) controlled to match load requirement with a maximum speed of 6300 rpm. The motors shall be protected by temperature sensors, and are suction gas cooled.

C. All chiller compressors shall be VFD controlled.

D. Capacity control shall utilize a VFD to unload each compressor from 100% to 25% of full load, resulting in a chiller minimum load of less than 15%. A VI (volume index) valve is used to optimize the efficiency at full and part load conditions.

E. The VFD for each compressor motor shall include a DC link reactor.

F. Compressor shall include an internal muffler to reduce pulsations in the system.

G. All VFDs on the chiller (compressor motors and fans) shall be fully air cooled and shall not require an additional glycol cooling system.

2.6 FLOODED EVAPORATOR:

A. Mechanically cleaned tubes in a shell-and-tube type evaporator with removeable heads.

B. Tubes shall be internally enhanced seamless-copper type rolled into tube sheets.

C. Shall be equipped with Victaulic-type water connections.

D. Shell shall be insulated with 3/4-in. (19-mm) PVC foam (closed-cell) with a maximum K factor of 0.28.

E. Design shall incorporate a minimum of 2 independent refrigerant circuits.

F. Evaporator shall be tested and stamped in accordance with ASME Code for a refrigerant working side pressure of 220 psig (1517 kPa). Cooler shall have a maximum water-side pressure of 300 psig (2068 kPa).

G. Evaporator shall have a evaporator drain and vent.

H. Low-ambient temperature protection: unit shall have factory-installed evaporator heater to protect evaporator from ambient temperature freeze down to 0°F (–17.8°C).

I. Cooler shall be provided with a factory-installed flow switch.

2.7 CONDENSER:

A. Aluminum fin/copper tube coils: Coil shall be constructed of seamless copper tubes mechanically bonded to aluminum fins. Fins shall have wavy enhancements.

B. Tubes shall be cleaned, dehydrated, and sealed.

C. Assembled condenser coils shall be pressure tested at the coil factory at 660 psig (5548 kPa) and subsequently leak tested at 145 psig (1000 kPa) and pressure tested at 350 psig (2413 kPA) at final unit assembly.

2.8 REFRIGERATION COMPONENTS:

A. Refrigerant circuit components shall include replaceable-core filter drier, moisture indicating sight glass, electronic expansion device, discharge service valve and liquid line service valves, and complete operating charge of both refrigerant R-134A and compressor oil.

2.9 CONTROLS, SAFETIES, AND DIAGNOSTICS:

A. Unit controls shall include the following minimum components:
1. Microprocessor with non-volatile memory. Battery backup system shall not be accepted.
2. Separate terminal block for power and controls.
3. Separate 115v power supply to serve all controllers, relays, and control components.
4. ON/OFF control switch.
5. Replaceable solid-state controllers.
6. Pressure sensors shall be installed to measure suction and discharge pressure. Thermistors shall be installed to measure cooler entering and leaving fluid temperatures and outside air temperature.

B. Unit controls shall include the following functions:
1. Automatic circuit lead/lag.
2. Capacity control based on leaving chilled fluid temperature and compensated by rate of change of return-fluid temperature with temperature set point accuracy to 0.1° F (0.06° C).

3. Limiting the chilled fluid temperature pulldown rate at start-up to an adjustable range of 0.2° F to 2° F (0.11° C to 1.1° C) per minute to prevent excessive demand spikes at start-up.
4. Seven-day time schedule.
5. Leaving chilled fluid temperature reset from return fluid and outside air temperature.
6. Chilled water pump start/stop.
7. Chiller control for parallel chiller applications without addition of hardware modules and control panels (additional thermistors and wells are required).
8. Timed maintenance scheduling to signal maintenance activities for pumps, strainer maintenance and user-defined maintenance activities.
9. Low ambient protection to energize evaporator heaters.
10. Single step demand limit control activated by remote contact closure.
11. Nighttime sound mode to reduce the sound of the machine by a user-defined schedule.

C. Diagnostics:
1. The control panel shall include, as standard, a color touch screen display with stylus allowing user to navigate through menus, select desired options and modify data.
2. Features of the display shall include:
    a. Multiple connection ports for USB, Ethernet or BACnet IP.
    b. Automatic reporting of alarms over email.
    c. Ability to graphically plot trends of system performance and conditions over time.
    d. Graphical summary display of current chiller operation and water conditions.
    e. Display shall allow access to configuration, maintenance, service, set point, time schedules, alarm history and status data.
    f. Three levels of password protection against unauthorized access to configuration and maintenance information, and display set-up parameters.
    g. Capability to provide email alarm notifications.
    h. Display shall be capable of displaying the last 50 alarms with clear full text description and time and stamp, and will store a snapshot of operating conditions before and after the 10 most recent alarms.
    i. Display run hours and number of starts for machine and individual compressors.
    j. Display current amp draw for each compressor and fans.
    k. The control system shall allow for software upgrade without the need for new hardware modules.

D. Safeties:
1. Unit shall be equipped with thermistors and all necessary components in conjunction with the control system to provide the unit with the following protections:
    a. Reverse rotation.
    b. Low chilled fluid temperature.
    c. Motor overtemperature
    d. High pressure.
    e. Electrical overload.
    f. Phase loss.
    g. Loss of chilled water flow.

2. Condenser fan and factory pump motors shall have external overcurrent protection.

2.10 OPERATING CHARACTERISTICS:

A. Unit, without modification, shall be capable of starting and running at outdoor ambient temperatures from 32 F to 125 F (0° to 52 C) for all sizes.

B. Unit shall be capable of starting up with 95 F (35 C) entering fluid temperature to the evaporator.

2.11 MOTORS:

A. Condenser-fan motors shall be totally enclosed, air over, variable speed, 3-phase type with permanently lubricated bearings and Class F insulation.

2.12 ELECTRICAL REQUIREMENTS:

A. Unit/module primary electrical power supply shall enter the unit at a single location.

B. Unit shall operate on 3-phase power at the voltage shown in the equipment schedule.

C. Control points shall be accessed through terminal block.

D. Unit shall be shipped with factory control and power wiring installed.

2.13 CHILLED WATER CIRCUIT:

A. Chilled water circuit shall be rated for 300 psig (2068 kPa).

B. Thermal dispersion proof of flow switch shall be factory installed and wired.

2.14 REQUIRED FEATURES

A. High-efficiency variable speed condenser fans:
   1. All fans on the unit shall have variable speed fan motors to provide higher part load efficiency and reduced acoustic levels. Each fan circuit shall have a factory-installed, independent variable speed drive with display. Variable speed drives are rated IP-55 enclosures and UL Listed. Low ambient control is included with variable speed condenser fans.

B. Unit-Mounted Non-Fused Disconnect:
   1. Unit shall be supplied with factory-installed, lockable, non-fused electrical disconnect for main power supply.

C. Condenser Coil Materials:
   1. Aluminum fin/copper tube coils:
      a. Coil shall be constructed of seamless copper tubes mechanically bonded to aluminum fins. Fins shall have wavy enhancements.
      b. The aluminum fins shall be coated with a flexible epoxy polymer coating uniformly applied to all coil surface areas without material bridging between fins. Coating process shall ensure complete coil encapsulation. Color shall be high gloss black with gloss — 60° of 65-90% per ASTM

D523-89. Uniform dry film thickness from 0.8 to 1.2 mil on all surface areas including fin edges. Superior hardness characteristics of 2H per ASTM D3363-92A and cross hatch adhesion of 4B-5B per ASTM D3359-93. Impact resistance shall be up to 160 in./lb (ASTM D2794-93). Humidity and water immersion resistance shall be up to minimum 1000 and 250 hours respectively (ASTM D2247-92 and ASTM D870-92). Coated aluminum-fin coils shall be capable of withstanding an 8000-hour salt spray test in accordance with the ASTM (American Society for Testing and Materials) (U.S.A.) B 117 Standard. Coil construction shall be aluminum fins mechanically bonded to copper tubes.

D. Minimum Load Control:
   1. Unit shall be equipped with factory-installed, microprocessor-controlled, minimum load control that shall permit unit operation down to a minimum of 15% capacity.

E. Condenser Coil Trim Panels:
   1. Unit shall be supplied with factory-installed coil covers and painted grilles to protect the condenser coil and internal chiller components from physical damage.

F. Security Grilles:
   1. Unit shall be supplied with factory-installed coil covers and painted grilles to protect the condenser coil and internal chiller components from physical damage.

G. Upper Hail Guard:
   1. Unit shall be equipped with a factory-installed option consisting of louvered panels on the ends of the machine which firmly fasten to the machine frame. These panels shall cover the unit from the top to the bottom of the coils, thus providing protection of the coils from hail damage.

H. BACnet Communication Option:
   1. Shall provide factory-installed communication capability with a BACnet network.

I. Compressor Suction Service Valve:
   1. Standard refrigerant discharge isolation and liquid valves shall enable service personnel to store the refrigerant charge in the evaporator or condenser during servicing. This factory-installed option (one valve per refrigerant circuit) shall allow for further isolation of the compressor from the evaporator vessel.

J. Suction Line Insulation:
   1. Insulation shall be tubular closed-cell insulation.

K. Control Transformer:
   1. Unit shall be supplied with a factory installed transformer that will allow supply control circuit power from the main unit power supply.

L. Freeze Protection Evaporator Heaters:
   1. Evaporator heaters shall provide protection from evaporator freeze-up to –20 F (–29 C).

M. Low Sound Kit:
   1. Unit shall be provided with factory installed sheet metal enclosures with sound

absorbing panels for each compressor as well as an external muffler between each compressor and its associated oil separator.

N. GFI Convenience Outlet
   1. Shall be factory installed and mounted with easily accessible 115V female receptacle and shall include a 4-amp GFI receptacle.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads, and other conditions affecting performance of central-station air- handling units.

B. Examine rough-in for hydronic piping and electrical knock-outs to verify actual locations of connections prior to installation.

C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install chillers level and plumb, in accordance with manufacturer's written instructions.

B. Arrange installation of units to provide access space around units for service and maintenance.

C. Piping installation requirements are specified in other Division 23 sections. The Drawings indicate the general arrangement of piping, valves, fittings, and specialties. The following are specific connection requirements:
   1. Arrange piping installations adjacent to units to allow unit servicing and maintenance.
   2. Connection piping to chillers with flexible connectors.
   3. Electrical Connections: The following requirements apply:
      a. Electrical power wiring is specified in Division 26.
      b. Temperature control wiring and interlock wiring as specified in Division 23, Section 230900 - "HVAC Facility Management System".
      c. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

3.3 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust water flow to indicated GPM flow rates.

B. Clean unit to remove foreign material and construction dirt and dust.

3.4 DAMAGED EQUIPMENT

A. Any and all equipment, parts, components, such as fans, casing, compressor, motors, etc., provided under this section which is either damaged by the contractor during rigging, installation or testing or which is received in damaged condition during shipping, transit, handling, or during installation and/or testing shall be totally replaced as a unit. Dented, or damaged superficial, non-structural, equipment jackets or surface casings such as, but not limited to; jackets, insulation, etc., shall either be repaired or replaced at the option and sole discretion of the Owner's Representative. If non-structural components are repaired, the finished product shall match original equipment exactly. Structurally damaged equipment shall be replaced.

B. Any equipment which develops surface rust, either through improper storage, handling or installation, shall be refinished by grinding the affected area down to bare (white) metal, then prepared with a rust preventive primer and finished with the original manufacturer=s touch-up paint to match existing color.

3.5 COMMISSIONING

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:
1. Remove shipping, blocking, and bracing.
2. Verify unit is secure on mountings and supporting devices and that connections for piping and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
3. Perform cleaning and adjusting specified in this Section.

B. Starting procedures for chiller:
1. Energize unit, verify proper operation of fan motors and compressors.
2. Measure and record motor electrical values for voltage and amperage.
3. Shut unit down and reconnect automatic temperature control operators.
4. Refer to Division 23, Section 230593 - "Testing, Adjusting, and Balancing" for procedures for chillers testing, adjusting, and balancing.

3.6 DEMONSTRATION & TRAINING

A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner's maintenance personnel on the following:
1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 01, "Closeout Submittals".
3. Provide Service Manuals for each air handler specified.

B. Provide three (3) hours of factory authorized training for each type or size of chiller.
1. Refer to Section 230010 - AMechanical General Provisions@ for videotaping requirements.
2. Schedule training with at least 7 days' advance notice.

END OF SECTION 236423

SECTION 237313
CENTRAL STATION AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary, and other Conditions) and Division 00 and 01 as appropriate, apply to the Work specified in this Section.

B. Refer to all Sections, as well as the Specifications for the other various trades and materials and be thoroughly familiar with all provisions regarding all work.

1.2 REFERENCES

A. Reference Standards
1. AFBMA 9: Load Ratings and Fatigue Life for Ball Bearings.
2. AMCA Standard 99: Standards Handbook.
3. AMCA /ANSI Standard 204: Balance Quality and Vibration Levels for Fans.
4. AMCA Standard 210: Laboratory Methods of Testing Fans for Ratings.
5. AMCA Standard 300: Reverberant Room Method for Sound Testing of Fans.
6. AMCA 320: Laboratory Method for Sound Testing of Fans Using Sound Intensity.
7. AMCA Standard 500: Test Methods for Louvers, Dampers and Shutters.
8. HRI Standard 1060: Air-to-Air Energy Recovery Ventilation Equipment.
9. AHRI Standard 410: Forced-Circulation Air-Cooling and Air-Heating Coil.
10. ASHRAE Standard 52: Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
11. UL Standard 900: Test Performance of Air Filter Units.
12. ASHRAE 84-91: Method of Testing Air-to-Air Heat Exchangers.
13. ASHRAE/ANSI Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems.
14. UL Standard 1995: Heating and Cooling Equipment.
15. ASTM A-525: Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
16. IEEE 112-B: Standard Test Procedures for Polyphase Induction Motors and Generators.
17. NEMA MG-1: National Electrical Manufacturers Association Motor Standards.
18. NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems.
19. SMACNA: Sheet Metal and Air Conditioning Contractors National Association.
20. NIH DRM 2020: National Institutes of Health Design Requirements Manual

1.3 SCOPE OF WORK

A. Coordination: Coordinate work performed under this section with work performed under the separate installation contract.

B. This Section includes factory-fabricated modular central station air handling units with coils for interior installations. The extent of air unit work is indicated by construction document drawings and schedules, and by the requirements of this section. Each unit is typically defined to include (but not by way of limitation) unit casings, fan and motor, mixing box, filters, coils (cooling, heating), drip pan, drains, and thermal/sound insulation.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections. Provide dimensions, weights, capacities, ratings, fan performances, etc.

B. Product data for each central station air handling unit indicated, including the following:
1. Shop Drawings: Dimensioned plan and elevation view drawings including assembly weights and location of all field connections.
2. Electrical Layouts: Single-line diagram of all electrical components furnished.
3. Electrical Schematics: Ladder type schematic drawing of the power and ancillary utility field hookup requirements, indicating all items that are furnished.
4. Product Data: Manufacturer's performance of each unit.
a. Shipping and operating weight of unit and/or sections.
b. Sound power projections at inlet, outlet and casing radiated per unit performed by an AMCA 300 accredited lab.
c. Piping connection sizes and approximate locations.
d. Door and window sizes and elevations.
e. Cross section details of the typical wall, floor and roof construction. Details of coil support in a coil bank. Drain pan details.
f. Materials of construction.
g. Unit finish.
h. Motor electrical characteristics, including motor technical data sheets.
i. Filter data sheets to include pressure drops.
j. Operating and Maintenance Data.
k. Component Data: Performance sheets shall include, as a minimum, the following:
i. Construction and component summary.
ii. Model number of the component.
iii. Input data used for selection.
iv. Net capacity and certified ratings that conform to the latest edition of AMCA 210, 310, 500 and AHRI 410 as applicable.
v. Air and water pressure drop when applicable.
vi. Fan performance to include fan curves.
vii. Rated load amp draw when applicable.

C. CLOSEOUT SUBMITTALS
1. Operation and Maintenance Data: Include data on design, inspection and procedures related to preventative maintenance. Installation, Operation and Maintenance Instructions Manual (IOM) shall be submitted at the time of unit shipment.
2. Warranty Documentation: Submittals shall include a copy of the warranty policy.
3. Record Documentation: A final record submittal will be provided after release for production.

1.5 QUALITY ASSURANCE

A. NFPA Compliance:
1. Central station air handling units and components shall be designed, fabricated, and installed in compliance with NFPA Standard 90A "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL):
   1. Electric coils, along with the complete central station air handling unit shall be listed and labeled by a NRTL. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

C. ARI Certification:
   1. Central-station air-handling units and their components shall be factory tested in accordance with the applicable portions of ARI 430 - AStandard for Central Station Air Handling Units@ and shall be listed and bear the label of the Air Conditioning and Refrigeration Institute (ARI).

D. Fire Hazard Ratings:
   1. Except as otherwise so specifically noted, provide central station air handling units thermal and sound insulation with insulation complying with a flame spread index of 25 or less, a fuel contributed index of 50 or less, and a smoke developed index of 50 or less.

E. AMCA Standards:
   1. As a minimum, comply with Air Movement and Control Association (AMCA) Standards as applicable to testing and rating of fans, and testing louvers, dampers and shutters.

F. SMACNA Compliance:
   1. As a minimum, comply with Sheet Metal and Air Conditioning Contractors National Association (SMACNA) AHVAC Duct Construction Standards@, Second Edition - 1995 with addendums, Chapter 6 - AEquipment & Casings@ and as applicable to central station air handling units, double wall casings, penetrations, access doors, and pressure requirements.

G. Qualifications - Manufacturers:
   1. Manufacturer shall be a company specializing in the design and manufacture of commercial / industrial custom HVAC equipment. The manufacturer shall have been in production of custom HVAC equipment for a minimum of 20 years.

H. Standard Factory Tests
   1. The fans shall be factory run tested to ensure structural integrity and proper RPM and shall be statically and dynamically balanced for continuous operation at the maximum rated fan speed and motor horsepower in accordance with AMCA 204.
   2. All electrical circuits shall be tested to ensure correct operation before shipment of the unit.
   3. Units shall pass quality control and be thoroughly cleaned prior to shipment.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements: All equipment shall be delivered to the job site suitably packaged and protected for overland trucking. In general, units shall be delivered in one piece unless indicated otherwise. Where building constraints, unit size or trucking limitations require that the unit must ship in more than one piece, the manufacturer shall indicate all split points on the shop drawings. All items shipped loose such as filters, steam humidifier assemblies, caulking, etc. shall be suitably secured in the unit or on a separate pallet.

B. Storage and Handling Requirements: Units must be stored in a clean dry area and protected from the weather and construction traffic. Carefully follow manufacturers' storage instructions if installation does not immediately follow arrival at the job site.

C. Deliver units from the factory properly secured, crated, and protected with factory plastic shrink wrap or other protective wrap. Tarping of units is unacceptable.

D. Lift and support units with the manufacturer's designated lifting or supporting points.

E. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.

1.7 SEQUENCING AND SCHEDULING

A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad.

B. Coordinate the size and location of structural steel support members.

1.8 START-UP REQUIREMENTS

A. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, condensate properly trapped, piping connections verified, and leak tested, belts aligned and tensioned, all shipping braces have been removed, and fan has been test run under observation.

1.9 WARRANTY

A. Manufacturer Warranty: Unit manufacturer to warrant its product to be free of defects in materials and workmanship under normal use when installed and operated in accordance with factory recommendations for a period of 18 months from date of shipment or 12 months after initial equipment start-up, whichever occurs first. Equipment found to be defective should be replaced or repaired.

B. Unit shall include a one year all parts and labor warranty

1.10 EXTRA MATERIALS

A. Furnish to the owner or install the following spare parts:
1. Provide one (1) set of filters for each central station air handling unit at Test & Balance Phase of the Project.
2. Provide one (1) set of filters for each central station air handling unit at final acceptance of the Project. The decision to either change the filters or store for future use shall be determined by the Owner’s Representative at Substantial Completion and shall be dependent upon the time frame between the TAB phase and Substantial Completion Date.
3. One (1) additional gasket for each sectional joint of each central station air handling unit.
4. One (1) set of access panel/door gaskets for each type and size of access panel/door.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. All Air Handling Units specified under this section shall be provided by the same manufacturer, an affiliate of that manufacturer or a subsidiary of that manufacturer.
  1. It is the intent of the specifications that modular air handling units be provided by a single manufacturer.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the Work include, but are not limited to, the following:
  1. Central Station Air Handling Units:
    a. Temtrol - basis of design
    b. Governair
    c. Prior Approved Equal
  2. Substitution Limitations: Other Equipment manufacturers shall be considered provided the construction specifications, capacities and performance criteria are met.

2.2 AIR HANDLING UNITS

A. General Description:
  1. Provide factory fabricated Air Handling Units with capacity as indicated on the schedule. The units consist of factory assembled components as shown on drawings and outlined on schedule, enclosed in a single or multiple piece casing as shown on the mechanical drawings.
    a. Filter Section:
      i. 2” pleated MERV 8 filters
    b. Coil Section(s):
      i. Emergency Electric Pre-heat and Secondary Electric Pre-heat coil
      ii. Chilled water coil (x2).
      iii. Ultra-Violet Lights (UV Lights) Section (x2)
    c. Fan Section:
      i. Direct drive plenum fan array fans
      ii. Individual backdraft dampers for each fan in the array.
    d. Final Filter Section
      i. 12” MERV-14 filters
    e. Discharge Plenum
  2. Units shall have overall dimensions as indicated and fit into the space available with adequate clearance for service as determined by the Engineer. Tags and decals to aid in service or indicate caution areas shall be provided. Electrical wiring diagrams and Installation, Operation and Maintenance Instructions Manual shall be attached to the control panel access doors within each unit.
  3. Units shall be shipped in one piece or multiple pieces as shown on mechanical drawings to accommodate freight as required, or to allow for reduced size building access or load limitations (specify maximum dimensions and or weight).

B. Regulatory Requirements

1. Each unit shall bear an ETL or UL label under UL Standard 1995 indicating the complete unit is listed as an assembly. ETL or UL listing of individual components, or control panels only, is not acceptable.
2. Additional Testing and Quality Assurance as explained in individual component / item sections in the following paragraphs of this specification.
3. Units shall carry the label of a Nationally Recognized Testing Laboratory (NRTL), or a Standards Council of Canada (SCC) approved lab (Testing Organization and Certifying Body).
4. Units shall comply with NFPA 70, National Electrical Code, as applicable for installation and electrical connections of ancillary electrical components of Air Handling Units.
5. All electrical components and assemblies shall comply with NEMA standards.

C. Performance / Design Criteria

1. Capacities: The attached schedules, tables and specifications are to be used as the selection criteria for the air handling equipment to include Air Flow Rates, External Static Pressures and Water Flow Rates. The following are to be equaled or better: Coil Face velocities and Filter Face Velocities. The following are to be met within 5% of specified values: internal air pressure drops.
   a. Sound Power Levels: The sound power level at the air handling unit discharge, air intake (return air and / or OSA intake), and casing radiated should not exceed the values given in the table shown below, when the unit is operating at maximum design airflow and static Pressure. Maximum Octave Band sound Power Level in dB RE 10E-12 watts.

Octave Band Frequency Sound Power (db re: 1 Picowatt)										
Frequency	63	125	250	500	1000	2000	4000	8000	LwA	Lw
DOAS-1										
OA Opening	66	66	86	77	72	73	68	61	81	87
SA Opening	77	74	84	74	72	65	58	53	79	86
Casing Radiated	71	62	73	62	59	52	47	45	67	76
Floor Radiated	60	57	64	40	35	35	35	35	56	66

   b. It shall be the option of the contractor to provide a quieter fan, acoustical lining, sound traps or other sound attenuating devices within the air handling unit to supplement the design to meet the specified levels above.
   c. The air handling units' sound power data shall be submitted for approval. The submittal shall include a complete description of the methods and procedures used to develop the sound power levels being submitted.

D. Unit Base and Floor
1. General: Base frame shall be attached to the unit casing at the factory.
2. Perimeter Base Rail
   a. Unit perimeter base shall be completely welded and constructed from 11 in Steel Tube structural tubing. Bolted or riveted bases are not acceptable.
3. Base internal Structure: Intermediate structural members as required to support all internal components.
4. Floor Material: Internal walk-on floor shall be 0.188 Alum Treadplate. Floor seams shall be sealed to create leak-free joints.
5. Thermal Break: Gasketed floor seams.
6. Base insulation: The floor cavity shall be insulated for air and water-tight construction with Polyurethane Foam at a minimum R-value of 20.
7. The outer sub-floor of the unit shall be made from 16Ga Galv to protect the insulation from external environment.
8. Deflection / Load: When rigging, base frame deflection shall be less than 1/360 of the unit length. The minimum floor design load is 150 pounds / square foot (distributed load), and the maximum point load on floor shall be 300 pounds (over 1 square foot).
9. Limitations: Bolted, riveted or formed channel bases are not acceptable. Single wall floors with glued and pinned insulation and no sub floor are not acceptable.
10. Lifting Lugs: Base shall be provided with lifting lugs, minimum (4) per section, and properly located to assure uniform loading. Lifting lugs shall be designed in accordance with unit weight and rigging requirements.
11. Unit Mounting: Unit shall be designed to be Slab Mounted.

E. Cabinet
1. Environment
   a. Indoor: Units shall be designed for indoor installation as indicated on the schedule. Indoor units will have a flat roof.
2. Construction
   a. ITF - Integrated Frame: The construction of the air handling unit shall consist of a (1" x 2") roll-formed steel frame with formed double wall casing panels. The exterior casing panels shall be attached to the gasketed (1" x 2") steel frame with corrosion resistant fasteners. All casing panels shall be completely removable from the unit exterior without affecting the unit's structural integrity. The double wall panel shall be removable from the outside of the unit without affecting the structural integrity of the unit.
3. Deflection
   a. ITF - Integrated Frame: The maximum deflection of walls and roof shall be L/240 at +/- 10" w.c. (L= span in inches). Deflection is measured at panel seams at the center of the span. If panels cannot meet this deflection, additional internal reinforcing is required.
4. Load: The minimum roof and wall load is 75 pounds / square foot (distributed load such as wind and snow). The maximum point load on the roof shall be 300 pounds (over 1 square foot).
5. Leakage: Air handlers shall be designed to meet maximum leakage of SMACNA class 3.
6. Exterior Material: 16Ga Galv.
7. Interior Material: 16Ga 304 SS.

8. Thermal Break
    a. Thermal Break: Casing shall be of the "no-through-metal" design. The casing shall incorporate insulating thermal breaks as required so that, when fully assembled, there's no path of continuous unbroken metal to metal conduction from inner to outer surfaces.
9. Caulking (Internal): Internal Calking shall be of Standard type.
10. Caulking (External): External Caulking shall be of Low VOC Sealant type.
11. Exterior Finish
    a. None: Unpainted.
12. Interior Finish
    a. None: Unpainted.
13. Insulation (Based on Liner Material Type)
    a. Solid Liner Insulation = Foam shall be 2.5 pcf with an effective thermal conductivity (C) of 0.059 BTU in/hr sq.ft°F). The foam insulation shall have an ozone depletion potential of 0, a global warming potential of 0 and is VOC exempt. Foam is UL 94HF1 rated - see drawing for locations.
    b. Exposed insulation edges in the airstream are not acceptable.

F. Access Doors
1. Full size access door(s) allowing for periodic maintenance and inspections shall be provided for all serviceable components as shown on the plans. Removable panels are not acceptable. Doors shall be solid double wall insulated construction. The door frame shall be extruded aluminum with a built-in thermal break barrier and full perimeter gasket. There shall be a minimum of two heavy duty latches per door. Latches shall be operable from both the interior and exterior of the unit.
2. Doors shall open against pressure or as shown on drawings.
3. Doors shall be located on each side of the unit
4. View Windows
    a. 12 in x 12 in Thermal Break: Dual-paned tempered glass with vacuum seal viewing windows, with molecular sieve sealant and thermally broken frames shall be supplied on doors as shown on unit drawings. Single paned windows are not acceptable.
5. Kill Switch
    a. Manually Operated: Access doors shall be equipped with a Manually Operated interrupt switch that shuts off the component it is wired to when a protected door is opened. See unit drawings for locations.
6. Access doors shall be equipped with an ETL, UL 1995 and OSHA approved tool operated safety latch.

G. Drain Pans
1. IAQ style drain pans shall be provided as shown on the drawings. All pans are to be pitched for complete drainage with no standing water in the unit. Drain pans shall be fabricated from 16Ga 304 SS with solid welded seams and equipped with a stainless-steel MPT drain connection diameter of 1.25 in. Pans shall be insulated between the liner and the main pan.

H. Lighting
1. Provide, furnish, and install factory internally wired, vapor tight, LED, marine type, lighting fixtures in each air handler section with aluminum globe and wire guard.
2. Provide red pilot lite wall switch with protective dust cover located outside cabinet adjacent to one door for all lights. Provide one (1) externally mounted electrical junction box with electrical leads for connection by Division 26 Contractor. All wiring and conduit for lights and switches shall be internal to the unit.

I. Safety
1. Provide and furnish an internally wired and installed Emergency Kill Switch outside the access panel/door of each fan section. Coordinate all interlock features of the Kill switch with Division 26 Contractor prior to bid. The intent is to provide emergency shutdown of the unit fan through the fan motor starter/VFD drive should an access panel be opened while unit is operating.

J. Fans
1. Impeller
a. Wheel Type - HPF-A100:
Fans shall be aluminum airfoil, Class III direct drive arrangement and shall be individually housed. Fans shall be certified by AMCA for performance.
2. Fan shall be housed in a "cell". Fan housing or "cell" shall be constructed of Galvanized Steel.
3. Fan housing or "cell" provided with perforated inner liner, Standard Melamine insulation, with either solid or perforated outer panels as required by applications.
4. Fan/motor assembly: Fan/motor shall be mounted within the housing on an adjustable slide rail base. Fan/motor assembly must be capable of either horizontal or vertical application.
5. Balancing
a. Wheel Type - HPF-A100:
Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, for fan application class BV-5 to meet or exceed a rotational imbalance Grade 0.55 (1.0 for 27" wheels) producing a maximum rotational imbalance of 0.022" per second peak, filter in. "Filter in" measurement indicates that the specified balance grade must be achieved at the submitted design operating speed for the fan(s).
6. Motors
a. AC Motors:
i. Motors shall be standard foot mounted type, TEFC or TEAO motors selected at the specified operating voltage, RPM, and efficiency as specified or as scheduled elsewhere.
b. Motors shall meet the requirements of NEMA MG-1 Part 30 and 31, section 4.4.2.
c. Motors shall be available in 1/2 HP increments at nameplate HP ratings from 1.5 HP through 12 HP.
d. All motors shall include permanently sealed bearings and shaft grounding means to protect the motor bearings from electrical discharge machining due to stray shaft current. Motors provided with hybrid ceramic bearings, when specified, do not require shaft grounding devices.
e. Steel cased motors and/or ODP motors are not acceptable.

7. Backdraft Dampers:
   Each fan applied in multiple fan applications shall be provided with an integral back flow prevention device that prohibits recirculation of air in the event a fan, or multiple fans, becomes disabled. The system effect for the submitted back flow prevention device shall be included in the calculation to determine the fan TSP for fan selection purposes and shall be indicated as a separate line-item SP loss in the submitted fan selection data. Manufacturers must provide independent lab certification of fan testing that indicates the system effects attributed to the submitted back flow prevention device in the submitted close-coupled mounting arrangement at the inlet of the fan. Fans submitted with discharge dampers will not be approved.
   Back Draft Damper performance data that is based on an AMCA ducted inlet and ducted discharge mounting configuration will not be accepted. Submitted Back flow prevention device data must be reflective of close-coupled mounting at the intake of the fan(s) per the project design documents. Motorized dampers or other motorized devices submitted for back flow prevention are not acceptable.
   AHU Manufacturers that do not manufacture the fans being submitted must provide tested and certified performance data for fans as installed in the AHU unit including the back draft damper system effects introduced by close-coupled back draft dampers at the fan inlet.
8. Fan Arrays
   a. Fan and motor assemblies shall be designed for application in multiple fan arrays.
   b. The fan array shall consist of multiple housed fans or "cells", spaced in the air way tunnel cross section to provide a uniform air flow and velocity profile across the entire air tunnel cross section and components therein.
   c. Each fan and motor assembly shall be removable through an access door located on the discharge side of the fan wall array without removing the fan wheel from the motor.
   d. All fans in multiple fan arrays shall be AMCA certified for performance per AMCA arrangement "A" testing configuration. The submitted fan performance shall be inclusive of system effects attributed to the fan mounting arrangement, fan enclosures, back draft dampers, and other fan appurtenances not considered when AMCA certified performance per AMCA arr. "A" is determined. Submitted AHU/fan performance that does not indicate allowances for system effects for the back flow prevention device(s), wheel enclosures, safety screens, bearing pedestals, belt guards, or the fan and motor enclosure in which each fan is mounted, will be returned to the contractor disapproved and will need to be resubmitted with all of the requested information included for approval. Added system effects for acoustic attenuators, or other devices required to meet the specified fan performance and sound power levels must be indicated in the submitted fan selection data.
   e. Fan system power requirements or sound power levels that fail to meet specified performance levels shall be corrected to meet specified performance levels at no additional cost to the owner. Any proposed corrections for power or sound deviations from the specified values must be submitted to the engineer for approval prior to implementation of any proposed corrective procedure.

f. Submittals for units providing less than the scheduled quantity of fans and/or spacing of fans for multiple fan arrays shall submit CFD modeling of the air flow profile for approval that indicates uniform velocity and flow across all internal components without increasing the length of the unit or changing the aspect ratio of the unit casing as designed.

g. Manufacturers that do not manufacture their own fans for the specific purpose of use in multiple fan arrays, shall provide a letter guaranteeing submitted AHU performance for flow, pressure, and acoustics at the perimeter boundary of the unit signed by an officer of the OEM fan manufacturer being submitted. Any corrective acoustical treatment, added airway tunnel lengths, increased electrical service, and any structural modifications necessary to meet the specified and scheduled performance shall be provided at no additional cost to the owner to meet the specified performance criteria. All proposed corrective actions, when required, must be submitted for approval and shall include a guarantee of performance, as listed above, at no additional cost to the owner.

h. It shall be the option to have the airflow performance tested. All tests shall be in accordance with AMCA Standard 210: Laboratory Methods for Testing Fans for Rating and AMCA Standard 203-90: Field Performance Measurement of Fan Systems.

9. Acoustical Performance
   a. The AHU unit shall provide the specified acoustical performance as scheduled for the unit supply discharge opening(s), RA opening(s), and the Outside air and Exhaust air opening(s).
   b. Coplanar silencer(s) and/or sound attenuator(s) shall be provided to meet specified acoustical requirements. Sound attenuator cross sectional area shall be selected to not exceed 500 fpm. Losses from sound attenuating devices must be included in the fan performance selection.
   c. Listed or alternate manufacturers providing fan arrays that incorporate fans which are not manufactured by the AHU manufacturer, must provide modeled acoustical performance of the AHU unit.
   d. Sound and performance data for approval showing only single fan performance for multiple fan array supplication will be returned without review.
   e. Any proposed remedy for deviations in submitted sound power levels shall be approved by a registered acoustical consultant as selected by the owner or architect. Costs for review of the proposed changes shall be borne by the contractor.
10. Electrical System: Provide a complete electrical and control system required to run the fan system including all equipment, material, electrical enclosures, electrical components and electrical labor.

K. Hydronic Coils
1. AHRI Certified Performance, continuous circuit, self-draining unless noted on performance output.
2. Piping Connections: Same end of coil.
3. Tube Material: Round Seamless Copper 0.035 in wall.
4. Tube Diameter: 0.625 in O.D. tube.
5. Fin Spacing: 6 through 12 FPI on 5/8" tube.
6. Fin Type: Corrugated plate with full drawn collar for accurate spacing.
7. Fin Material / Thickness: Aluminum 0.010 in.

8. Fin and Tube Joint: Tubes are mechanically expanded.
9. Coil Headers: Type L Seamless copper with 5% silver brazed joints. Vent & Drain located at high and low point to provide gravity drain.
10. Connection Material: Red Brass.
11. Connection Type: MPT.
12. Coil Casing: 16Ga 304 SS.
13. Leak Testing: Entire coil assembly submerged in water and filled with Nitrogen at 315 PSI.
14. Coil Working-Pressure Rating: 250 psig at 300 °F.
15. Max coil rows – 8 rows
16. Max cooling coil face velocity – 500 fpm
17. Maximum coil size – 10’x3’ – If coils require to be larger than the stated dimensions, then multiple coils shall be provided.
    a. Each coil shall be valved separately so that if any individual coil fails, it can be isolated and drained while remaining coils stay in operation.
    b. Coils shall be installed to allow the removal of individual coils without disturbing the pipe header.
    c. Return headers for stacked coils shalled be piped in reverse-return configuration.

L. Filter Section
1. Provide filters of the type indicated on the schedule. Factory fabricated filter sections shall be of the same construction and finish as the unit. The filters shall be manufactured by AAF, Filtration Group or equal. Filters shall be in compliance with ANSI/UL 900 – Test Performance of Air Filters. Filter sections shall be designed for a maximum of 500 fpm.
2. Filter Frames and Racks
    a. Filter frames and racks shall be completely factory assembled and designed for industrial applications.
    b. Filter frames and racks shall be applied in low efficiency filter applications and will be either upstream or side accessible.
    c. Side accessible filter racks shall have an oversized access door on the exterior of the air handler, centered on the filter rack for easy filter removal.
    d. Filter racks shall be designed for a maximum of 500 fpm, or meet or exceed the area specified in the mechanical schedule.
    e. Filter Frames to be fabricated from no less than 16 gauge Galvanized.
    f. Filter racks/blank-offs shall be fabricated from 16Ga 304 SS material.
    g. All filter holding frames must be caulked in between them to minimize bypass air through the frames.
3. Filter Frame Sizes (Low Efficiency): Preferred 24 in x 24 in.
4. Pleated Type
    a. The filter shall consist of a pleated media, media support grid, and enclosing frame.
    b. The media shall be non-woven cotton fabric and shall be designed to consistently increase efficiency throughout service life of filter with an initial MERV rating as listed in schedule.
    c. The media support shall be a welded wire grid with an effective open area of not less than 90%.
    d. The grid shall be bonded to the filter media to eliminate media oscillation and pull away.
    e. The enclosing frame shall be constructed of rigid, heavy duty, high wet strength beverage board.

f. The frame shall be bonded to the filter pack.

5. Box Type
   a. The filter shall be a high-performance, deep pleated, totally rigid type and shall consist of a glass fiber media, media support frame, contour stabilizers, and enclosing frame.
   b. The filter media shall be a high density microfine glass fiber laminated to a non-woven synthetic backing to form a lofted filter blanket.
   c. The media shall provide superior dust holding, moisture resistance and overall performance with an initial MERV rating as listed in schedule.
   d. The media support shall be a welded wire grid with an effective open area of not less than 96%.
   e. The grid shall be bonded to the filter media to eliminate media oscillation and pull-away.
   f. The grid shall support the media both vertically and horizontally.
   g. Contour stabilizers shall be permanently installed on both the air entering and exiting sides of the filter media pack to ensure the pleat configuration is maintained throughout the life of the filter.
   h. The enclosing frame shall be constructed of galvanized steel and shall be constructed and assembled to provide a rigid and durable enclosure for the filter pack.
6. Differential Pressure Gages (at each filter section):
   a. Housing shall be constructed of a glass filled nylon case and acrylic lens. Exterior finish shall be coated black.
   b. Accuracy shall be ±5% of full scale throughout range at 70°F.
   c. Pressure limits shall be 30 psig continuous to either pressure connection.
   d. Temperature limits shall be 20 to 120°F.
   e. Diameter of dial face shall be 2.33 in.
   f. Process connections shall be barbed, 3/16-in. for ID tubing.

M. Electric Heating Coils
1. Heater Type shall be Open Coil Duct Heaters as manufactured by Indeeco or equivalent.
2. Electric heating coils shall meet or exceed the size, wattage and number of steps, and match the input and control voltages as specified in the equipment schedule.
   a. Manufacturer: Indeeco or approved equal
   b. Heaters shall be furnished with balanced three phase steps.
   c. Heaters shall be UL listed for zero clearance.
   d. Elements shall be constructed of 80% nickel and 20% chromium.
   e. Steps shall be arranged to prevent stratification when operating at less than full capacity.
   f. Terminal insulators and bracket bushings shall be constructed of ceramic and securely positioned.
   g. Heater frames shall be constructed from heavy gauge galvanized steel to ensure structural rigidity and have vertical galvanized steel supports.
   h. A terminal box shall be provided with solid cover to minimize dust infiltration.
   i. Heater terminal box must be totally enclosed and must be without perforated or expanded metal covers, louvers, or grills in order to meet paragraph 5.6 of UL Standard 1096.
   j. A disc type automatic reset thermal cut-out {manual-reset high limit} shall be furnished for primary over-temperature protection.

k. For secondary protection, a sufficient number of heat limiters in the power lines shall deenergize elements if the primary cutout fails.
l. All safety devices shall be serviceable through the terminal box without removing the heating coil from the air handler.
m. Disconnecting break magnetic connectors and a pressure-type airflow switch set .07" W.C. as required by UL shall be provided.
n. A supplementary manual-reset high-limit temperature switch shall be provided in accordance with ETL.

3. A Non-Fused disconnect shall be provided.
4. Fusing per step shall be provided.
5. Heater shall be of Low Watt density (35W/in2) for VAV applications.

N. UV-C Lights
1. Fixtures
a. Fixture is factory-assembled and tested.
b. It has a powder coated steel housing, 3 knock-outs for wiring ease, multiple access points, a 12V safety switch for up to six (6) HVAC access points, lamp/power supply indicator, M12 Lamp Connector cable, IP67 waterproof lamp connector, Fixture Framing, quick slip lamp holder, and UV-C lamps.

2. Housing
a. Housing is constructed of 16ga powder-coated steel.
b. They are designed to facilitate NEC-style power supply installations inside or outside of plenums.
c. The Housing accommodates the required number of power supplies while protecting against electrical shock and moisture incursion, includes M12 lamp Wiring Cable connection points.

3. Power Supply
a. The Power Supply is a waterproof, Type 1, outdoor, high-power factor, electronic rapid start type with overload and "end of lamp life" circuit protection that maximizes lamp radiance, life, and system reliability at temperatures of 33°F to 170°F.
b. Input: 120-277VAC, 50/60 Hz, with a sound rating of A.
c. The power supply can ensure a minimum of 9000 hours of lamp life, with 85% of its initial output at the end of the lamp's useful life. The power supply is protected against "end of lamp life" conditions.

4. Lamp Connector Cable
a. IP67 LAMP CONNECTOR CABLE is UL/CUL listed, 4-pin Single-Ended (SE) type capable of accommodating a 4-pin single-ended lamp.
b. The IP67 Lamp Plug is constructed of UV resistant materials and designed to connect the lamp to the Lamp Plug creating a water-tight connection to protect against electrical shock, moisture and separation.
c. It includes a four (4) foot cable with an M12 connector.

5. Wiring Cables
a. Wiring cables extension options of 5-foot, 10-foot and 20-foot lengths and include M12 male and female connectors.
b. Cables can be combined to be of sufficient length to facilitate lamp connection to a remotely located power supply.
c. The cable shall be capable of carrying the striking and operational voltage required to properly energize and maintain the UV-C Lamp.

6. Lamps
a. Lamps are non-proprietary, single ended, very high output, hot cathode, T5, 4-pin, base types that produce broadband UV-C at 254 nm and

produce the specified output at any airflow velocity and temperatures of 33°F to 170°F.

b. They are sleeved with EncapsuLamp™ (FEP) for protection in case of accidental breakage and are non-ozone producing types.

c. The minimum useful lamp life is 9,000 hours, with no less than 85% of original output, depending on conditions.

7. Reflector

a. Reflector fixture cover is constructed of heavy gauge, specular finished aluminum alloy with approximately 85% reflectance at 254 nm wavelength.

8. Independent Testing: All UV-C components are tested and labeled to UL ABQK.

O. Electrical Power and Controls

1. General

a. All electrical and automatic control devices not previously called out or listed in this section are to be furnished and installed in the field by others.

b. The unit shall feature a mounted permanent nameplate displaying, at a minimum, the Manufacturer, serial number, model number, date of manufacture and current and voltage readings.

c. The unit must have an ETL or UL Listing and bear the appropriate mark.

d. An interlocking mechanism is furnished on the fan section access door. The de-energizing switch is compliance with CAL-OSHA, ETL and the mechanical protection requirements of UL 1995.

2. Wiring and Conduits

a. All wiring and electrical connections shall be of (75°C) insulated copper wires, copper bus bars and copper fittings throughout. Power supply terminals shall be identified with permanent markers.

b. Wiring Type

i. EMT Galvanized / Non-Watertight: Conduit shall consist of a combination of EMT, or flexible metal conduit as required. Liquidtite flexible metal conduit may be used outside the air tunnel for wet locations.

ii. Electrical switches should have a 120 VAC GFI receptacle for a separate 120-volt power supply. The 120 VAC is provided by the Electrical Contractor..

c. Unit sections, as indicated on drawings, shall be equipped with a Vapor Proof 14W LED service light with guard.

d. Lights shall be wired to a main switch for a separate 120-volt power supply. The 120 VAC is provided by the Electrical Contractor.

e. All control panels shall have a short circuit current rating of 5 KA (V3 Standard).

P. Emergency Drain Pan

1. Emergency drain pan supplied and installed by the sheet metal contractor shall be provided below all air handling units.

a. The pan shall be constructed of welded, 16-gauge, stainless steel, extending 6" beyond unit all around and turning up a minimum of 6" around the perimeter and water piping inlet valves at each air handler.

b. A 1-1/4" x 1-1/4" x 1/8" stainless steel angle frame shall be welded around the top of the pan.

c. Extend a Type L hard copper drain line (minimum 1-1/4" or size of equipment drain) to floor drain in the mechanical room or as indicated on the drawings.
d. Install automatic float switch in drain pan and interlock with fan motor.

Q. Emergency Drain Pan Float Switch
1. Provide an emergency drain pan (Low Voltage Condensate Over-Flow Safety Switch) float switch below all air handling units equipped with an emergency drain pan.
a. Interlock float switch for AHU to send an alarm to the building BAS system whenever water level in emergency drain pan exceeds the setpoint adjustment of the float switch.
b. Float switch shall not connect to the AHU’s smoke detector in any fashion.
c. Float switch shall only be wired and/or connected to the Building BAS system.
d. Voltages:
i. 11 to 27 volts A/C or D/C
e. Construction:
i. Cast aluminum weatherproof enclosure.
ii. Microchip technology
iii. SPDT Alarm Contacts
iv. LED’s (Green/Red) for power and alarm indication
v. Test switch
vi. Adjustable detection level
vii. All wiring shall be in conduit.
2. Manufacturers: Subject to compliance with the above requirements, manufacturers offering products which may be incorporated in the Work include, but are not limited to, the following:
a. Technologies Incorporated
b. Little Giant Pumps, Inc.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads, and other conditions affecting performance of central-station air- handling units.
B. Examine rough-in for hydronic piping, condensate drainage piping, and electrical knock-outs to verify actual locations of connections prior to installation.
C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL
A. Air Handling Unit Casing Penetrations:
1. All air handler casing penetrations (electrical, control, piping, etc.) shall be thoroughly sealed with insulating foam type expanding insulation.
2. Ensure that all surfaces are clean and dry prior to installation.
3. Install insulation in accordance with manufacturer=s recommendations.
B. Install central station air handling units level and plumb, in accordance with manufacturer's written instructions.
1. Support floor-mounted units on concrete equipment bases using neoprene pads.

2. Suspended Units: Suspend units from structural steel support frame using threaded steel rods and vibration isolation springs.
3. Provide emergency drain pans below each unit and pipe to condensate/overflow drain.

C. Arrange installation of units to provide access space around air- handling units for service and maintenance.

D. Piping installation requirements are specified in other Division 23 sections. The Drawings indicate the general arrangement of piping, valves, fittings, and specialties. The following are specific connection requirements:
1. Arrange piping installations adjacent to units to allow unit servicing and maintenance.
2. Connection piping to air handling units with flexible connectors.
3. Connect condensate drain pans using manufacturer's recommended size (minimum 1-1/2 inch), Type L copper tubing. Extend to the nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at all changes in direction.
4. Duct installations and connections are specified in other Division 23 sections. Make final duct connections with flexible connections.
5. Electrical Connections: The following requirements apply:
   a. Electrical power wiring is specified in Division 26.
   b. Temperature control wiring and interlock wiring as specified in Division 23, Section 230900 - "Building Automation System".
   c. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

3.3 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust water coil flow, with control valves to full coil flow, to indicated GPM flow rates.

B. Adjust damper linkages for proper damper operation.

C. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Inspection: Arrange, provide, and pay for a factory authorized service technician/representative to perform the following:
1. Inspect the field assembly of components and installation of fans including piping, ductwork, and electrical connections.
2. Prepare a written report on findings and recommended corrective actions.
3. Witness equipment operation and certify compliance with manufacturer=s recommendations.

3.5 DAMAGED EQUIPMENT

A. Any and all equipment, parts, components, such as fans, casing, bearings, motors, etc., provided under this section which is either damaged by the contractor during rigging, installation or testing or which is received in damaged condition during shipping, transit, handling, or during installation and/or testing shall be totally replaced as a unit. Dented, or damaged superficial, non-structural, equipment jackets or surface casings such as, but not limited to; water jackets, insulation, etc., shall either be repaired or replaced at the option and sole discretion of the Owner's Representative. If non-structural components are repaired, the finished product shall match original equipment exactly. Structurally damaged equipment shall be replaced.

B. Any equipment which develops surface rust, either through improper storage, handling or installation, shall be refinished by grinding the affected area down to bare (white) metal, then prepared with a rust preventive primer and finished with the original manufacturer’s touch-up paint to match existing color.

3.6 COMMISSIONING

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:
1. Remove shipping, blocking, and bracing.
2. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Set outside-air and return-air mixing dampers to minimum outside air setting.
7. Comb heating and cooling coil fins for parallel orientation.
8. Install clean filters.
9. Verify manual and automatic volume control, and fire and smoke dampers in connected ductwork systems are in the full-open position.
10. Disable automatic temperature control operators.

B. Starting procedures for central station air handling units:
1. Energize motor, verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM on approved shop drawings.
2. Measure and record motor electrical values for voltage and amperage.
3. Shut unit down and reconnect automatic temperature control operators.
4. Refer to Division 23, Section 230593 - "Testing, Adjusting, and Balancing" for procedures for air handling system testing, adjusting, and balancing.

3.7 DEMONSTRATION & TRAINING

A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner's maintenance personnel on the following:
1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 01, "Closeout Submittals".
3. Provide Service Manuals for each air handler specified.

B. Provide three (3) hours of factory authorized training for each type or size of air handling unit.
1. Refer to Section 230010 - Mechanical General Provisions for videotaping requirements.
2. Schedule training with at least 7 days' advance notice.

END OF SECTION 237313