SECTION 23 05 00

BASIC MECHANICAL MATERIALS AND METHODS

PART 1 – GENERAL

1.01 PROVISIONS INCLUDED

A. Include General Conditions.

B. Supplementary General Conditions

C. Division 0 “Procurement and contracting Requirements”.

D. Division 01 “General Requirements”.

E. Division 02 “Existing Conditions”.

F. See Division 21 for Fire Protection

G. See Division 22 for Plumbing.

H. See Divisions 26, 27 and 28 for Electrical.

I. Section 019113 Commissioning and requirements which may affect the work of this Section.

J. Examine all other Sections of the specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

K. Coordinate work with that of all other Trades affecting, or affected by work of this Section. Cooperate with such Trades to ensure the steady progress of all work under the Contract.

1.02 DEFINITIONS

A. Words in the singular shall also mean and include the plural, wherever the context so indicates and words in the plural shall mean the singular, wherever the context so indicates.

B. Wherever the terms "shown on drawings" are used in the specifications, they shall mean "noted", "indicated", "scheduled", "detailed", or any other diagrammatic or written reference made on the drawings.

C. Wherever the term "provide" is used in the specifications it will mean "furnish" and "install", "connect", "apply", "erect", "construct", or similar terms, unless otherwise indicated in the specifications.

D. Wherever the term "material" is used in the specifications it will mean any product", "equipment", "device", "assembly", or "item" required under the Contract, as indicated by trade or brand name, manufacturer's name, standard specification reference or other description.

E. The terms "approved", or "approval" shall mean the written approval of the Architect.

F. The term "specification" shall mean all information contained in the bound or unbound volume, including all "Contract Documents" defined therein, except for the drawings.

G. The terms "directed", "required", "permitted", "ordered", "designated", "prescribed" and similar words shall mean the direction, requirement, permission, order, designation or prescription of the Architect. The terms "approved", "acceptable", "satisfactory" and similar words shall mean approved by, acceptable or satisfactory to the Architect. The terms "necessary", "reasonable", "proper", "correct" and similar words shall mean necessary, reasonable, proper or correct in the judgment of the Architect.

H. "Piping" includes in addition to pipe or mains, all fittings, flanges, unions, valves, strainers, drains, hangers and other accessories relative to such piping.

I. "Concealed" means hidden from sight in chases, furred spaces, shafts, hung ceilings, embedded in construction or in crawl spaces.

J. "Exposed" means not installed underground or "concealed" as defined above.

K. "Invert Elevation" means the elevation of the inside bottom of the pipe.

L. "HVAC, Plumbing, and/or Fire Protection Contractor" shall refer to the Contractor or his Subcontractors responsible for furnishing and installation of all work indicated on the HVAC, Plumbing, and/or Fire Protection drawings and specifications, as applicable and or referenced to each Trade in the Architectural and/or Structural documents.

M. "Mechanical Contractor" shall refer to the Fire Protection, Plumbing, HVAC and ATC Contractors, as applicable.

N. “Commissioning Agent (CA)” shall refer to the party employed by the Owner to witness the demonstration of all systems according to the commissioning plan. Refer to Section 019113.

1.03 **CODES, STANDARDS AND REFERENCES**

A. All materials and workmanship shall comply with all applicable Codes, Specifications, Local and State Ordinances, Industry Standards and Utility Company Regulations, latest editions.

B. In case of difference between Building Codes, State Laws, Local Ordinances, Industry Standards and Utility Company Regulations and the Contract Documents, the Mechanical Contractor, as applicable, shall promptly notify the Architect in writing of any such difference.

C. In case of conflict between the Contract Documents and the requirements of any Code or Authorities having jurisdiction, the most stringent requirements of the aforementioned shall govern for budgetary purposes. However, no work will proceed until the Architect determines the correct method of installation.

D. Should any Contractor, as applicable, perform any work that does not comply with the requirements of the applicable Building Codes, State Laws, Local Ordinances, Industry Standards and Utility Company Regulations, he shall bear all costs arising in correcting the deficiencies, as approved by the Architect.

E. Applicable Codes and Standards shall include all State Laws, Local Ordinances, Utility Company Regulations and the applicable requirements of the following accepted Codes and Standards, without limiting the number, as follows:
   1. National Electrical Code (NEC)
   2. Environmental Protection Agency (EPA)
   3. STATE -- Environmental Air Quality Protection Agency
   4. STATE --Energy Code
   5. International Building Code (Latest Adopted Edition), including all adopted STATE -- Supplements
   6. STATE - Fire Prevention Regulations and Elevator Regulations
   7. Local Ordinances, Regulations of the Local Building Department and Fire Department
   8. (Applies only to Hospitals) Guidelines for Construction and Equipment of hospital and Medical Facilities, as published by A.I.A. Press, ISBN 1-57165-002-4, U.S. Dept. of Health and Human Services
   9. Recommendations of the National Fire Protection Association (NFPA), latest applicable edition adopted, in general and in particular:
      a. Life Safety, NFPA 101
      b. HVAC, NFPA 90A, 90B
      c. Removal of Smoke and Grease Laden Vapors from Commercial Cooking Equipment, NFPA 96
      d. (Applies only to Hospitals) Hospitals, NFPA 99
   10. Recommendations of ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers), including:
      a. ASHRAE 90.1
      b. ANSI/ASHRAE 62-Ventilation for Acceptable Indoor Air Quality
      c. ANSI/ASHRAE 15-Safety Code for Mechanical Refrigeration
      d. ANSI/ASHRAE 110-Method of Testing Performance of Laboratory Fume Hoods
      e. ANSI/ASHRAE 55-Thermal Environmental Conditions for Human Occupancy
   11. (Applies only to Labs) In addition to the above Codes and Standards, the research laboratory systems will also be based on the specific requirements and/or recommendations of the following as they relate to laboratory systems:

a. Occupational Safety and Health Administration (OSHA) S29 CFR Part 1910, Health and Safety Standards; Occupational Exposures to Toxic Substances in Laboratories; Proposed Rule. Federal Register July 24, 1986
b. ANSI/AIHA Z9.5 American National Standard for Laboratory Ventilation
c. NFPA 45 - Standard on Fire Protection for Laboratories Using Chemicals, Chapters, 9-2.8, 9-2.9
d. NFPA 56 - Safety Standard for Laboratories in Health-Related Institutions, Chapter 3-3.5
e. Scientific Apparatus Makers Association (SAMA)
f. National Cancer Institute - Safety Standards for Research Involving Chemical Carcinogens
g. National Research Council - Prudent Practices of Handling Hazardous Chemicals in Laboratories
h. National Safety Council - Fundamentals of Industrial Hygiene
i. National Institute of Health

F. In these specifications, references made to the following Industry Standards and Code Bodies are intended to indicate the accepted volume or publication of the Standard. All equipment, materials and details of installation shall comply with the requirements and latest revisions of the following Bodies, as applicable:

1.	AMCA	Air Moving and Conditioning Association
2.	ANSI	American National Standards Institute
3.	ARI	American Refrigeration Institute
4.	ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
5.	ASME	American Society of Mechanical Engineers
6.	ASTM	American Society of Testing Materials
7.	AWS	American Welding Society
8.	CS	Commercial Standards, U.S. Department of Commerce
9.	FM	Factory Mutual
10.	FS	Federal Specification, U.S. Government
11.	MSS	Manufacturers Standardization Society of the Valve and Fittings Industry
12.	NEMA	National Electrical Manufacturers Association
13.	SMACNA	Sheet Metal and Air Conditioning Contractors' National Association
14.	UL	Underwriters Laboratories, Inc.

G. Each Contractor for the work under his charge, shall give all necessary notices, obtain and pay for all permits, pay all governmental taxes, fees and other costs in connection with his work; file for necessary approvals with the jurisdiction under which the work is to be performed. Each Contractor shall obtain all required Certificates of Inspection for his work and deliver same to the Architect before request for acceptance of his portion of work and before final payment is made.

H. All equipment shall be installed per manufacturer's recommendations and requirements. The Contractor shall notify the Engineer in writing when they intend to deviate from manufacturer's installation guidelines. The Engineer shall advise if the installation is acceptable prior to installation.

1.04 **SUBMITTALS**

A. Submit detailed shop drawings or brochures for approval of equipment and material proposed to be used on this project. Furnish the number of copies required by General Conditions.

B. Documents submitted shall show the following:
1. Principal dimensions and details of construction.
2. Operating and maintenance clearances.
3. Weights of principal parts and total weights with information required for the design of supports and foundations.
4. Sizes and location of piping and connections.

5. Performance data, including pump and fan curves; sound data including sound power dB levels in 1/3 octave bands.
6. Data on electric motors, including brake horsepower of driven equipment, nameplate ratings and classes, sound data, starting and running full load currents, required starter size and recommended overload heater ratings.
7. Approval stamp of Underwriters' and other authorities having jurisdiction of Contract Drawings requiring such approval.
8. Certified performance guarantees.
9. Calculations and details for refrigeration for field assembled systems including description of specialties and pressure drops, layout of piping with lengths fittings, and refrigerant specialties, and capacity curves for evaporator and compressor showing balance points.
10. Minimum scale for sheet metal plans and piping plans shall be ¼ inch equal 1 foot.

C. Submit brochures that contain only that information which is relative to the particular equipment or materials to be furnished. Do not submit catalogs that describe several different items other than those items to be used unless irrelevant information is marked out and relevant material is clearly marked.

D. Specifications Compliance Statement
1. The manufacturer shall submit a point by point statement of compliance with the specifications.
2. The statement of compliance shall consist of a complete copy of the project specifications with a line by line compliance statement.
3. Where the proposed system complies fully, such shall be indicated by placing the word "comply" opposite the line or paragraph number.
4. Where the proposed system does not comply, or accomplishes the stated function in a manner different from that described, a full description of the deviation shall be provided.
5. Where a full description of a deviation is not provided, it shall be assumed that the proposed system does not comply with the paragraph in question.
6. Submissions which do not include a point by point statement of compliance as specified shall be disqualified.

1.05 **GUARANTEE**

A. (Change references as applicable) Attention is directed to provisions of the General Conditions and Supplementary General Conditions regarding guarantees and warranties for work under this Contract.

B. Manufacturers shall provide their standard guarantees for work under this Contract, unless specified otherwise. However, such guarantees shall be in addition to and not in lieu of all other liabilities which the manufacturer and GC / CM may have by Law or by other provisions of the Contract Documents. In any case, such guarantees and warranties shall commence when the Owner accepts the various systems, as applicable and as determined by the Architect. The guarantees and warranties will remain in effect for a minimum period of (1) year thereafter except where longer periods are specifically stated and specified.

C. All materials, items of equipment and workmanship furnished under HVAC, shall carry the warranty against all defects in material and workmanship. Any fault due to defective or improper material, equipment, workmanship or design which may develop shall be made good, forthwith, by and at the expense of the Contractor responsible, including all other damage done to areas, materials and other systems resulting from this failure.

D. Each Contractor shall guarantee that all elements of the systems provided under his Contract, are of sufficient capacity to meet the specified performance requirements as set forth herein or as indicated on the drawings.

E. Upon receipt of notice from the Owner of failure of any part of the systems or equipment during the guarantee period, the affected part or parts shall be replaced by the responsible Contractor.

F. Each Contractor shall furnish, before the final payment is made, a written guarantee covering the above requirements.

1.06 **COMMISSIONING**

A. The TBA Contractor must also include sufficient man-hours within their bids, for their participation with the Commissioning Team and the rebalancing/readjusting/resetting all device setpoints, as required. For additional work, refer to Section 019113.

1.07 **THE PRE-FABRICATED VENDOR**

A. The Pre-Fabricated vendor shall faithfully execute his work according to the terms and conditions of the Contract and specifications and shall take all responsibility for and bear all losses resulting to him in the execution of his work.

B. The Pre-Fabricated vendor shall be responsible for the location and performance of work provided under his Contract as indicated on the Contract Documents. All parties employed directly or indirectly by each Contractor shall perform their work according to all the conditions as set forth in these specifications.

C. The Pre-Fabricated vendor shall furnish all materials and perform all work in accordance with the project specifications and any supplementary documents provided by the Architect. The work shall include every item shown on the drawings and/or required by the specifications as interpreted by the Owner. All work and materials furnished and installed shall be new and of the best quality and workmanship. The Pre-Fabricated vendor shall cooperate with the Owner and Engineer so that no error or discrepancy in the Contract Documents shall cause defective materials to be used or poor workmanship to be performed.

1.08 **COORDINATION OF WORK**

A. Locations of piping, ductwork, conduits and equipment shall be adjusted to accommodate the new work with interferences anticipated and encountered during installation. The Pre-Fabricated vendor shall determine the exact routing and location of all systems prior to fabrication or installation of any system component. Accurate measurements and coordination drawings will have to be completed to verify dimensions and characteristics of the various systems' installations.

B. Lines which pitch shall have the right-of-way over those which do not pitch. For example, waste piping shall normally have the right-of-way. Lines whose elevations cannot be changed shall have the right-of-way over lines whose elevations can be changed.

C. Offsets, transitions and changes of direction in all systems shall be made as required to maintain proper headroom and pitch of sloping lines whether or not indicated on the drawings. The Pre-Fabricated vendor shall provide manual air vents and drains as required for his work to affect these offsets, transitions and changes in direction, as applicable.

D. All work shall be installed in a way to permit removal (without damage to other parts) of coils, filters, control appurtenances, fan shafts and wheels, filters, belt guards, sheaves and drives and all other system components provided under this Contract requiring periodic replacement or maintenance. All piping shall be arranged in a manner to clear the openings of swinging overhead access doors, ceiling tiles and cleaning access doors in ductwork.
   1. Access to any and all components requiring servicing, adjustment, calibration, maintenance or periodic replacement shall be provided so that the Owner's operations personnel can freely gain access without removal of any materials other than the access panel or ceiling tile. Access shall be understood to mean free, clear and unobstructed from the floor up to the device and/or component being serviced. Access panels for VAV/CV boxes shall be 24" x 24" minimum.
   2. Fire rated access doors with closers shall be provided for all rated assemblies.

E. The Contract Drawings are diagrammatic only intending to show general runs and locations of piping, ductwork, equipment, terminals and specialties and not necessarily showing all required offsets, details and accessories and equipment to be connected. All work shall be accurately laid out with other Trades to avoid conflicts and to obtain a neat and workmanlike installation which will afford maximum accessibility for operation, maintenance and headroom.

F. Where drawing details, plans and/or specification requirements are in conflict and where pipe or duct sizes of same pipe or duct run are shown to be different between plans and/or between plans and sections or details, the most stringent requirement will be included in the Contract. HVAC systems and equipment called for in the specification and/or shown on the drawings shall be provided under this Contract as if it were required by both the drawings and specifications. However, prior to ordering or installation of any portion of work which appears to be in conflict, such work shall be brought to Owner's and Engineer's attention for direction as to what is to be provided.

G. Final location of all air distribution devices, thermostats, heaters, control devices, sprinkler heads, etc., shall be coordinated by the Pre-Fabricated vendor, as applicable. (**Note**: Sprinkler head locations shall provide the specified coverage rating and water flow density, and shall be in accordance with all applicable Codes and in full compliance with the requirements of the Owner's insurance carrier.) Offsets of ductwork, added sheet metal, fittings, elbows, flexible connections, etc., shall be provided as required to comply with the Architectural reflected ceiling plans and/or installation details. Obtain approval of locations of all devices from Architect in the field, prior to installation.

H. Equipment shown on the Plumbing, Fire Protection, HVAC and/or Architectural drawings to be provided with services, such as exhaust ductwork, piping, traps, drains, valves, etc., shall be included under this Contract as applicable, including all piping or ductwork connections to systems, to make equipment completely operable. Additional sheet metal, flexible fittings, etc., shall be provided to accomplish the above requirement, as required, all as part of this Contract, at no additional cost to the Owner.

1.09 **COORDINATION DRAWINGS**

A. Before materials are purchased, fabricated or work is begun, The Pre-Fabricated vendor shall prepare coordination drawings for all floors/areas, including buried systems/services (all-Trade-composite at ¼" scale), showing the size and location of his equipment and lines, in the manner described herein under General Requirements.

B. The cost of producing and reproducing the drawings will be included under the Contract of the Pre-Fabricated vendor, including the cost or preparation of the Architectural building outlines. This process may include multiple revisions to these drawings which will be included in the cost. The intent is to provide a fully coordinated set of documents between trades no matter how many times they may have to be redone.

C. In addition to the regular coordination drawing review, the mechanical work will also be reviewed by the Owner/Engineer to ensure that the system and equipment arrangements are suitable to provide maintenance access and service as follows:
   1. Valves and instrumentation should be grouped where possible and positioned in accessible locations.
   2. Valves on pipes of 6" and larger, positioned above 7'-0" in height from the operating level, will be provided with chain operated valve wheels and be located where chains will not interfere with primary access through the mechanical room.
   3. Location of control/diagnostic panels shall be shown and identified on the mechanical room coordination drawings.

D. Highlight all fire rated partitions on the Coordination Drawings for appropriate coordination.

E. The main paths for the installation or removal of equipment from mechanical and electrical rooms shall be clearly indicated on the Coordination Drawings.

F. Fabrication shall not start until Coordinate Drawings have been distributed to all parties as indicated herein.

G. Distribution of Coordination Drawings:
   1. The Owner's Project Manager shall provide one print of each Coordination Drawing to:
      a. Specialty trade Subcontractor.
      b. Owner.
      c. Engineer.

H. After distribution:
   1. Resolve all interferences not previously identified.

I. Coordination Drawings include but are not necessarily limited to:
   1. Structure.
   2. Partition/room layout, including indication of smoke and fire resistance rated partitions.
   3. Ceiling layout and heights.
   4. Light fixtures.
   5. Access panels.
   6. Sheet metal, heating coils, heat pumps, grilles, diffusers, etc.
   7. All heating piping and valves.
   8. Smoke and fire dampers.
   9. Soil, waste and vent piping.
   10. Major water and gases.
   11. Major electrical conduit runs, panelboards, feeder conduit and racks of branch conduit. Motor control centers, starters and disconnects.
   12. Sprinkler piping and heads.
   13. All equipment, including items in the Contract as well as O.F.C.I. and O.F.I. items.
   14. Equipment located above finished ceiling requiring access for maintenance and service. In locations where acoustical lay-in ceilings occur indicate areas in which the required access area may be greater than the suspected grid systems.
   15. Rainwater Piping.
   16. Existing conditions, including, but not limited to, Mechanical, Plumbing, Fire Protection and Electrical items.
   17. ATC panels.

1.10 **RECORD DRAWINGS**

A. Each Contractor shall maintain, current at the site, a set of Contract Drawings for his portion of the work on which he shall accurately show the actual installation of all work provided under his Contract indicating any variation from the Contract Drawings, in accordance with the General Conditions and Supplementary General Conditions. Changes whether resulting from formal change orders, requests for information, or other instructions issued by the Architect shall be recorded. Include changes in sizes, location and dimensions of piping, ducts, equipment, etc.

B. Each Contractor shall indicate progress by coloring-in various pipes, ducts and associated appurtenances exactly as they are erected. This process shall incorporate both the changes noted above and all other deviations from the original drawings whether resulting from job conditions encountered or from any other causes.

C. The marked-up and colored-up prints will be used as a guide for determining the progress of the work installed. They shall be inspected periodically by the Architect and Owner's representatives and they shall be corrected if found either inaccurate or incomplete. This procedure is mandatory. Marked up drawings shall include all flow diagrams, schedules, details and control diagrams.

D. Each Contractor shall meet at a minimum on a monthly basis, with the Owner's representative to transfer the information from his HVAC, Plumbing, Fire Protection, etc., marked-up and colored-up prints to a set which will become the basis for preparation of record drawings.

E. When the work is completed, each Contractor shall provide hard copies to the Owner’s Project Manager, drawing plots marked "Record Drawings.” The Contractor shall bear all costs of producing Record Drawings, providing all necessary drawing changes and printing the reproducible drawings for the work under his charge.

1.11 **GIVING INFORMATION**

A. Each Contractor shall keep himself fully informed as to the shape, size and position of all openings required for his apparatus and shall give information to the Architect and other Contractors **[or Subcontractors]** sufficiently in advance of the work so that all openings may be built in advance.

B. The manufacturers listed within this specification have been preselected for use on this project. No submittal will be accepted from a manufacturer other than those specified. Should any Contractor wish to propose a substitution during the bid period, such request shall be made in writing to the Architect, at least (15) working days, prior to bid date. If substitutions are deemed acceptable, such items shall be issued as an Addendum, prior to bid due date. The above requirement is mandatory.

1.12 **EQUIPMENT AND MATERIALS**

A. Equipment and materials shall be delivered to the site and stored in original sealed containers, suitably sheltered from the elements, but readily accessible for inspection by the Architect until installed. All items subject to moisture damage such as controls, filters, etc., shall be stored in dry, heated spaces.

B. Each Contractor shall have his equipment tightly covered and protected against dirt, water and chemical or mechanical injury and theft. At the completion of the work, equipment and materials shall be cleaned, polished thoroughly and turned over the Owner in a condition satisfactory to the Architect. Damage or defects developing before acceptance of the work shall be made good at each Contractor's **[or Subcontractor's]** expense as applicable.

C. Each Contractor shall make necessary field measurements to ascertain space requirements, for equipment and connections to be provided under his Trade and shall furnish and install such sizes and shapes of equipment to allow for the final installation to conform to the drawings and specifications.

D. Manufacturers' directions shall be followed completely in the delivery, storage, protection and installation of any equipment. Promptly notify the Architect in writing of any conflict between any requirements of the Contract Documents and the manufacturer's directions and obtain the Architect's written instructions before proceeding with the work. Should any Contractor perform any work that does not comply with the manufacturer's directions or written instructions from the Architect, he shall bear all costs arising in correcting any deficiencies that should arise.

E. Each Contractor shall furnish and install all equipment, accessories, connections and incidental items necessary to fully complete the work under his Contract for use, occupancy and operation by the Owner.

F. Where equipment of the acceptable manufacturers requires different arrangement or connections from those shown, it shall be the responsibility of each Contractor to install the equipment to operate properly and in harmony with the original intent of the drawings and specifications. When directed by the Architect, each Contractor shall submit drawings showing the proposed installation. If the proposed installation is approved, each Contractor shall make all necessary changes in all effected related work provided under other Sections including location of roughing-in connections by other Trades, electrical requirements, piping, supports, insulation, etc. All changes shall be made at no increase in the Contract amount or additional cost to the other Trades and/or Owner.

G. Testing Agency Labeling Requirements
   1. All equipment and materials required for installation under these specifications shall be new and without blemish or defect.
   2. All equipment shall meet OSHA standards.
   3. Equipment and materials shall be products which will meet with the acceptance of the Authorities Having Jurisdiction (AHJ) over the work and as specified hereinbefore and below.
      a. Where such acceptance by the AHJ of any given product is contingent upon having the FM Global, it shall be provided with an FM Global label and constructed in compliance with FM Global’s standards and guidelines.
      b. All products shall be listed and labeled by UL or other national testing laboratories such as ETL and the products shall be so labeled.
         1) Label of Underwriters Laboratories, ETL or other nationally recognized testing agency acceptable to the Authorities Having Jurisdiction.

2) This Labeling shall include not just the control panel and/or motor but all wiring and devices included in the package as a complete package. Note: Providing a series of individually labeled electrical devices that are then assembled into a package does not meet this requirement, the whole assembly must be labeled as an assembly. The manufacturers have the option of having the equipment inspected and Labeled at the factory or at the site after installation. This requirement shall supersede any other specification language hereinbefore or hereinafter that requires only portions of the equipment to be labeled.
3) Some examples of packaged equipment requiring Labeling:
   a) Sump pumpsets
   b) Ejector pumpsets
   c) Laboratory waste ejector pumpsets
   d) Fuel oil transfer pump skids
   e) Steam condensate pumpsets
   f) Duplex air compressor system
   g) Air handling units (packaged and custom built-up)
   h) Cooling towers
   i) Chillers
   j) Boilers
   k) Feed water equipment
   l) pH Neutralization system skids
   m) High purity water system skids (such as RODI units)
   n) Laboratory and/or Medical Air compressor skids
   o) Vacuum pumpsets
   p) Water pressure booster systems
   q) Animal watering system skids
   r) Cooling tower water filtration system
   s) Cooling coil condensate water collection and discharge systems

4. HVAC/Smoke Control System Operation
   a. On/Auto/Off switches and status indicators (LEDS) shall be provided for monitoring and manual control of each fan, damper, HVAC control unit, stairwell pressurization fan, space pressurization and smoke exhaust fan. To ensure compliance, the units supplied shall meet the following **UL categories: UUKL, PAZX, UDTZ, QVAX** as well as the requirements of NFPA 90A, HVAC, and NFPA 92A & 92B, Smoke Control. The control system shall be field programmable for either 90A operation or 92A/B operation to allow for future use and system expansion.
   b. All devices shall be UUKL listed.

H. All equipment of one type (such as valves, fans, air handling units [packaged or custom built], air terminals, heat pumps, plumbing fixtures, etc.), shall be the product of one manufacturer.

I. Equipment pre-purchased on behalf of the Owner or by the Owner himself, if assigned to any of the Contractors, shall be received, inspected, installed, etc., as if it was purchased by the Contractors as applicable. All guarantees, service contracts, etc., shall be the same as for all other equipment provided under this Contract.

1.13 CUTTING AND PATCHING

A. Each Contractor shall be responsible for all core drilling, as required for work under his Contract, but in no case shall he cut into any structural elements without the written approval of the Architect.

B. All cutting, rough patching and finish patching, shall be provided under this Contract.

C. All concrete and masonry equipment bases shall be provided under this Contract.

1.14 USE OF PREMISES

A. Each Contractor shall confine all of his apparatus, storage of materials and construction to the limits indicated on the drawings and directed by the Architect and he shall not encumber the premises with his materials.

B. In storing materials within areas (structure or ground), or when used as a shop, each Contractor shall consult with the Owner's Project Manager and shall restrict his storage to space designated for such purposes. Each Contractor will be held responsible for repairs, patching or cleaning arising from any unauthorized use of premises.

C. Notwithstanding any approvals or instructions which must be obtained by each Contractor from the Architect in connection with use of premises, the responsibility for the safe working conditions at the site shall remain each Contractor's. The Architect or Owner shall not be deemed to have any responsibility or liability in connection therewith.

D. Air handling unit or cooling tower sections shall not be used for storage of materials. The HVAC Contractor will be responsible for securing, and maintaining the equipment clean. The above requirement is mandatory.

1.15 **PROTECTION/CLEANLINESS**

A. All materials such as valves, fittings, piping, ductwork, plenums, grilles, registers, diffusers, etc., shall be properly protected from the accumulation of dirt, dust, debris or any other contaminants. All ductwork and piping openings shall be temporarily closed by each Contractor **[or Subcontractor]** installing same, so to prevent obstruction and damage, as a minimum at the end of each working day or more often if required by job conditions. Each Contractor shall take precautions to protect his materials from damage and theft.

B. Each Contractor shall furnish, place and maintain proper safety guards for the prevention of accidents that might be caused by the workmanship, materials, equipment or electrical systems provided under his Contract.

1.16 **DAMAGE CORRECTION AND EXTRA WORK**

A. Each Contractor shall be held responsible and shall pay for all damages caused by his work to the new and existing building structures and new and existing equipment, piping, duct systems, etc., and all work and finishes installed under this Contract in the new or in existing building. Repair of such damage shall be done as herein before specified, at the expense of each Contractor and to the Architect's satisfaction.

B. Each Contractor shall promptly correct all work provided under his Contract and rejected by the Architect as defective or as failing to conform to the Contract Documents whether observed before or after completion of work and whether or not fabricated, installed or completed. Each Contractor shall bear all costs of correcting such rejected work.

C. No claim for extra work will be allowed unless it is authorized by the Architect in writing before commencement of the extra said work.

1.17 **TOUCH-UP PAINTING**

A. Each Contractor shall thoroughly clean all equipment and systems provided under this Contract from rust, splatters and other foreign matter or discoloration, leaving every part of each system in an acceptable prime condition. Each Contractor, for the work under his Contract, shall refinish and restore to the original condition all equipment and piping which has sustained damage to the manufacturer's prime and finish coats of paint and/or enamel.

1.18 **HOUSEKEEPING PADS**

A. Coordinate housekeeping pads for:
   1. All equipment indoors or outdoors
   2. All floor supports or braces

B. Pads shall be 6" above the finished floor for air handling units and 4" above the finished floor for all other equipment.

C. Each pad shall be a minimum of 6" larger then the equipment, support or isolation base in all directions.

D. Pads shall be formed, poured with concrete, and tooled by the Owner's Project Manager.

1.19 DUCT AND PIPE SLEEVES, PLATES AND ESCUTCHEONS, FIRESTOPPING AND SMOKEPROOFING

A. Where piping and/or ductwork pass through masonry or concrete walls or drywall partitions or floors, each Contractor shall provide and set individual sleeves for each pipe or duct and all other work under his charge, as necessary for passage of all pipes and/or ducts. Sleeves shall be of sufficient size to provide 1/2" air space around the pipe or duct passing through (including insulation where pipes or ducts are internally/externally insulated). All openings shall be sealed, smokeproofed and made tight. Each Contractor shall be responsible for the exact location of sleeves provided under his Contract and shall coordinate all requirements for piping and ductwork sleeves.

B. Each Contractor, for work under his charge, shall determine the required inside diameter of each individual wall opening or sleeve before ordering, fabrication or installation.

C. Sleeves and inserts shall not be used in any portions of the building, where their use would impair the strength or construction features of the building. Elimination of sleeves must be approved by the Architect.

D. Provide chrome plated brass escutcheons with set screw for exposed piping, in all areas except in mechanical rooms. In this area use plain brass or cast iron escutcheons suitable for painting. All escutcheons shall be sized to fit the bare pipe or insulation in a snug and neat manner. They shall be of sufficient size to cover sleeved openings for the pipes and of sufficient depth to cover sleeves projecting above floors. Escutcheons shall be as manufactured by Beaton & Caldwell, Dearborn Brass, or Grinnell.

E. Pipe or duct sleeves shall be made of Schedule 40 pipe, 20 gauge galvanized steel or 16 gauge steel as follows:
   1. Sleeves on pipes passing through masonry or concrete construction shall be Schedule 40 pipe.
   2. Sleeves on ducts passing through concrete construction shall be 20 gauge steel unless required otherwise by item 4 below.
   3. Sleeves on pipes or ducts passing through fire rated partitions shall be 16 gauge steel.
   4. Sleeves on pipes or ducts passing through non-rated drywall construction shall be 20 gauge galvanized steel.

F. Pipe or duct sleeves shall be set as follows:
   1. Set sleeves 1" above finish floor, (except set sleeves, 6" above finish floor at penthouses or mechanical rooms and 6” above finished roof) and flush on each side of walls. Coordinate roof penetrations with roof Subcontractor.
   2. Sleeves shall be set securely in place before concrete is poured when placed in concrete construction.
   3. Provide sheet metal sleeves for all duct penetrations and cover with sheet metal plates all penetrations after ductwork has been installed through walls/floors.

G. Each Contractor shall fire stop, smoke stop, and/or acoustically seal the space between the sleeves provided under his Contract and piping or ductwork as applicable, as follows:
   1. See Specification Section 230584 Through Penetration Firestopping System

H. Except as otherwise specified, underground piping passing through exterior walls or foundation slabs on grade, shall have penetration closures of the modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening. Links shall be loosely assembled with bolts to form a continuous belt around the pipe and with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the rubber sealing elements to expand and provide an absolutely watertight seal between the pipe and wall, reducing chances of cathodic reaction between these members. Each Contractor for work under his charge shall determine the required inside diameter of each individual wall opening or sleeve before ordering, fabrication or installation. The inside diameter of the wall opening shall be sized to fit the pipe and ensure a watertight joint. Where applicable, when installing seals, take into account the pipe O.D. if non-standard due to coating or jacketing.

1.20 **MISCELLANEOUS IRON AND STEEL**

A. Each trade shall provide all primary and secondary steel supports and hangers as shown on the drawings and/or as required to support equipment, ductwork, piping, exhaust fans, or any other materials provided under the work of this Section.

B. The work of this Section of designing, furnishing and installing all miscellaneous metal work associated with the system, and related items as indicated on the drawings and/or as specified herein, and includes, but is not limited to the items listed herein below.

C. The scope of work shall include:
   1. Exhaust fan support platforms including ship ladders, steel grating for decking, cross-bracing and floor stands.
   2. Intermediate beams to hang ductwork and piping from the roof. All piping and ductwork must be hung from beam or supported from the floor. Provide supplemental steel for support of equipment.
   3. Support of ductwork and piping in shafts in addition to support provided by structure.
   4. Support of ductwork via floor stands as required.
   5. Heat exchanger support racks.
   6. Piping support in underground concrete trench and manholes.
   7. Pipe anchors in the building.
   8. Hangers, brackets, angle irons or rods required for the support and protection of HVAC, plumbing and fire protection equipment.
   9. Field prime painting of galvanized steel and field finish painting.

D. Shop Drawings for General Miscellaneous Items
   1. Submit Shop Drawings of all miscellaneous metal items to Architect for approval, showing sizes and thickness of all members, types of materials, methods of connection and assembly, complete dimensions, clearances, anchorage, relationship to surrounding work by other Trades, shop paint, and other pertinent details of fabrication and installation.

E. The Subcontractor shall engage the services of a Professional Engineer registered within the state wherein the project is located to prepare complete Design Drawings and structural design computations based on, and closely following, the design and details on the Drawings. The Design Drawings and structural design computations, with the Engineer's seal affixed thereto, shall be submitted to the Architect for review. The structural design computations shall provide a complete structural analysis, including anchors and fastening devices, and shall certify as to conformation to governing laws and codes. These submittals, upon review, must be sufficient, when taken in conjunction with this Specification to provide the complete basis of the fabrication and erection.

F. Samples
   1. Submit duplicate samples of all materials to be furnished under this Section if, and in size and form, requested by Architect.

G. Do not order materials or begin fabrication until Architect's approval of submittals has been obtained.

H. In addition to the governing laws and codes, the following Specifications and Codes form a part of this Specification:
   1. American Iron and Steel Institute applicable standards.
   2. American Institute of Steel Construction "Code of Standard Practice for Steel Buildings and Bridges" and "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings".
   3. American Welding Society Code: Standard Code for Arc and Gas Welding in Building Construction.

I. All materials shall be new stock, free from defects impairing strength, durability or appearance and of best commercial quality for each intended purpose.
   1. Unless other wise specifically called for, work of this Section shall be fabricated of structural steel conforming to ASTM Specification A36.

2. Steel pipe shall be seamless steel pipe conforming to ASTM Specification A53, Schedule 40.
3. Steel tubing shall be seamless steel tubing conforming to ASTM Specifications A500 to A501.
4. Construction specialties such as slotted inserts, wedge inserts, etc., shall be as manufactured by Hohmann and Barnard, Gateway Erectors, Inc., Richmond Screw Anchor Co. or equal approved by Architect.
5. Non-ferrous metals shall be as specified under descriptions of specific items, herein below.

J. Provide all anchors, bolts, sockets, sleeves, and other parts required for securing each item of work of this Section to the construction, including furnishing to concrete workers all required insets and sleeves for use at concrete.
1. All exposed fastenings shall be of the same material and finish as the metal to which applied, unless otherwise noted.
2. Welding rods shall conform to AWS Standards and the recommendation of the welding rod manufacturer.
3. Shop primer for other ferrous surfaces shall be a high-quality, lead-free, rust-inhibitive primer, Tnemec No. 10-99 Metal Primer or equivalent by Devoe and Raynolds Co., Carboline or equal.

K. Metal surfaces shall be clean and free from mill scale, flake, rust and rust pitting. Metal work shall be well formed and finished to required shape and size, true to details, with straight, sharp lines and angles and smooth surfaces. Curved work shall be true radii. Exposed sheared edges shall be eased.

L. Weld all permanent connections. Welds shall be continuous on all exposed surfaces and where required for strength on concealed surfaces. Exposed welds shall be ground flush and smooth, with voids filled with metallic filling compound (metallic filling compound not permitted on surfaces to receive hot-dip galvanizing). Tack-welding will not be permitted unless specifically called for. Do not use screws or bolts where they can be avoided. Where used, heads shall be countersunk, screwed up tight, and threads nicked to prevent loosening.

M. Fastenings shall be concealed where practicable. Thickness of metal and details of assembly and supports shall give ample strength and stiffness. Joints exposed to weather shall be formed to exclude water.

N. Do all cutting, punching, drilling and tapping required for attachment of anchor bolts and other hardware and for attachment of work by other Trades. All such cutting, punching, drilling, etc., shall be done prior to hot-dip galvanizing of the various components.

O. Live loads shall be not less than the minimum required by law. Where specific live load are not set forth in the laws and codes applicable to this work, and are not given on the Drawings or in this Specification, designs shall be such as to support the live loads which may normally be imposed without failure, without deflection of more than 1/360 of length of any member, and without permanent deformation, all with a factor of safety of not less than 2 1/2 to 1.

P. Shop Painting
1. All ungalvanized ferrous metals under this Section shall be given a shop coat of rust inhibitive primer of type specified above.
    a. Immediately before shop painting, remove all rust, loose mill scale, dirt, weld flux, weld spatter, and other foreign material with wire brushes and/or steel scrapers. Power tool clean in accordance with SSPC SP-3 (Power Tool Cleaning). Remove all grease with oil by use of solvent recommended by paint manufacturer. Sandpaper exposed surfaces as required to produce smooth, even finishes.
    b. Apply paint by spray process in strict accordance with manufacturer's printed instructions to uniform thickness(es) recommended by manufacturer. Apply thoroughly and evenly and work well into corners and joints taking care to avoid sags and runs.

c. Do not paint surfaces to be embedded in concrete, or to be welded in the field. After field welds are complete, grind smooth and flush, thoroughly clean and then apply specified primer over all unprimed in the field by brush roller.
d. After erection, sand smooth and retouch all portions of the shop coats chipped or damaged during erection, and coat all field welds and connections with primer equivalent to that used for the shop coat.

Q. Installation
1. All materials shall be carefully handled and stored under cover in manner to prevent deformation and damage to the materials and to shop finishes, and to prevent rusting and the accumulation of foreign matter on the metal work. All such work shall be repaired and cleaned prior to erection.
2. Work shall be erected square, plumb and true, accurately fitted, and with the tight joints and intersections. All anchors, inserts and other members to be set in concrete or masonry shall be furnished loose by this Trade to be built-into concrete and masonry and by those Trades as the work progresses. Later cutting or drilling shall be avoided wherever possible.
3. All metal work shall be rigidly braced and secured to surrounding construction, and shall be tight and free of rattle, vibration, or noticeable deflection after installed.
4. Where members, other than expansion bolts or inserts, are fastened into concrete, set such members in holes formed as specified below, and secure permanently in place by installation of proprietary-type expanding grout manufactured specifically for such purpose, used strictly in accordance with manufacturer's directions. Holes to receive members shall be formed with galvanized sheetmetal sleeves, expanded polystyrene foam, or other approved method to provide at least 1/2 inch clearance around entire perimeter. At exposed applications, hold expanding grout back 1/2 inch from finish surface and fill voids with Portland cement grout to match color and texture of surrounding concrete surface.
5. Electrolytic Isolation
a. Where dissimilar metals are to come into contact with one another, isolate by application of a heavy coating of bituminous paint on contact surfaces in addition to shop coat specified above. Do not permit the bituminous paint in any way to remain on surfaces to be exposed or to receive sealant.

R. Description of Major Items
1. The items described below constitute the major part of the work of this Section, but are not intended or implied to cover each and every item that may be required to properly complete the work. Carefully review the Drawings to determine the full extent of the miscellaneous metal work required.

S. Steel Ladders/Platforms
1. Fabricate and install interior steel ladder at fans, air handling units, filter racks and all equipment requiring service. Ladders shall have a safety cage as required by OSHA regulations.
2. Except as may be otherwise indicated on the Drawings, ladder shall be minimum 16 inches wide, fabricated of minimum 3/8 inch by 2 1/2 inches hot rolled steel rails and minimum 3/4 inches outside diameter steel pipe rungs. Rungs shall be spaced 12 inches on center and shall be continuously welded to the rails. Provide a pair of steel clip angles or wall brackets at bottom and steel anchor plates or wall brackets at top, welded to the rails, as indicated.
3. Exterior steel ladders shall be hot dip galvanized after fabrication as specified hereinbefore. Rungs are to have non-slip surfaces.
4. All shall be OSHA and ANSI compliant.

T. Gratings and Frames
1. Fabricated and install steel gratings and frames at fan platforms.
2. Steel grating frames shall consist of a steel angle perimeter frame constructed of steel angles, at least 4 inches by 4 inches by 3/8 inches carried around perimeter with coped or

mitered, full-welded corners. Perimeter frames shall be anchored with 7/16 inch minimum diameter expansion bolts or other suitable devices of adequate capacity, at corners, two (2) per beam end and spaced not more than 2 feet on center around full perimeter.

3. Steel Gratings shall be pressure-locked type, with bearing bars spaced 1 3/16 inch on center and cross-bars spaced 4 inches on center. Sizes of bars shall be as required by manufacturer's loading tables to limit deflection of any member across any span to 1/240th of the span at live load of 100 pounds per square foot. Gratings shall be as manufactured by Borden Metal Products, Co., Irving Subway Grating Co., Reliance Steel Products Co., approved by Architect.
4. All (gratings and) frames shall be hot-dip galvanized after fabrication as specified hereinbefore (aluminum, FRP).

U. Miscellaneous Items
1. Carefully review all Drawings for miscellaneous metal items required but not specifically listed above, such as miscellaneous steel clip angles, miscellaneous steel bracketing, and other miscellaneous metal items as indicated on the Drawings, reasonably implied therefrom, or reasonably necessary for the thorough completion of the work.
2. Provide rigid and secure anchorage of all components whether or not specifically described in complete detail on the Drawings.

V. Piping supports shall be coordinated with the building structure and shall span between roof beams as required.

1.21 WATERPROOFING, FLASHING AND COUNTERFLASHING

A. Unless specifically indicated otherwise on the drawings, each Contractor shall provide all counterflashing and waterproofing of all piping, ductwork and equipment provided by him, which pierce roofs, walls and other weatherbarrier surfaces. All work under this paragraph shall be coordinated with the GC / CM.

B. All work shall be performed in a workmanlike manner to ensure weatherproof installation. Any leaks developed due to each Contractor's work shall be repaired at his expense, to the Architect's satisfaction.

C. Pipes passing through slabs shall have the sleeve extended above floors as hereinbefore specified to retain any water and the space between the pipe and sleeve caulked waterproof fire stopping. The top and the bottom shall be sealed with monolastic caulking compound.

D. All flashing required for ductwork and piping penetrations shall be provided by the GC / CM.

1.22 ELECTRICAL WORK, MOTORS, MOTOR CONTROLLERS

A. See Section 230513 MOTORS AND CONTROLLERS.

B. See Divisions 26, 27 and 28 for Electrical.

1.23 IDENTIFICATION OF MATERIALS

A. See Section 230553.

1.24 VALVE TAGS, NAMEPLATES AND CHARTS

A. See Section 230553.

1.25 PARTS LIST AND INSTRUCTIONS FOR OPERATION AND MAINTENANCE

A. Each Contractor shall thoroughly instruct the representative(s) of the Owner, to the complete satisfaction of the Architect, in the proper operation of all systems and equipment provided by him. Each Contractor shall make arrangements, via the GC / CM as to whom the instructions are to be given in the operation of the basic and auxiliary systems and the periods of time in which they are to be given. The Architect shall be completely satisfied that the representative of the Owner has been thoroughly and completely instructed in the proper operation of all systems and equipment before final payment is made. If the Architect determines that complete and thorough instructions have not been given by each Contractor to the Owner's representative, then each Contractor shall be directed by the Architect to provide whatever instructions are necessary until the intent of this paragraph of the specification has been complied with. All time

required for Owner's instruction to satisfy the above requirements shall be included in this Contract. No extra compensation for such instructions will be allowed.

B. Each Contractor, including but not limited to, the HVAC Contractor, shall submit to the Architect for approval, a total of (6) typed sets, bound neatly in loose-leaf binders, of all maintenance and operating instructions for the installation, operation, care and maintenance of all equipment and systems. All data and literature furnished shall be specific for the make and model of the equipment furnished. General non-specific catalog data will not be acceptable. Information shall indicate possible problems with equipment and suggested corrective action. The manuals shall be indexed for each type of equipment. Each section such as fans, valves, plumbing fixtures, hot water heaters, boilers, air handling units, etc., shall be clearly divided from the other sections. A sub-index for each section shall also be provided. The methodology of setting-up the manuals shall be submitted to the Architect and Owner through the Owner's Project Manager for approval prior to final submission of manuals.

C. The instructions shall contain information deemed necessary by the Architect and shall include, but not be limited to, the following:
   1. Instructional classes on equipment and systems operation for Owner's representative and maintenance personnel, by engineering staff of each Contractor. Minimum of 48 hours of instruction for minimum of (6) people. Instruction shall include:
      a. Explanation of manual and its use.
      b. Summary description of the HVAC systems.
      c. Purpose of systems.
   2. System
      a. Detailed description of all systems.
      b. Illustrations, schematics, block diagrams, catalog cuts and other exhibits.
   3. Operations
      a. Complete detailed, step-by-step, sequential description of all phases of operation for all portions of the systems, including start-up, shutdown, adjusting and balancing. Include all posted instruction charts.
   4. Maintenance
      a. Parts list and part numbers.
      b. Maintenance, lubrication and replacement charts and manufacturer's recommendations for preventive maintenance, as applicable to his work.
      c. Troubleshooting charts for systems and components.
      d. Instructions for testing each type of part.
      e. Recommended list of on-hand spare parts.
      f. Complete calibration instructions for all parts and entire systems.
      g. Instruction for charging, filling, draining and purging, as applicable.
      h. General or miscellaneous maintenance notes.
   5. Manufacturer's Literature
      a. Furnish complete listing for all parts required for models actually furnished.
      b. Names, addresses and telephone numbers of manufacturers and suppliers.
      c. Describe and operation of all models actually furnished.
      d. Furnish all and only pertinent brochures, illustrations, drawings, cuts, bulletins, technical data, certified performance charts and other literature with the model actually furnished to be clearly and conspicuously identified.
      e. Internal wiring diagrams and engineering data sheets for all items and/or equipment furnished under each Contract.
      f. Guarantee and warranty data.
   6. Each Contractor shall furnish instructions for lubricating each piece of equipment installed by him. Instructions shall state type of lubricant, where and how frequently lubrication is required. Frame instructions under glass and hang in a location as directed by Architect.

1.26 **MANUFACTURER'S REPRESENTATIVE AND COMMISSIONING OF SYSTEMS**

A. Each Contractor shall provide, at appropriate time or as directed by the Architect, the on-site services of a competent factory trained Engineer or authorized representative of particular

manufacturer of equipment provided under his Contract, such as for the air handling units, automatic temperature controls, building automation system (BAS), fire pump, domestic hot water heaters, boilers, etc., provided under this Contract, to instruct the Owner, inspect, adjust and place in proper operating condition any item provided by him, as applicable.

B. The HVAC Contractor, as applicable, shall commission and set in operating condition all major equipment and systems, such as the condenser water, hot water and all air handling systems, etc., in the presence of the applicable equipment manufacturer's representatives, and the Owner and Architect's representatives. In no case will major systems and equipment be commissioned by any of the Contractor's forces alone, without the assistance or presence of the equipment manufacturers.

C. A written report shall be issued by the particular equipment manufacturer and the Mechanical Contractor summarizing the results of the commissioning and performance of each system for the Architect's record. No additional compensation will be allowed for any Contractor for such services.

D. The Contractor shall prepare and submit to the Architect for acceptance, a schedule of anticipated system commissioning. No system shall be commissioned without prior acceptance of the schedule by the Architect and Owner. No systems shall be commissioned prior to submittal and acceptance of Operation and Maintenance Manuals.

1.27 **CONNECTIONS TO EQUIPMENT**

A. Each Contractor shall provide all duct and/or pipe connections, condensate traps, drains, overflows, relief valves and vents, power connections, etc., to make equipment operable, as provided under other Sections of the specifications, as shown on the Architectural and/or each Trade's drawings and herein specified, including final connections to equipment to result in a complete system, fully operational. Coordinate location of all equipment with Architect. Obtain installation diagrams and methods of installation of all equipment from manufacturers. Follow instructions strictly. If additional information is required, obtain same from Architect. If equipment is indicated on the Architectural drawings, it shall also be construed and understood by the Mechanical Contractor to be constructed as shown on the HVAC drawings and shall be fully serviced and connected at no extra cost to the Owner.

1.28 **SMOKE DETECTION AND FIRE SAFETY SYSTEMS**

A. All duct or unit mounted smoke detectors shall be furnished and wired to the building fire alarm system by the Electrical Contractor. All smoke detectors required in units and ducts and for smoke barrier dampers shall be installed in the field by the HVAC Contractor. Refer to the Contractor Coordination Matrix contained under item **1.34** of this section.

B. All smoke dampers, except in built-up air handling units, shall be furnished by the ATC Contractor with electric actuators field wired by the ATC Contractor. Dampers shall be field installed by the HVAC Contractor, except dampers in the air handling units.

C. The Electrical Contractor, when providing smoke detectors, shall include additional contacts, as required and coordinated with the ATC Contractor, to allow for other control functions, as specified hereinafter. Close coordination must be exercised to allow for the provision of contacts.

D. All smoke detectors shall be installed as recommended by the smoke detection system manufacturer in sheet metal ducts or plenums to ensure that the sensing elements are effective and shall coordinate installation of smoke detectors with the Electrical Contractor and detector manufacturer.

E. The HVAC Contractor shall provide access doors to make all such detection heads accessible, and shall provide bracing for smoke detection sampling tubes, as recommended by the detector manufacturer, to properly and securely support such tubes.

F. If duct smoke detectors are required to be installed in ducts that are exposed to outside ambient conditions, they shall be installed in ventilated accessible weatherproof enclosures. See details on HVAC Drawings.

1.29 **ELECTRICAL ROOM REQUIREMENTS**

A. The HVAC Contractor [or Subcontractors] shall not install any piping, ductwork or equipment in or through electrical rooms, transformer rooms, electrical closets, telephone rooms or elevator machine rooms, unless piping, ductwork or equipment is intended to serve these rooms. If any Contractor violates this requirement, he shall remove and/or relocate all items as required at his expense and to the satisfaction of the Architect.

1.30 **HOISTING EQUIPMENT AND MACHINERY**

A. All hoisting equipment and machinery required for the proper and expeditious prosecution and progress of the work under this Contract shall be furnished, installed, operated and maintained in safe condition by each Contractor for his material and/or equipment delivered to the designated hoisting area. All costs for hoisting operating services shall be borne by the Mechanical Contractor for all equipment and work under his charge.

1.31 **STAGING**

A. All staging, exterior and interior, required to be over 8'-0" in height, shall be furnished and erected by each Contractor for work under his charge and maintained in safe condition by him for proper execution of his work.

1.32 **PHASING, DEMOLITION AND MAINTAINING EXISTING SERVICES**

A. During the execution of the work, required relocation of existing equipment and systems in the existing areas where new work and connections are scheduled to be made shall be performed by each Contractor as indicated on the drawings, as required by the job conditions and as determined by the GC / CM in close cooperation with the Architect and Owner's designated representative to facilitate the installation of the new systems and completion of this Contract. The Owner will require the continuous operation of all existing systems, while demolition, relocation work of new tie-ins are being performed. (Renovation work only.) Outages required for construction purposes shall be scheduled for the shortest practical periods of time, in coordination with the Owner's designated representative for specific, mutually agreeable periods of time after each of which the interruption shall cease and service shall be restored. This procedure shall be repeated to suit the Owner's working schedule as many times as required until all work is completed.

B. Prior to any deactivation and relocation, capping, valving, tie-in or demolition work, consult the drawings and arrange a conference with the Architect and the Owner's representative in the field to inspect each of the items to be deactivated, removed or relocated. Care shall be taken to protect all equipment designated to be relocated and reused. Give notice to all parties, with a minimum of (5) working days in advance.

C. All draining of existing systems, filling and venting required to remove and relocate existing piping systems shall be included and provided under this Contract as required to perform the various equipment or piping relocations or new tie-ins.

D. Except as otherwise noted, all deactivation, safe capping, valving, etc., of systems designated to be demolished shall be provided by each Trade, as applicable, and all demolition, removal and disposal of demolished materials shall be performed by the GC / CM. All equipment scheduled to be removed shall be inspected by the Owner, and, if he decides that such equipment is to be salvaged, each Contractor shall deliver said equipment to an area within the site boundaries as determined by the Owner and Architect.

E. The phasing of the work shall be performed in strict accordance with the GC / CM construction schedule. The new systems will be installed and completely commissioned prior to occupancy. Coordinate requirements for temporary heat or rerouting of existing services as required to accomplish the construction schedule.

1.33 **CONTROL WIRING**

A. The ATC Contractor shall provide all control and interlock wiring for all systems provided under the HVAC, plumbing and ATC Contracts.

B. All control wiring shall be installed in conduit and in accordance with the respective equipment manufacturer's requirements, and all connections shall be provided by the Mechanical and/or the ATC Contractor. All conduit and wiring provided by these Contractors shall be installed in accordance with the requirements of Section 26 of the specifications.

1.34 **COMPONENT COORDINATION**

A. The HVAC, ATC and Electrical Contractors Scope of Work shall be implemented in accordance with the following matrix:

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring
Smoke Detectors	26	23	26	25	26
Smoke Dampers in or at AHUs	23	23	N/A	N/A	N/A
Smoke Damper Actuators in or at AHUs	Damper Mfr	23	26	25	N/A
Smoke Dampers	23	23	N/A	N/A	N/A
Smoke Dampers Actuators	Damper Mfr	23	26	28	N/A
Fire Dampers	23	23	25	25	N/A
Supply and Exhaust Boxes	23	23	25	25	N/A
Box Flow Pick-Up	Box Mfr	Box Mfr	N/A	Box Mfr	N/A
Box Damper Actuator	25	Box Mfr	25	25	N/A
Box DDC Controller	25	Box Mfr	25	25	N/A
Box Coil Valve	25	23	N/A	25	N/A
Supply/Exh.	25	23	N/A	25	N/A
Valve Actuator	25	25	N/A	25	N/A
Supply Valve Reheat Coil	23	23	N/A	N/A	N/A
Reheat Coil Valve	25	23	N/A	25	
Laboratory Control Panel	25	25	26	25	N/A
Sheet Metal Damper	23	23	N/A	N/A	N/A
Sheet Metal Damper Actuators	25	25	25	25	
Energy Meters	25	23	26	25	N/A
Flow Measuring Stations	25	23	N/A	25	N/A
DDC Panels	25	25	26	25	N/A
Air Compressor	25	25	26	25	N/A
Air Dryer	25	25	26	25	N/A
Fuel Oil System	23	23	26	25	N/A
Control Valves	25	23	25	25	N/A
Humidifiers	23	23	N/A	25	N/A
Humidifier Valve	23	23	N/A	25	N/A
Humidifier Airflow Switch	25	25	N/A	25	N/A
VSDs at EAHU	23	23	26	25	N/A

PART 2 – PRODUCTS

2.01 **NOT USED**

PART 3 – EXECUTION

3.01 **NOT USED**

END OF SECTION

SECTION 23 05 19.20

HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Section 230500 and other Division 1 Specification Sections, apply to this Section.

1.02 WORK INCLUDED

A. Secure all permits and local/state approvals for the installation of all components included under this Section.

1.03 RELATED SECTIONS

A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

1.04 REFERENCES

A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.

B. ASME: American Society of Mechanical Engineers

C. ANSI: American National Standards Institute
   1. B16.1: Cast Iron Pipe Flanges and Flanged Fittings
   2. B16.3: Malleable Iron Threaded Fittings
   3. B16.4: Cast Iron Threaded Fittings
   4. B16.5: Pipe Flanges and Flanged Fittings
   5. B16.22: Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
   6. B31.1: Power Piping

1.05 SUBMITTALS

A. See Section 230500 and General Conditions for additional requirements.

B. Product Data: Include steam/condensate specialties, pipe fittings and accessories. Provide manufacturers catalogue information.

C. Manufacturer’s Installation Instructions: Indicate hanging and support methods, joining procedures.

D. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.06 QUALITY ASSURANCE

A. Installer: Company specializing in performing work of the type specified in this section, with documented experience.

1.07 REGULATORY REQUIREMENTS

A. Conform to ASME B31.9 code for installation of steam and condensate piping systems including specialties.

B. Welding Materials and Procedures: Conform to ASME (BPV IX) and applicable state labor regulations.

1.08 DELIVERY, STORAGE AND HANDLING

A. Provide temporary end caps and closures piping and fittings. Maintain in place until installation.

B. Protect piping systems and specialties from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.09 **ENVIRONMENTAL**

A. Do not install equipment when environmental conditions are outside the specific limitations of the referenced codes and manufacturer's recommendations.

PART 2 - PRODUCTS

2.01 **GENERAL**

A. Provide thermometers and gauges:
   1. At each inlet and outlet of each air handling unit coil
   2. At each pump
   3. At each heat exchanger
   4. At each boiler
   5. At each chiller
   6. At each cooling towers cell
   7. At each flow meter station
   8. As shown on the drawings
   9. As required

B. Thermometers and pressure gauges shall be provided for the above described equipment regardless of pipe size. If pipe size is such that the installation of wells or taps is not feasible, then oversized pipe to accommodate the above installation requirements.

C. No products containing mercury will be acceptable.

2.02 **THERMOMETERS**

A. Acceptable manufacturers subject to compliance with the specifications.
   1. Weksler
   2. Moeller
   3. Taylor
   4. Dresser
   5. WIKA Instrument Corp.
   6. Miljoco

B. All thermometers in liquids shall have separable sockets.

C. Thermometers shall be with glass fronts, aluminum or phenol cases, and adjustable as required for ready reading from the floor.

D. All thermometers shall use non-toxic liquid filled magnifying lens front tubes.

E. All thermometers shall have 9" scales and 12" cases.

F. All thermometers shall be accurate to ±1% of scale range.

G. Thermometer ranges shall be selected so that the normal operating range of each will occur in the middle half of the total range and so that under minimum and maximum conditions thermometers will not be harmed.

2.03 **THERMOMETER WELL**

A. 304 or 316 stainless steel tapered shank.

B. Where installed in insulated systems provide extended neck.

C. 3/4 inch NPT process connection; 1/2 inch NPT instrument connection and nominal 1/4 inch bore.

2.04 **GAUGES**

A. Acceptable manufacturers subject to compliance with the specifications.
   1. Weksler
   2. Dresser
   3. Fisher & Porter
   4. WIKA Instrument Corp.
   5. Miljoco

B. Except for the automatic temperature control system, gauges shall be constructed with bourdon type bronze tubes, stainless steel movements, white dials, black micrometer adjustable points, aluminum or phenol surface mounted beaded cases, matching aluminum or phenol screwed rings and bottom connections. All gauges shall have 4 1/2" diameter cases. All gauges shall be accurate to 1% of scale range.

C. Gauge ranges shall be selected such that the normal operating range of each will occur in the center of the total range and under minimum and maximum conditions no gauge will be harmed.

D. All gauges shall be provided with needle valves

1. Barstock needle Valves shall be equal to:
   a. Crane
   b. Edward
   c. Dresser.
   d. WIKA Instrument Corp.

E. Gauges installed in pump discharge piping shall be provided with snubbers and steam with siphons equal to Ray.

2.05 **PRESSURE/TEMPERATURE TAPS**

A. Acceptable manufacturers subject to compliance with the specifications.
1. Sisco P/T Plugs.
2. Peterson Equipment Company.
3. Fairfax Company
4. WIKA Instrument Corp.

B. All pressure/temperature taps shall have a solid brass 1/4" or 1/2" NPT fitting (test plug).

C. Test plug shall be capable of receiving either a pressure or temperature probe 1/8" o.d. Valve core shall be neoprene for temperatures 60°F to 200°F, nordel to 350°F, and shall be rated zero leakage from vacuum to 1000 psig.

D. The Contractor shall also furnish the following:
1. Pressure gauge adapters with 1/16" and 1/8" o.d. probe
2. 5" stem pocket testing thermometers for 25° to 125°F (chilled water)
3. 5" stem pocket testing thermometers 0° to 220°F (hot water)
4. 5" stem pocket testing thermometers 50° to 500°F (temperatures above 220°F).
5. A Master test kit which shall contain
   a. A 2 1/2" test gauge of suitable range
   b. A gauge adapter with 1/16" and 1/8" o.d. probe
   c. A 5" stem pocket testing thermometers 0° to 220°F
   d. A 5" stem pocket testing thermometers 50° to 550°F).

2.06 **PRESSURE DIFFERENTIAL GAUGE**

A. Acceptable manufacturers subject to compliance with the specifications.

1. Similar to ITT Barton Instruments Company.

B. Dual rupture proof liquid filled bellows having integral temperature compensation.

C. Designed to withstand repeated overranges equal to the working pressure of the instrument housing without causing a calibration change. Gauge and components shall be suitable for a working pressure of 200 psig and a water temperature of 200 degrees F.

D. Motion transmission is by a hermetically sealed torque tube, no lubrication required.

E. Dial shall be a minimum of 6 inches round. Indicator case shall be fabricated from die-cast aluminum and finished in black epoxy paint. The indicating scale shall be graduated uniformly for measurement of differential pressure.

F. Scale shall be calibrated in 1 psig increments. Full scale range shall be from 0 to 25 psig.

G. The indicating mechanism shall consist of a precision-made, jeweled, rotary movement. It multiplies rotation of the torque tube through a gear and pinion to the indicating pointer. The indicating pointer shall traverse a 270 degree arc. The movement shall have micrometer screws for convenient zero and range adjustments. Zero and range adjustments shall be made without removing the scale plate or the pointer. The rotary movement and the pointer should be fully protected from overrange in either direction.

H. Accuracy shall be within 2 percent of the full scale differential pressure range when operating at or below 200 psig.

I. A three-valve manifold shall be used. The manifold shall provide two block valves and a bypass valve for installation and zero check. Valves shall also be provided on the instrument housings for bleeding or venting.

J. Two 10 foot neoprene hoses shall be included with the differential pressure gauge. Hoses shall be equipped with 1/4 inch NPT male fittings for connecting to the manifold. The other end of the hoses shall have an adaptor to mate with the pressure temperature tap.

K. The differential pressure gauge, valve manifold, bleed valves, hoses and instruction booklet shall all be placed in a plastic carrying case. The gauge indicator and manifold shall be permanently mounted on the base of the case. The case cover shall be equipped with a handle fastened to the base with toggle type latches.

L. Differential pressure gauge shall be similar to ITT Barton Model 247A.

2.07 RELIEF VALVES

A. Acceptable manufacturers subject to compliance with the specifications.
   1. Bell and Gossett, ITT
   2. Amtrol
   3. Watts Regulator Company
   4. Kunkle Valve Company

B. Relief valve body shall be of iron or bronze construction.

C. ASME rated direct spring loaded type, level operated, non-adjustable factory set discharge pressure.

D. For expansion tank application, select system relief valve pressure setting and equipment relief valve pressure setting as indicated on mechanical contract drawings.

E. Pressure relief valve shall be suitable for maximum system operating pressure and temperature.

2.08 AIR VENTING AND DRAINAGE

A. Manual air vent.
   1. Provide hose end ball valves, (minimum size 1/2" with chains and caps), or larger where shown or required by the service.
   2. See HVAC Valve specification

B. Automatic air vent.
   1. Acceptable manufactures subject to compliance with the specifications:
      a. Armstrong
      b. Bell and Gossett
   2. Float type with isolating valve, cast iron body, stainless steel float, stainless steel valve, and valve seat. Suitable for 300 psig operating pressure and 300 degrees F system temperature.
   3. Vents shall be designed to eliminate air from the system automatically without permitting the passage of water.
   4. Minimum size shall be 3/4” or as indicated or required.
   5. Similar to Armstrong Model 1-AV.

C. Drains

1. Provide ball valves with caped hose connections, (minimum size 3/4"), or larger where shown or required by the service.
2. See HVAC Valve specification.

PART 3 – EXECUTION

3.01 THERMOMETER INSTALLATION

A. Shall be installed in accordance with manufacturer recommendations, Contract Drawings and reviewed submittals.

B. Shall be turned as such to be readily visible from the operating floor.

C. Thermometers subject to vibration or physical damage shall be adequately supported and protected.

3.02 THERMOMETER WELL

A. Shall be installed in accordance with manufacturer recommendations, Contract Drawings and reviewed submittals.

3.03 PRESSURE RELIEF VALVE

A. Shall be installed in accordance with manufacturer recommendations, Contract Drawings and reviewed submittals.

3.04 PRESSURE DIFFERENTIAL GAUGE

A. Shall be installed in accordance with manufacturer recommendations, Contract Drawings and reviewed submittals.

B. Provide differential pressure gauge package to user after system balancing.

3.05 GAUGE INSTALLATION

A. Shall be installed in accordance with manufacturer recommendations, Contract Drawings and reviewed submittals.

B. Shall be turned as such to be readily visible from the operating floor.

C. If the gauge is more than 8'-0" above the floor or cannot otherwise be made readily readable, extended pipe connections gauge to a readable location.

D. Gauges subject to vibration or physical damage shall be adequately supported and protected.

3.06 PRESSURE/TEMPERATURE TAPS INSTALLATION

A. Shall be installed in accordance with manufacturer recommendations, Contract Drawings and reviewed submittals.

B. Provide pressure taps wells for all in-duct or in-box water coils.

3.07 AIR VENTING INSTALLATION

A. Manual air vent
   1. Provide all high points in closed water piping systems shall be relieved of air through accessible manual vents on the high points of the pipe lines and at the equipment. Vent valves on piping and equipment shall be 1/2" ball valves with chains and caps and with discharge pipes to convenient points for catching discharge.
   2. Provide access doors to all vents.

B. Automatic air vent
   1. Provide as indicates and at expansion tank connection to main pipe.
   2. Pipe to spill over floor drain or sink.

3.08 DRAINAGE

A. Grade all piping for drainage through equipment or through accessible drain valves so that system can be conveniently freed of water by gravity flow.

B. Provide drains from air handling units and from air intake and other intake and exhaust plenums with traps. Traps shall be a minimum of 4", unless the static pressure requires additional trap depth. Discharge drains to nearest floor drain.

END OF SECTION

SECTION 23 07 19

HVAC PIPING INSULATION

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Section 230500 and other Division 1 Specification Sections, apply to this Section.

1.02 WORK INCLUDED

A. Furnish and install all piping insulation, vapor barriers, jackets, finishes, adhesives, cements and accessories to make a complete insulated system for all piping, valves, fittings, joints, offsets and flanges specified herein.

B. All insulation system materials shall conform to the maximum flame spread/smoke developed ratings specified herein.

C. Hard insulation material shall be provided at all hangers.

D. Insulate the following:
   1. All scheduled piping, all valves, fittings, elbows, flanges and accessories.
   2. All piping exposed to weather including provision of additional weatherproof jacket.
   3. All cold water make-up piping and valves. All drain and overflow piping receiving cold water. Piping to/from expansion/compression tanks.
   4. All vents and blow-offs in mechanical rooms and elsewhere within reach of personnel.
   5. Emergency generator piping and entire exhaust systems.
   6. Piping jacket covers.
   7. All heat traced piping.

1.03 RELATED SECTIONS

A. Examine all drawings and criteria sheets and all other Section of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

1.04 REFERENCES

A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.

B. Material standards shall be as specified or detailed hereinafter and as follows:
   1. ASTM A 666 – Standard Specification for Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar.
   2. ASTM B 209 – Standard Specification for Aluminum and Aluminum-Alloy Steel and Plate.
   3. ASTM B 209M – Standard Specification for Aluminum and Aluminum-Alloy Sheet and plate (Metric).
   4. ASTM C 177 – Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus.
   5. ASTM C 195 – Standard Specification for Mineral Fiber Thermal Insulating Cement.
   6. ASTM C 240 – Standard Test Methods of Testing Cellular Glass Insulation Block.
   7. ASTM C 449/C 449M – Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
   8. ASTM C 518 – Standard Test method for Steady-State Heat Flux Measurements and Thermal Insulating and Finishing Cement.
   9. ASTM C 533 – Standard Specification for Calcium Silicate Block and Pipe Terminal Insulation.
   10. ASTM C 534 – Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
   11. ASTM C 547 – Standard Specification for Mineral Fiber Pipe Insulation.
   12. ASTM C 552 – Standard Specification for Cellular Glass Thermal Insulation.

13. ASTM C 578 – Standard Specification for Preformed, Cellular Polystyrene Thermal Insulation.
14. ASTM C 591 – Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
15. ASTM C 610 – Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation.
16. ASTM C 795 – Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
17. ASTM C 921 – Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
18. ASTM D 1056 – Standard Specification for Flexible Cellular Materials – Sponge ore Expanded Rubber.
19. ASTM D 1667 – Standard Specification for Flexible Cellular Materials – vinyl Chloride Polymers and Copolymers (Closed-Cell Foam).
20. ASTM D 1784 – Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
21. ASTM D 2842 – Standard Test Method for Water Absorption of Rigid Cellular Plastics.
22. ASTM E 84 – Standard Test Method for Surface Burning Characteristics of Building Materials.
23. ASTM E 96 – Standard Test Methods for Water Vapor Transmission Materials.
24. NFPA 225 – Standard Method of Test of Surface Burning Characteristics of Building Materials.
25. UL 723 – Standard for Test for Surface Burning Characteristics of Building Materials.
26. ANSI/ASHRAE 90.1 – Energy Conservation in New Buildings.

1.05 SUBMITTALS

A. See Section 230500 and General Conditions for additional requirements.

B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

C. Manufacturer’s Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

D. Installation Graphic Details.

E. Buildings Seeking LEED Certification
   1. All adhesives and sealants used in projects that are seeking LEED certification shall comply with the following:
      a. Adhesives and Sealants for Insulation: All adhesives and sealants used on interior building insulation shall comply with the South Coast Air Quality Management District (SCAQMD) Rule #1168; VOC limits shall comply with the limits indicated in Table 1 of LEED Version 2.2, Indoor Environmental Quality Section, Credit EQ-4.1. Those limits correspond to an effective date of the SCAQMD Rule #1168 of July 1, 2005, and Rule Amendment date of January 7, 2005.
      b. Coatings and Mastics for Insulation: All coatings and mastics used on interior building insulation shall comply with VOC limits set forth by Green Seal
      c. GS-11 and comply with the South Coast Air Quality Management District (SCAQMD) Rule #1113; VOC limits shall comply with the limits indicated in
      d. Table 1 of LEED Version 2.2, Indoor Environmental Quality Section, Credit EQ-4.2.
      e. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

1.06 QUALITY ASSURANCE

A. All insulation materials, finishes, coatings, cements, jackets and other insulation accessories shall have minimum composite or individual fire hazard ratings as well as thickness and "C" values conforming to State Building Codes which control building construction materials that may be used on this project. Where specification requirements exceed the Code requirements, the specification shall govern.

B. Piping insulation for the various piping systems and associated equipment shall be composed of materials which are non-combustible and/or provide a fire resistive system of insulation which complies with the applicable Code having jurisdiction. Generally, it is required that fire hazard ratings shall not exceed the following, except as noted:
   1. Flame Spread Rating 25 (No Exceptions)
   2. Smoke Developed Rating: 50

C. All fire hazard ratings shall be as determined by NFPA 255 "Method of Test of Surface Burning Characteristics of Building Materials", ASTM E84 or UL 723.

D. All insulation materials herein specified shall be used subject to the manufacturer's temperature limitations and their compatibility with other materials.

E. Installation of all insulation work shall be executed by a qualified Insulation Contractor who is thoroughly experienced in this particular type of work and who has adequate facilities and equipment for installation of all insulation work herein specified and who is familiar with the requirements of the Code enforcing Authorities as to fire hazard rating.

F. The finished installation shall present a neat and workmanlike appearance with all jackets smooth, with all vapor barriers sealed and intact.

G. Where insulation is specified for piping, insulate similarly all connections, vents, drains and any piping connected to system subject to heat loss or gain. Do not cover vent petcocks, cleanouts or other maintenance points on equipment unless identified on the insulation with removable access panels or covers.

H. All chilled water system piping, components and accessories are to be insulated in a manner so as to provide a complete, uninterrupted vapor barrier.

1.07 **REGULATORY REQUIREMENTS**

A. Conform to maximum flame spread/smoke developed rating of 25/50 in accordance with ASTM E 84, NFPA 255, or UL 723.

1.08 **DELIVERY, STORAGE AND PROTECTION**

A. Accept materials on site, labeled with manufacturer’s identification, product density and thickness.

B. All materials shall be stored in a dry area free from moisture and debris.

1.09 **ENVIRONMENTAL REQUIREMENTS**

A. Maintain ambient conditions required by manufacturers of each product.

B. Maintain temperature before, during and after installation for minimum of 24 hours.

PART 2 – PRODUCTS

2.01 **MANUFACTURERS ACCEPTABLE FOR PRODUCT TYPES INDICATED CONTINGENT UPON PRODUCTS' COMPLIANCE WITH THE SPECIFICATIONS**

A. Insulation:
   1. Manville Corporation.
   2. Owens-Corning Fiberglass Corporation.
   3. Armstrong World Industries, Incorporated.
   4. Certainteed Corporation.
   5. Knauf

B. Elastomeric insulation
   1. Armacell

C. Mastics and adhesives:
   1. Childers Products Company.
   2. H. B. Fuller Company, Foster Products Division.
   3. 3M Company Adhesives, Coatings and Sealers.
   4. Armstrong World Industries, Incorporated.
   5. Ruston Plant.

6. Chicago-Mastic
7. Insul-Coustic
8. St. Clair Rubber
9. Vimasco
10. Baldwin-Ehret-Hill

D. Pipe insulation of hanger and support:
1. Pipe Shields, Inc.
2. Rilco Manufacturing Company.
3. Elcen Metal Products Company.
4. Power Piping Company.
5. NPS Industries.

E. PVC fitting covers:
1. Manville, Corporation.
2. Ceel-Co.
3. Certainteed, Corp.
4. Cell Co. Plastics

2.02 **GENERAL**

A. Adhesives and insulation materials: Composite fire and smoke hazard ratings maximum 25 for flame spread and 50 for smoke developed for pipe insulation. Adhesives to be waterproof when cured.

B. The installation of thermal insulating materials coverings and coatings containing asbestos fibers is forbidden.

C. Insulation shall not be chemically reactive to the metal over which it is applied. Insulation installed on steel shall be neutral or slightly alkaline. Insulation installed on aluminum shall be neutral or slightly acidic.

2.03 **MATERIALS AND COMPONENTS**

A. Fiberglass insulation:
1. Pre-molded pipe fiberglass: Recommended temperature to 850 degrees Fahrenheit with facing. Molded in one piece split or hinged circular sections in three foot lengths for piping and tubing. Insulation shall be made from long, fine, glass fibers bonded together with a thermosetting resin. Insulation shall have a minimum density of 4.0 pounds per cubic foot and a K value of 0.23 at 75 degrees Fahrenheit mean temperature. Insulation furnished with facing as specified below and as indicated in insulation schedule. Insulation similar to Owens-Corning Type SSL-II. Pressure sensitive tapes using rubber based or acrylic based adhesives are not permitted.
2. Pipe and tank fiberglass: Recommended temperature to 450 degrees F with facing. Insulation shall be made from long, fine, glass fibers bonded together with a thermosetting resin. Insulation shall have a minimum density of 3 pounds per cubic foot and a k-valve of 0.27 btu in/(Hr sq.ft. degree F) at 75 degrees F main temperature. Insulation furnished with facing as specified below and as indicated in insulation schedule. Insulation similar to Manville pipe and tank insulation. Pressure sensitive tapes using rubber based or acrylic based adhesives are not permitted.
3. Flexible fiberglass: Recommended temperature to 250 degrees Fahrenheit. Glass fibrous flexible blanket insulation having density of 0.75 pounds per cubic foot and a K value of 0.30 at 75 degrees mean temperature. Insulation furnished with facing as specified below and indicated in insulation schedule. Insulation and jacket similar to Owens-Corning Type SSL-II.
4. Use pipe and tank fiberglass only when premolded pipe fiberglass is not available. Pipe and tank insulation shall not be used on pipe sizes 24 inches and smaller.

B. Equipment insulation:

1. Rigid fiberglass: Recommended temperature to 450 degrees F. Fiberglass rigid board having a density of 3.0 pounds per cubic foot and a K value of 0.23 at 75 degrees F mean temperature. See schedule for facing type.
2. Flexible fiberglass: Recommended temperature to 250 degrees F with facing. Glass fibrous flexible blanket insulation having a density of 0.75 pounds per cubic foot and a K value of 0.30 at 75 degrees F mean temperature.
3. Rigid fiberglass high temperature: Recommended temperature to 850 degrees Fahrenheit. Fiberglass high temperature board having a density of 3 pounds per cubic foot and a K value of 0.30 at 200 degrees Fahrenheit mean temperature.

C. Closed-Cell Elastomeric
1. Insulation material shall be a flexible, closed-cell elastomeric insulation similar to AP Armaflex as manufactured by Armacell LLC.
2. The product shall meet the requirements as defined in ASTM C 534.
3. Insulation materials shall have a closed-cell structure to prevent moisture from wicking.
4. Insulation material shall be manufactured without the use of CFCs, HFCs or HCFCs.
5. Insulation material shall be formaldehyde free, low VOCs, fiber free, dust free and resists mold and mildew.
6. Materials shall have a flame spread index of less than 25 and a smoke-developed index of less than 50 when tested in accordance with ASTM E 84, latest revision.
7. In addition, the product, when tested, shall not melt or drip flaming particles, the flame shall not be progressive and all materials shall pass simulated end-use fire tests.
8. Materials shall have a maximum thermal conductivity of 0.27 Btu-in./h-ft2- °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
9. Materials shall have a maximum water vapor transmission of 0.08 perm-inches when tested in accordance with ASTM E 96, Procedure A, latest revision.

D. Insulation facing:
1. Code ASJ: All service jacket composed of high intensity white chemically treated Kraft paper reinforced with fiberglass yarn and mesh and laminated to aluminum foil with a fire retardant adhesive. Longitudinal laps and butt strips shall be a minimum of 3 inches.
2. Code FSKL: 0.35 mil aluminum foil reinforced with fiberglass yarn reinforcing scrim and laminated to chemically treated fire resistive Kraft paper having a minimum 35 pound per inch width tensile strength when tested in accordance with ASTM D 828. Water vapor permeability 0.04 perms. Longitudinal laps and butt strips shall be a minimum of 3 inches.

E. Additional insulation jacket:
1. ADJ-1: Approximately 6 ounce per square yard glass cloth jacket with thread count of 5 strands per square inch.
2. ADJ-2: Approximately 2 ounce per square yard glass cloth jacket with a thread count of 10 strands by 10 strands per square inch. Jacket shall be used for covering pipe and pipe fittings.
3. ADJ-3a: 0.016 inch thick aluminum jacket conforming to ASTM B-209 with a 1 mil factory applied polykraft moisture barrier. Longitudinal joints shall be placed at the side of the pipe facing downward at either the 4 o'clock or 8 o'clock position so as to shed water. Aluminum fitting covers, two piece elbows, tees, valve and flange covers, etc., with a 1 mil polykraft or acrylic vapor barrier.
4. ADJ-3b: 0.020 inch thick aluminum jacket conforming to ASTM B-209 with a 3 mil factory applied polykraft moisture barrier. Longitudinal joints shall be placed at the side of the pipe facing downward at either the 4 o'clock or 8 o'clock position so as to shed water. Aluminum fitting covers, two piece elbows, tees, valve and flange covers, etc., with a 3 mil polykraft or acrylic vapor barrier.
5. ADJ-4: 20 mil PVC jacket suitable for all types of paint. Similar to Manville Zeston 25/50.
6. ADJ-5: (Not used)
7. ADJ-6 A finish jacket of an Asbestos-free and woven as high temperature, heat-resistant fabric. Lagging Cloth having a treated weight of 24 oz./sq.yd. Material shall be suitable for

a sustained operation at 1100°F. Calcium silicate piping for generator exhaust piping shall also be jacketed with corrugated aluminum.

8. ADJ-7: 0.16-inch thick type T-316 stainless steel jacket. Alloys conforming to ASTM A-240. System shall have a 3-mil polykraft vapor barrier.

F. Adhesives:
   1. Code ADH-1: Fibrous adhesive, non-flammable, quick setting adhesive for calcium silicate. Similar to Childers CP-97, 98.
   2. Code ADH-2: Fast-drying vinyl base coating and lagging adhesive. Similar to Childers CP-50A HV2.
   3. Code ADH-3: Fast-drying neoprene base adhesive for lap joints of foil-faced facing applied over pipe insulation. Similar to Childers CP-82.
   4. Code ADH-4: Adhesive for use in adhering fiberglass board or blanket insulation to pipe and equipment. 3M Company Insulation Adhesive No. 35 or 38 non-flammable adhesive.

G. Caulking components:
   1. Code CC-1: For use with foam glass and/or joint sealant applications. Flexible elastomeric vapor barrier sealant. Similar to Childers CP-76.

H. Mastics:
   1. Code MAS-1: Vapor barrier mastic made with an elastomeric resin. For indoor use. Similar to Childers CP-30.
   2. Code MAS-2: A non-water vapor barrier asphaltic emulsion coating, breathing type, for above ground installations. Similar to Childers CP-10.
   3. Code MAS-3: Vapor barrier mastic made with an elastomeric resin. For outdoor use.

I. Tie wire:
   1. Tie wire for securing insulation in place shall be type 304 stainless steel annealed steel wire of gauge and proper spacing as recommended by the insulation manufacturer. Wire shall be drawn up tightly enough to become embedded in the insulation and the ends of the loop twisted, bent over, and pressed into the insulation so as to leave no ends protruding.

J. Banding:
   1. 3/8 inch x 0.02 inch type 304 stainless steel for pipe insulation.
   2. 3/4 inch x 0.02 inch type 304 stainless steel for additional insulation jackets.

K. Wire mesh:
   1. Wire mesh shall be one inch by No. 20 BGW hexagonal mesh galvanized.
   2. Expanded metal: Expanded metal shall be 1/2 inch Hi-Rib metal lath of copper bearing steel.

L. Tape:
   1. Lead foil tape shall be 3M Company Lead Foil Tape No. 422, 4 mil thick, acrylic adhesive, 2 inch wide.
   2. Vinyl plastic tape, silver gray, flame resistant, vapor barrier sealant tape on rigid and flexible insulation material for warm or cold air ducts. Similar to 3M Company Duct Sealing Tape No. 474.
   3. Aluminum foil tape, dead soft aluminum foil, point seal on stick pin, metal patching, moisture barrier, heat reflecting and general sealing on aluminum facing foil. Similar to 3M Company Aluminum Foil Tape No. 425.

M. Staples:
   1. Staples shall be galvanized clad outward clinching insulation staples.

N. Insulating cement:
   1. Insulating cement shall be a mineral-fiber (wool) ASTM C 195 base material having essentially the same insulating characteristics as the adjacent insulation. Similar to PABCO High Temperature Insulating Cement. Insulating cement shall be applied in layers to a maximum thickness of 1/2 inch at one time. Each layer shall be allowed to dry thoroughly before subsequent layers are applied.

O. Finishing cement:
   1. Finishing cement ASTM C 449 shall be diatomaceous silica thermal insulating materials with a suitable proportion of heat resistant binder, hydraulic setting insulating cement capable of withstanding maximum temperature of 700 degrees Fahrenheit. When mixed with water it shall be a plastic mix suitable for trowel applications and shall present a hard, smooth and durable surface after drying. Similar to PABCO No. 127.

P. Combination insulating and finishing cement:
   1. Similar to Ryder One Coat or equal.

Q. Welding studs:
   1. Welding studs shall be capacitor type split pin or TCP tipped insulation pins with speed clips. Similar to Nelson Stud Welding Spec. 28.

PART 3 – EXECUTION

3.01 PREPARATION

A. No insulation shall be applied until the surfaces of the equipment to be insulated are thoroughly cleaned and until pipes and equipment to be insulated have been leak tested and proven tight and accepted by the Engineer.

B. Insulation shall not be applied to piping or equipment until authorization is given to the Contractor by the Engineer. Contractor shall submit a request for authorization. If any insulation is applied without first obtaining authorization, it will be the Contractor's responsibility to remove the insulation and apply it again if so directed.

C. Ensure surface is clean and dry prior to installation. Ensure insulation is dry before and during application. Finish with systems at operating conditions.

D. The execution of the insulation work shall be in strict accordance with the best practices of the trade and with the specifications.

E. The insulation shall be handled and applied in a manner that will not adversely affect its structural or insulating properties.

F. The installation instructions provided by the insulation material manufacturer of all materials specified in this Section shall be followed when installing these materials. Where the specifications are in conflict with manufacturers' instructions, such conflicts shall be brought to the attention of the Engineer for a decision.

G. Welding operations will not be permitted on certain specific items of equipment, piping and components for the application of studs, pins, support rings, angles, etc. Contractor shall obtain permission in writing from the Engineer to perform any welding.

H. Coat to seal all insulating cement and calcium silicate surfaces with primer similar to Childers CP-53 or equal before applying any mastic coating.

3.02 PIPING INSULATION INSTALLATION

A. Ensure insulation is continuous through interior walls. Pack around pipes with fire proof self-supporting insulation material, fully sealed. Insulation on all cold surfaces where vapor barrier jackets are specified must be applied with a continuous, unbroken vapor seal. Hangers, supports, anchors, and other heat conductive parts that are secured directly to cold surfaces must be adequately insulated and vapor sealed to prevent condensation.

B. Insulate fittings, valves, unions, flanges, and strainers. Do not insulate flexible connections and expansion joints. Terminate insulation neatly with PVC or aluminum end caps.

C. Pre-molded fiberglass, or mineral wool, where specified) insulation for straight pipes shall be applied, neatly fitted around piping and sealed with adhesive ADH-3. Adhesive shall be applied to only one side of each joint and shall not be applied to the pipe surface.

D. Where two sections of pipe insulation butt together provide a 3 inch wide butt strip of same facing material as adjacent insulation facing. Adhere neatly in place using adhesive ADH-3.

E. All pipe elbows shall be insulated with short radial and mitered pieces of board or block insulation or pre-molded pieces of pipe insulation. Each piece shall be butted tightly against the adjoining piece and all joints, seams, voids and irregular surfaces shall be filled with insulating cement finished to a smooth, hard and uniform contour. Coat with MAS-1 mastic and reinforce with ADJ-2 additional jacket. In addition, place a fitted PVC cover (ADJ-4) over insulated elbow exception. Tape elbow to adjoining insulation.

F. All valves and fittings shall be insulated with pre-molded fittings, sectional pipe insulation, or blocks of the same material and thickness as used for the adjacent pipe. Flange insulation shall overlap the adjoining pipe insulation by not less than the thickness of the pipe insulation. Sectional pipe covering or block insulation shall be cut to fit, and each section butted closely to the next and held in place with tie wire.

G. Fittings on pipe lines in finished and concealed areas shall be covered with pre-molded fiberglass pipe fitting insulators Insul-Coustic or equal, where sizes are available, otherwise, use mitercut segments of molded pipe insulation, wire in place with joints and raw edges sealed with adhesive and smoothed out with a coat of insulating cement.

H. On cold pipes the fittings shall be finished with (2) coats of an approved vapor barrier mastic, reinforced with glass cloth extending 2 inches onto adjacent pipe insulation. Hot pipes shall be finished in a similar manner except the mastic need not be of the vapor barrier type.

I. Insulation shall cover the entire surface of the fittings and bodies of the valves up to and including the bonnets, and to the valve stuffing box studs, bolts, or nuts. All joints, seams, and irregular surfaces shall be filled with insulating cement. The insulated surfaces shall be covered with a 1/4 inch thick layer of finishing cement and heavily coated with vapor barrier mastic MAS-1 for cold services and mastic MAS-2 for hot services and reinforced with ADJ-2 additional jacket. Mastic shall be trowelled to a smooth and well-shaped contour compatible with adjoining pipe insulation jackets as specified.

J. Use ADJ-4 covers over fittings and flanges everywhere except when ADJ-3a, or ADJ-3b is specified.

K. Repair separation of joints or cracking of insulation due to thermal movement or poor workmanship on all joints of all piping.

L. All instrument connections for thermometers, thermocouples, gauges, test connections, flow meters, etc., on insulated pipes, vessels, or equipment shall be insulated. The insulation shall be shaped at these connections by tapering it to and around the connection with insulating cement and finishing with finishing cement, vapor barrier adhesive, applicable mastic, or caulking compound.

M. Where removable flange and valve insulation is required or specified, installation shall conform to the following:
   1. Removable flange insulation shall be made from sectional pipe insulation of the same thickness as that on the adjoining pipe or from block insulation 1/2 inch thinner than the pipe insulation and finished with insulating cement. Insulation jackets shall be the same as adjoining pipe insulation unless indicated otherwise.
   2. When flange covers are made from sectional pipe insulation, they shall enclose the flanges and be long enough to extend at least 2 inches over the adjacent pipe insulation on each side of the flange. The space between the flange cover and the pipe insulation shall be filled with insulating cement. Secure the flange cover in place with stainless steel banding.
   3. When flange covers are made from block insulation, they shall be made in two halves. Each half shall consist of mitered blocks wired to 1/2 inch galvanized hardware cloth mesh. This wire frame, with its attached insulation, shall then be secured to the flanges with tie wire. The insulation cover shall be long enough to extend at least 2 inches over the adjacent pipe insulation on each side of the flange. The space between the flange cover and the pipe insulation shall be filled with insulating cement. The whole flange cover assembly shall be finished with 1/2 inch of insulating cement applied in two coats.

After the first coat is dry, the second coat shall be trowelled to a smooth hard finish. All surfaces shall then be finished with jackets as specified in the schedule.

4. Removable valve insulation covers shall be constructed in the same manner as for flanges with the following exception; the two part section shall be divided on the vertical center line of the valve body, bonnet, flange or joint.
5. When specified to insulate the complete valve, the hand wheel or lug wrench shall be removed to accommodate the valve bonnet box. The valve bonnet box shall be constructed in a one piece closure, one end closed, one end opened to fit up to the valve body insulation. Securing the valve and bonnet box sections, sealing and pointing of the insulation shall be done in same manner as specified for flange covers.
6. Unless indicated as removable, a permanent installation as previously specified shall be used.
7. Protect insulation on piping 2 ½" and up where supported in hangers by means of calcium silicate rigid pipe insulation or jackets. Saddles or shaped galvanized steel pieces approximately 10" long by half the circumferences of insulated pipe.
8. All piping shall have been tested and approved prior to installation of insulation.
9. All piping or surfaces where subject to condensation on the outside shall be insulated including vaporseal finish.

PART 4 – SCHEDULES

4.01 **PIPING INSULATION SCHEDULE: (ASJ = "All-Service-Jacket")**

Service	Type Insulation and Thickness (Inches)	Facing	Additional Jacket*
Hot Water Heating, Glycol Systems & Condensate Water (up to 200°F) Up to 2" 2 1/2" & Up	Molded Fiber Glass 2 2	 ASJ ASJ	
Chilled Water Up to 2" 2 1/2" & Up	Molded Fiber Glass 1 1/2 2	 ASJ ASJ	
Condenser Water (up to 100°F) Up to 12" 14" & Up	Molded Fiber Glass 1 2	ASJ ASJ ASJ	
Condensation Drains & Vents, Cold Water Make-up	Molded Fiber Glass 1	 ASJ	
Emergency Generator Exhaust Piping	Hydrous Calcium Silicate 3 1/2	ADJ-6	ADJ-3b
Piping with Heat Trace	Molded Fiber Glass min 3", but thicker if noted above.	ASJ	ADJ-3b
All outdoor piping	Two times thickness scheduled		ADJ-3b
Others not scheduled	Molded Fiber Glass 1	ASJ	

*Including elbows, fittings, valves, complete system.

A. Refer to jacket specifications for finish covering to be installed on calcium silicate insulation in finished areas.

B. Where "Finishing Cement" finishes are scheduled, refer to specifications for Cement herein for materials, method of application, thickness, etc.

C. Provide vapor barrier on all cold water and rainwater piping.

D. Piping exposed to weather shall be insulated with pipe insulation using double the thicknesses scheduled hereinbefore, up to 24 inches beyond the point where pipes enter the building. Provide weatherproof jacket as hereinafter specified.

E. Equipment drains and floor drains from cooling coils as well as drinking fountain waste shall be insulated 6 feet downstream from connection point.

END OF SECTION

SECTION 23 21 23

HVAC HYDRONIC PUMPS AND ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Section 230500 and other Division 1 Specification Sections, apply to this Section.

1.02 WORK INCLUDED

A. Furnish and install all pumps for all systems which are part of the building HVAC systems. This shall include all accessories specified in this Division and as shown on the drawings.

B. All pumps shall be new and manufactured for the specific purpose of circulating chemically treated water to the building HVAC systems.

C. All pumps, circulators and system components shall be installed in accordance with state and local codes.

D. Secure all permits and local/state approval for the components as specified and included under this Section.

1.03 RELATED SECTIONS

A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

1.04 REFERENCES

A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.

B. Material standards shall be as specified or detailed hereinafter and as follows:
1. NEMA MG1 – Motors and Generators; National Electrical Manufacturers Association.
2. NEMA OS1 – Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports; National Electrical Manufacturers Association; 1989.
3. NFPA 70 – National Electrical Code.
4. UL 778 – Standard for Motor-Operated Water Pumps.
5. ASME – Section VIII, Unfired Pressure Vessels.

C. Reference Standards
1. AFBMA: Anti-Friction Bearing Manufacturers Association.
   a. 1-84 - Terminology for Anti-Friction Ball and Roller Bearings and Parts.
   b. 9-84 - Load Ratings and Fatigue Life for Ball Bearings.
   c. 11-78 -Load Ratings and Fatigue Life for Roller Bearings.
   d. 20-77 -Metric Ball and Roller Bearings Conforming to Basic Boundary Plans.
2. ASTM: American Society for Testing and Materials.
   a. A 48-Gray Iron Castings.
   b. B 62-Standard Specification for Composition Bronze or Ounce Metal Castings.
   c. B 584-Standard Specification for Copper Alloy Sand Castings for General Applications.
3. HI: Hydraulics Institute.
   a. Hydraulic Institute Standards.
4. ANSI B15.1
5. OSHA: Occupational Safety and Health Administration, U.S. Department of Labor.

1.05 SYSTEM DESCRIPTION

A. Provide base mounted, horizontal axial split-case, or vertical mounted split-case, double-suction, single-stage centrifugal pumps, or base mounted, single-stage end suction radial

pumps, as shown on the drawings. Capacity, RPM, head and electrical motor characteristics shall be as scheduled on the drawings.

1.06 **SUBMITTALS**

A. See Section 230500 and General Conditions for additional information.

B. Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics, connection requirements and all dimensional data including operating weights.

C. Manufacturer's Installation Instructions: Indicate hanging and/or support requirements and recommendations.

D. Millwright's Certificate: Certify that base mounted pumps have been aligned.

E. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions and replacement parts list.

F. In addition to items specified elsewhere provide:
1. Large scale certified pump curves indicating operating points.
2. Detailed motor data.
3. Detailed coupling data
4. Detailed seal data.
5. All pump construction data.
6. Detailed bearing data.
7. Base details
8. Dimensioned pump and motor drawing.

1.07 **QUALITY ASSURANCE**

A. Manufacturer Qualifications: Company specializing in manufacturing, assembly and field performance of pumps, with minimum three (3) years of documented experience.

B. Alignment: Base mounted pumps shall be aligned by qualified millwright.

1.08 **REGULATORY REQUIREMENTS**

A. Products Requiring Electrical Connection: Listed and classified by UL 778 testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

B. Provide certificate of compliance from authority having jurisdiction, indicating approval of welders.

1.09 **DELIVERY, STORAGE AND HANDLING**

A. All pumps shall be delivered in containers and shall be kept in a dry and protected area.

B. All pumps shall be given 2 coats of rust-resistant paint at the factory prior to installation.

1.10 **ENVIRONMENTAL**

A. Do not paint or install pumps when environmental conditions are outside the specific limitations of the referenced codes and manufacturer's recommendations.

PART 2 - PRODUCTS

2.01 **MANUFACTURERS ACCEPTABLE FOR PRODUCT TYPES INDICATED CONTINGENT UPON PRODUCTS' COMPLIANCE WITH THE SPECIFICATIONS**

A. Base mounted pumps:
1. Armstrong

B. In-line circulators:
1. Armstrong

C. Expansion Tanks
1. Armstrong

D. Air Separators
   1. Bell and Gossett
   2. Amtrol
   3. Spirotherm

2.02 **PUMPS GENERAL**

A. Statically and dynamically balance rotating parts.

B. Construction shall permit complete servicing without breaking pipe or motor connections.

C. Pumps to operate at 1750 rpm unless scheduled or specified otherwise.

D. Pumps of the same type shall be from one pump manufacturer.

E. Motors shall be in accordance with Section Motors, unless otherwise specified.

F. Provide guards around shafts and couplings in accordance with OSHA and ANSI recommendations.

G. All parts shall be suitable for variable frequency drives; including but not limited to motor, pump, all pump components, coupling, and base.

H. Design and performance requirements:
   1. Scheduled design flow, design head, pump efficiency, and motor horsepower are minimum acceptable.
   2. Scheduled design brake horsepower and speed are maximum acceptable.
   3. Pump curve shall rise continuously from maximum flow to cut off.
   4. Shut-off head shall be approximately 20 percent greater than design head, unless otherwise indicated in pump schedules.
   5. Pump brake horsepower not to exceed motor horsepower rating over entire operating range (from shut-off to run-out). Motor shall not operate in service factor
   6. Suitable for parallel operation.
   7. Pumps shall operate within the preferred operation region as defined by the Hydraulics Institute.
   8. Select pump for operation at or near peak efficiency.
   9. Cavitation-free at all points on curve.
   10. Impeller diameter shall not exceed 90 percent of the maximum cutwater diameter.
   11. Vibration levels of pump shall be within the vibration limits established by hydraulic institute.

2.03 **BASE MOUNTED PUMPS**

A. Type: Centrifugal, single or multi-stage where noted, base mounted flexible coupled, single or double suction as noted.
   1. Casing:
      a. Casing shall be constructed of cast iron ASTM A 48 Class 30A or better.
      b. Casing shall be rated for 1.25 times the scheduled working pressure with a minimum rating of 150 psig.
      c. Cast iron castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters and other defects.
      d. Casing shall have flanged suction and discharge per ANSI B16.1 for sizes 2-1/2 inch and larger. Smaller sizes shall be threaded connections.
      e. Casing shall have a tapped and threaded plug for an air vent.
      f. Casing shall be provided with a threaded drain plug at the lowest point.
      g. Casing shall be provided with a seal flush connection.
      h. Casing wearing rings shall be replaceable and constructed of bronze ASTM B 584 or ASTM B 62.
      i. Casing shall be base supported.
      j. Casing shall be vertically or horizontally split as indicated.
   2. Impeller:
      a. Impeller shall be constructed of one piece bronze ASTM B 584 or ASTM B 62.
      b. Fully enclosed design.

c. Impeller shall be keyed to the shaft and secured with a stainless steel, 300 series washer and bolt. Bolt to tighten in direction opposite rotation of impeller.
d. Dynamically balanced for smooth, low vibration operation over the operating range from shut-off to run out.
e. Impeller shall be provided with replaceable wear rings.

3. Shaft:
   a. Shaft shall be solid stainless steel AISI 316 turned, ground and polished and ring gauged for accuracy.
   b. Shafts shall be polished to a minimum 16 microinch finish.
   c. Shaft deflection shall not exceed 0.002 inches in the round.
4. Shaft sleeve:
   a. Design such that there is no contact between the pump shaft and the pumped liquid.
   b. Shaft sleeve shall be stainless steel, AISI 316 or AISI 416.
   c. Provide O-ring or gasket to prevent leakage of pumped liquid.
5. Shaft seals:
   a. Mechanical type.
      1) Stainless steel hardware and spring.
      2) EPT rings, carbon rotating face against a tungsten carbide nickel binder seat.
      3) Seals shall be balanced type for all pumps with 100 psig or greater suction pressure.
      4) API 610 seal number: USTFM. Similar to John Crane Type 1 or 2 material code **0**$_{(28)}$**-P**$_{(66)}$**-1- 0**$_{(15)}$**-1**.
      5) Provide a bypass line from the discharge side of the pump casing to the seal faces. Design to ensure adequate flushing and proper lubrication.
   b. Provide Doxie or equal cyclone separator on seal flushing lines on all pumps with a head of 25 PSIG or greater.
6. Bearings:
   a. Grease lubricated ball bearings.
   b. L-10 life minimum 100,000 hours.
7. Motor:
   a. Refer to Section 230513 – Motors and Controllers for requirements.
8. Drive coupling:
   a. Flexible coupling with OSHA and ANSI type coupling guard.
   b. Suitable for variable speed drive.
   c. Suitable for system duty, fluid, and service temperature.
9. Similar to T.B. Woods (the coupling service factor shall not be less then 2).
   a. Base:
      1) Cast iron or fabricated steel base with drip rim and tapped NPT connection for drain.
      2) Common base for pump and motor.
10. Painting:
    a. Pump components shall be thoroughly degreased, deburred and sandblasted as required before the application of any primers or paint.
    b. Prime coat components before assembly; finish coat after assembly.
11. Nameplate:
    a. Provide pump with a nameplate constructed of 18-8 stainless steel securely fastened to pump casing by stainless steel pins.
    b. Locate nameplate for easy visibility.
12. The rating conditions and other data below, as a minimum, shall be clearly stamped on the nameplate.
    a. Manufacturer, address, telephone number.
    b. Pump model number.
    c. Pump serial number.
    d. Size (including impeller diameter scheduled in inches).
    e. Type.
    f. Equipment designation as listed on the pump schedule.

g. Flow scheduled (gallons per minute).
h. Dynamic head scheduled (feet of water).
i. Efficiency (percent).
j. Shut-off head (feet of water).
k. Speed (RPM).

2.04 **IN-LINE CIRCULATOR**

A. Casing: Bronze cast iron rated for 125 psi working pressure.

B. Impeller: Bronze.

C. Shaft: Hardened alloy steel with integral thrust collar and oil lubricated bronze sleeve bearings.

D. Seal: Carbon rotating against a stationary ceramic seat.

E. Provide additional pipe supports to support weight of pump, motor, fittings and accessories.

2.05 **EXPANSION AND COMPRESSIONS TANKS**

A. Provide expansion and compression tanks, air separator and other pump hydronic accessories, as shown and as scheduled on the drawings.

B. Tanks shall be the pressurized captive air bladder type.

C. Provide replaceable elastomeric bladder suitable for a maximum operating temperature of 240°F

D. Provide integral steel base ring for vertical mounting.

E. Tanks shall be constructed and certified to ASME Section VIII
1. Pressure rating150 psig
2. Temperature of 240°F

F. Provided with charging valve enclosure, remote air connector coupling, system connection and lifting rings.

G. Tanks shall be provided with factory applied rustproof coat of paint to the exterior of tanks.

2.06 **AIR SEPARATORS**

A. Provide air separator with flanged inlet and outlet connections.
1. Provided with drain connection with valve.
2. Shall be tangential type.
3. Bottom blow down.
4. Full size removable strainer.

B. Pressure drop shaft be 1 foot of water and maximum velocity shall be 4 fps.

2.07 **MAKEUP AND RELIEF VALVES**

A. See Specification Section 230519.20.

PART 3 – EXECUTION

3.01 **PUMP INSTALLATION**

A. Pumps shall be installed so as to ensure easy accessibility for service or removal and replacement of all components such as, but not limited to, impellers, motors, drive couplings, bearings, strainers, other pump appurtenances and isolators.

B. The Contractor shall receive and inspect all pumps and motors to ensure they are received without defect.

C. All defective or damaged pumps shall be returned to the manufacturer by the Contractor for replacement.

D. The Contractor shall properly protect all equipment to prevent damage from water, dirt, etc. Protection shall include temporary plastic wrap to keep equipment in original factory condition.

E. Set pump on concrete base, anchor, level and grout according to manufacturer's instructions. Where specified or where indicated in the equipment schedule on the mechanical drawings provide vibration isolators under pump base.

F. Provide line sized shutoff valve and strainer on suction and line sized silent check valve and flow control balancing valve on discharge unless otherwise noted on mechanical drawings.

G. Decrease from line size, with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. Provide supports under elbows on pump suction and discharge line sizes 4 inches and over.

H. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation and operate within 25 percent of midpoint of published maximum efficiency curve.

I. Refer to pump detail on mechanical drawings for other accessories to be provided.

J. Provide drains for bases and stuffing boxes piped to and discharging over floor drain. Provide air cock and drain connection on horizontal pump casings.

K. Manufacturer representative shall check, laser align, and certify base mounted pumps 25 motor horsepower and over, before start-up. Pump and drive shall be aligned in accordance with Hydraulic Institute Standards.

L. Pumps shall be installed so as to ensure easy accessibility for service or removal and replacement of all components such as, but not limited to, impellers, motors, drive couplings, bearings, strainers, other pump appurtenances, isolators, and flex connections.

M. The Contractor shall receive and inspect all pumps and motors to ensure they are received without defect. All defective or damaged pumps shall be replaced.

N. The Contractor shall properly protect all equipment to prevent damage from water, dirt, etc.

3.02 **EXPANSION TANK**

A. Provide where indicated in the drawings.

B. Install in accordance with manufacturer’s installation instructions.

C. Charge with air to the specified pressure prior to the system fill.

3.03 **AIR SEPARATOR**

A. Provide where indicated on the drawings.

B. Install in accordance with manufacturer’s instructions.

END OF SECTION

SECTION 235212

HOT WATER ELECTRIC BOILERS

PART 1 – GENERAL

1.01 SUBMITTALS

A. Product Data
   1. Include details of equipment assemblies.
   2. Include diagram(s) for dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagram(s) for power, signal, and control wiring.
      a. 1-84 – Terminology for Anti Friction Ball and Roller Bearings and Parts.

B. Field quality-control reports

C. Boiler Manufacturer’s Certification:
   1. ASME Stamp on the boiler vessel.
   2. cULus packaged boiler label affixed to the control panel.

1.02 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.
   1. Manufacturer’s printed operation and maintenance manuals shall be submitted prior to final acceptance by the engineer. Operation and maintenance manuals shall contain, operating instructions, cleaning procedures, replacement parts list, maintenance and repair data, etc.

B. Manufacturer’s data reports.
   1. Form H-2.
   2. ASME CSD-1 certification.
   3. Factory Acceptance Test Report.
   4. Source quality-control.

C. Start-up reports.
   1. The specified factory tests have been satisfactorily performed.
   2. The specified field tests have been satisfactorily performed.
      a. The boiler and other associated mechanical and electrical equipment are properly coordinated and integrated to provide a complete and operable boiler package.

1.03 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or provide replacement components of boilers that fail in materials or workmanship within specified warranty period.
   1. Warranty period
      a. The pressure vessel shall be warranted against defective workmanship and materials for a period of ten (10) years. This warranty does not include issues caused by improper water treatment or incorrect use and/or abuse of the boiler.
      b. Heating elements shall be warranted against defective workmanship and materials for a period of five (5) years. This warranty does not include issues caused by improper water treatment or incorrect use and/or abuse of the boiler.
      c. All parts not covered by the above shall carry a two (2) year warranty from shipment.

1.04 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   1. "National Electrical Code," Article 424, Part VII.

B. ASME Compliance: Fabricate and label boilers to comply with the current version of the ASME Boiler and Pressure Vessel Code, Section IV.

C. UL Compliance: Test boilers for compliance with UL 834. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

D. Boiler and controls shall be compliant with ASME CSD-1 Code requirements.

E. For securing boiler to concrete base.
   1. Seismic Fabrication Requirements: Attach a base skid to any boiler pressure vessel, accessories, and components. Boiler manufacturer shall provide anchoring pockets in boiler skid base. Contractor shall anchor boilers to meet specification requirements.

PART 2 – PRODUCTS

2.01 ELECTRIC BOILER

A. Manufacturers:
   1. Cleaver Brooks – Model WB (Basis of Design)

B. Description: Each unit shall be a complete boiler with automatic controls. The boiler, with all piping and wiring, shall be a factory package. Each boiler shall be neatly finished, thoroughly tested and properly packaged for shipping. Boiler design and construction shall be in accordance with Section IV of the ASME Code for hot water heating boilers with a maximum working pressure of 160 PSIG.

C. Pressure Vessel:
   1. Vertical carbon steel with welded heads and flanged element insertion openings.
   2. The boiler shall have one supply connection and one return water connection. The supply and return connections shall be positioned so that water flow cannot short circuit heating elements.

D. Casing:
   1. Jacket: 18 gauge metal wrapped casing.
   2. Control compartment enclosures: NEMA 250, Type 1A.
   3. Finish: Enamel.
   4. Insulation: Minimum two (2) inch thick, mineral-fiber insulation having minimum 1-1/2 lbft3 density surrounding the heat exchanger. Radiation and convection losses shall not exceed 0.5% of total boiler output.

2.02 HEATING ELEMENTS

A. The heating elements shall be individually field replaceable with standard tools.
   1. Heating elements shall be mounted on circular flanges for convenient inspection.
   2. Heating elements shall be secured using torqued ferrule fittings.

B. The heating elements watt density shall not exceed 75 watts per square inch.

C. The heating elements shall be Incoloy 800 sheathed.

D. The heating elements length shall not exceed 36 inches.

2.03 TRIM

A. Safety valve(s) shall be ASME Section IV approved side outlet type. Size shall be in accordance with code requirements and set to open at specified pressure or maximum allowable boiler pressure.

B. Pressure gauge.

C. Thermometer.

D. Solid state low water cut-off probe control with manual reset and test switch.

E. Status lights for power on, high temperature cutoff, low water cutoff, step status for each step.

F. Manual air vent

G. Auxiliary low water cutoff

H. Alarm horn (electronic sounder)

I. Automatic isolation valves

2.04 CONTROLS

A. All controls to be panel mounted and located on the boiler as to provide ease of servicing the boiler without disturbing the controls and also located to prevent possible damage by water according to UL and CSA requirements.

B. When multiple boilers are to be installed together, a system integration control shall be provided to stage up to four (4) boilers using a separate boiler lead-lag panel.
   1. The control shall include automatic selection of needed boilers based on load demand. The control shall monitor supply water heater temperature, return water temperature to each boiler, and shall communicate to boilers using a 4-20mA analog signal.

C. Boilers controls shall communicate with BACnet I/P building management system utilizing a protocol translator for requirements other than the native ModBus RTU.
   1. Protocol translator mounted in a NEMA 1 panel with power supply and terminals.
   2. Protocol translator shipped loose for installation in boiler control panel with required power supply.

D. The boiler controls shall include provisions for remote setpoint.

E. Include provisions for shutting down the boiler on loss of system pump signal.

F. Include a flow switch and provisions for shutting down the boiler on loss of flow.
   1. Mount flow switch to the boiler return nozzle

G. Step control capabilities shall include:
   1. 1-Step: (1) On/Off temperature switch.
   2. 2-Steps: (2) On/Off temperature switch.
   3. 3-Steps+: (1) solid state electronic proportional temperature control with progressive step control, adjustable span, and interstage time delay.
      a. Temperature and set-point temperature shall be displayed at all times. A supply water temperature transmitter shall be provided and wired to the PID process controller.
      b. Control shall be equipped with a touchscreen display for set up, trouble shooting, and operational display, and shall include ModBus communication capability.
      c. Control shall include the programming to control of up to two heating demand loops.
      d. Set-points and configurations shall be factory pre-configured. Parameter settings are to be established to suit jobsite conditions and to be configured at the time of initial jobsite operation.
      e. Boiler shall have capability to have 24/7 remote monitor without connections to a BMS through an encrypted secure channel. The remote interface shall have the following features and capabilities.
         1) Display real time boiler system operation, runs hours, inlet/outlet water temps, alarms, and more.
         2) View data on mobile app and customizable online dashboard
         3) Multiple user authorization with different levels of access
         4) Multiple site integration to allow user to see all boiler plants and control individual plants
         5) Email and text alerts
         6) Data trending
   4. Silicon controlled rectifier (SCR) control

2.05 **ELECTRICAL POWER**

A. Electrical power supply shall be 480 volts, 60 cycle three phase.

B. Main lugs for supply circuits.
   1. Mechanical lugs bolted to copper bus bars or distributions blocks with pressure connectors.
   2. Panel electrical short circuit current rating (SCCR) shall be 10,000 amps interrupting current.

C. Fused 120V control circuit transformer.

D. Supplemental internal branch circuit fuses, current limiting, non-renewable, rated at 200,000 amps interrupting capacity.

E. Magnetic contactors rated at 500,000 cycles, 50A resistive up to 600V.

F. Housed in NEMA 250, Type 1A enclosure with louvers.

G. Wiring shall be numbered and color coded to match a wiring diagram.
   1. Install factory wiring outside of an enclosure in a metal raceway or conduit.
   2. Minimum heating element wire size shall be #8 AWG.
   3. Minimum control circuit wire size shall be #16 AWG.

H. Field power interface shall be to non-fused disconnect switch or molded case magnetic circuit breaker.
   1. Disconnect shall be through the door type and mounted directly to boiler main electrical cabinet.
   2. Disconnect shall be shipped loose for installation by others.
   3. Ground fault current interrupting (GFCI) circuit breaker
   4. Panel mounted power meter to measure and display input voltage, amperage, and/or power.
      a. Data Logging:
         1) Totalized power consumption (kWh)
         2) Real-time clock
         3) Limit alarms
      b. Communications over Ethernet

2.06 **QUALITY CONTROL**

A. Hydrostatic Test: Factory to perform a functional controls test for all safety devices; perform hydrostatic test; and continuity test for contactors and relays

B. Test and inspect factory-assembled boilers, before shipping, according to most current ASME Boiler and Pressure Vessel Code.

C. All wiring shall be in compliance with the National Electric Code.

PART 3 – EXECUTION

3.01 **BOILER INSTALLATION**

A. Installation shall be provided by the contractor in accordance with the requirements of the codes specified hereinbefore. All of the contractor's work shall be performed by experienced personnel previously engaged in boiler plant construction and shall be under the supervision of a qualified installation supervisor.

B. Equipment Installation:
   1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases.
   2. Comply with requirements for seismic-restraint devices.
   3. Install equipment in strict compliance with manufacturer's installation instructions.
   4. Install equipment in strict compliance with state and local codes and applicable NFPA standards.
   5. Maintain manufacturer's recommended clearances around sides and over top of equipment.
   6. Install components that were removed from equipment for shipping purposes.
   7. Install components that were furnished loose with equipment for field installation.
   8. Provide all interconnecting electrical control and power wiring.
   9. Provide all piping for boiler pipe connections.

3.02 **CONNECTIONS**

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect hot-water piping to supply and return boiler tappings with shutoff valve and union or flange at each connection.

E. Install piping from safety relief valves to nearest floor drain or point of safe discharge.

F. Ground equipment according to specification requirements.

G. Connect wiring according to specification requirements.

3.03 **FIELD QUALITY CONTROL**

A. General: The boiler supplier's factory authorized service organization shall be responsible for performance of inspections, start up and testing of the package boiler, and accessory equipment and materials furnished under this Section. All labor, equipment, and test apparatus shall be furnished by the authorized service organization. All equipment defects discovered by the tests shall be rectified either by the service organization or boiler manufacturer.

B. Equipment inspection: Boiler representative shall inspect boilers and other equipment upon arrival, verifying completeness of equipment supplied and potential damages. All shipped loose components, to be mounted and installed on boiler by contractor.

C. Equipment shall be flushed prior to start-up per the water treatment company guidelines and product installation manual requirements.

D. Pre start-up walk through: Boiler representative shall review the installation with the mechanical contractor prior to start-up and note any required changes prior to start-up.

E. Start-up shall be conducted by experienced and factory authorized technician in the regular employment of the authorized service organization, and shall include:

F. Demonstrate that boiler, controls, and accessories comply with requirements of this Section as proposed by the boiler and accessories supplier. Pre-test all items prior to scheduling the final testing that will be witnessed by the test engineer.

G. Demonstrate that boiler performs at different rates of load to ensure progressive step controller function.

H. Auxiliary Equipment and Accessories: Observe and check all valves, electric motors and other accessories and appurtenant equipment during the operational and capacity tests for leakage, malfunctioning, defects, and non-compliance with referenced standards or overloading as applicable.

I. Commissioning Requirements:
   1. Set up operating set points
   2. Set up modulating process controller
   3. Check all safeties, including low water cutoff and high limits.
   4. Check heating elements for moisture accumulation.

3.04 **DEMONSTRATION**

A. Training to include all safety procedures, maintenance procedures, control operations, and diagnostic procedures. Training to be provided in a single 2 hour continuous session to accommodate operator's availability on site.

END OF SECTION

SECTION 23 57 00

HEAT EXCHANGERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Section 230500 and other Division 1 Specification Sections, apply to this Section.

1.02 WORK INCLUDED

A. Furnish and install all heat exchangers to make a complete and operations system.

B. All system components shall be installed in accordance with local code including supports and bases.

C. Secure all permits and local/State approval for the installation of all components included under this Section.

D. Provide factory assembled and tested shell and tube or plate-and-frame heat exchangers with plate quantity, capacity, temperature range, physical dimensions and other characteristics, as scheduled on the drawings and as hereinafter specified.

E. Provide piping, valves, controls, fittings and accessories as required and shown on the drawings.

1.03 RELATED SECTIONS

A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

1.04 REFERENCES

A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.

B. Material standards shall be as specified or detailed hereinafter and as follows:
   1. ASME (BPV VIII, 1) – Boiler and Pressure Vessel Code, Section VIII, Division 1 – Rules for Construction of Pressure Vessels; 1995.

1.05 SUBMITTALS

A. See Section 230500 and General Conditions for additional requirements.

B. Product Data: Provide date with dimensions, locations and size of tappings and performance date.

C. Shop Drawings: Indicate dimensions, locations and size of tappings and performance data.
   1. Design Data: Indicate in sufficient detail to verify that heat exchangers meet or exceed specified requirements.
   2. Test Reports: Indicate pressure tests.

D. Manufacturer’s Instructions: Indicate installation and support requirements.

E. Operation and Maintenance Data: Include start up and shut down instructions, assembly drawings and spare parts list.

1.06 REGULATORY REQUIREMENTS

A. Conform to ASME (BPV VIII, 1) – Boilers and Pressure Vessels Code for manufacture of tubular heat exchangers and heat exchanger shells and plate and frame type heat exchangers.

B. Conform to ASME Code Form #U-1 for unfired pressure vessels.

1.07 DELIVERY, STORAGE AND HANDLING

A. Protect internals from entry of foreign material by temporary caps on flanged openings.

PART 2 - PRODUCTS

2.01 PLATE AND FRAME HEAT EXCHANGERS

A. Acceptable manufacturers subject to compliance with the specifications:
   1. Bell & Gossett
   2. Mueller
   3. Patterson-Kelly

B. Heat exchangers shall conform to the latest ASME Code for Unfired Pressure as detailed in Form #U-1 and shall be Code stamped for design pressure, 225 psig test pressure as scheduled on the drawings.

C. Heat exchanger construction shall consist of an epoxy coated steel frame with steel plate carriers, steel compression bolts, gaskets, Type AISI 304 stainless steel replaceable plates, and an aluminum or galvanized steel protective plate pack shroud.

D. A minimum of 25% capacity shall be included in the frame length to allow for future expansion. Each heat exchanger shall be of single-pass construction with all connections on the fixed frame plate to facilitate cleaning of the unit and shall be designed to accept ANSI flanged connections.

E. Fouling factor for both sides shall be 0.00025 or as scheduled.

PART 3 - EXECUTION

3.01 PLATE FRAME HEAT EXCHANGER INSTALLATION

A. Plate-and-frame heat exchangers shall be installed in accordance with manufacturer's recommendations, Contract Drawings, and reviewed submittals.

B. The heat exchanger shall be installed level with ample room for opening with wrenches. Provide room for piping valves, flexible couplings and support piping at connections.

C. Provide flanged connections, vents, drains and relief valves.

D. Provide adequate space for service.

E. Provide adequate space for heat exchanger removal.

3.02 START UP SERVICE

A. Provide start-up service by a factory approved and certified technician.

END OF SECTION

SECTION 23 64 16
WATER COOLED MAGENTIC BEARING CENTRIFUGAL CHILLERS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Semi-hermetic, direct drive, magnetic bearing, multi-stage, water-cooled centrifugal chiller with single or multiple compressors.

1.02 SUBMITTALS

A. Acceptable refrigerants on which chiller performance is based are R-513A, R-514A, R-1233zd and any refrigerant that has a GWP less the 700. All proposals for chiller performance must include an AHRI approved selection for the specified refrigerants.

B. Submit drawings indicating assembled dimensions, operating weight, load distribution, and required service and access clearances.

C. Submit product data indicating options and specialties, electrical requirements, and wiring diagrams and connections. Indicate accessories, valves, strainers, and thermostatic valves required for the complete system.

D. Submit rigging, installation, and startup procedures. Include operations and maintenance data for both the chiller and starter or variable-speed drive. Include location, size, and type of field piping connections.

E. Submit performance data indicating energy input versus cooling load output from 100 to 25 percent of full load with constant entering condenser water temperature.

1.03 REGULATORY REQUIREMENTS

A. Conform to AHRI Standard 550/590 code for rating and testing of water chillers.

B. Conform to UL 1995 - Standard for Heating and Cooling Equipment, Safety Standard.

C. Conform to ANSI/ASME SECTION VIII Boiler and Pressure Vessel Code for construction and testing of centrifugal chillers as applicable.

D. Conform to latest revision of ANSI/ASHRAE STANDARD 15 code for construction and operation of centrifugal chillers.

E. Unit shall bear the AHRI Certification Label for the specific type of water chiller as applicable.

F. Chiller manufacturer shall provide LEED-NC EA Credit 4 enhanced refrigerant management. Calculation for each chiller shall be based on the factors as specified by the U.S. Green Building Council based upon equipment life of 25 years.

1.04 DELIVERY AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, chiller loading, local transportation requirements, unloading, storage, and final setting.

B. Protect chiller and controls from physical damage. Leave factory shipping covers in place until installation. The entire unit must be shrink wrapped with an environmentally recyclable material standard. The material shall include an imbedded desiccant to minimize/eliminate internal moisture.

1.05 WARRANTY

A. Provide a standard unit parts and labor warranty for one year from startup or 18 months from factory shipment, whichever favors the Owner.

B. Chiller manufacturer shall provide a whole unit parts, labor and refrigerant warranty for a period of 10 years from start-up. The warranty must be provided by the manufacturer; third party insurance/warranty coverage is not acceptable. The chiller manufacturer shall provide an original factory warranty certificate for each chiller listing as a minimum chiller model, serial number, and warranty information as specified. Payment shall not be released until the owner receives original certificates. Warranty coverage is per the factory, not local sales offices.

Validated service and scheduled maintenance performed by acceptable servicing companies per manufacturer required.

C. When startup of the purchased equipment will be delayed beyond six months after shipment, an optional delayed startup warranty shall be provided to postpone the commencement date of the standard parts warranty for up to one full year from the date of startup. This will also defer the commencement of any additional purchased warranties. This warranty must be ordered before startup.

1.06 **MAINTENANCE SERVICE**

A. All inspections and service of units shall be accomplished by factory trained and authorized servicing technicians.

B. All labor for leak checking the chiller according to the manufacturer's IOM and documentation must be included.

C. In conjunction with and supporting Factory warranty OEM shall furnish complete factory authorized service and maintenance of Applied Chillers for **2** years from Date of Substantial Completion. All work shall be done by manufacturer's commercial warranty agent.

D. OEM shall provide and report quarterly, semiannual, and annual maintenance in compliance with or better than ASHRAE Standard 180-2008.

E. Include maintenance items as recommended in manufacturer's operating and maintenance data.

F. Submit copy of service call work orders and summary report to the Owner, including description of work performed, operating performance status and noted exceptions.

1.07 **VERIFICATION OF CAPACITY AND EFFICIENCY**

A. All proposals for chiller performance must include an AHRI approved selection method. Verification of date and version of computer program selection or catalog is available through AHRI.

B. Performance Tolerances
   1. The following allowable tolerances must be followed
      a. The chiller shall achieve 100% of the nameplate rated capacity under test conditions specific to the project temperatures, flow rates and efficiency requirements. No deviations shall be allowed.
      b. The tolerance on allowable capacity is as defined by AHRI Standard, but shall not dictate the results of the factory capacity test.
      c. The IPLV/NPLV and full load conditions shall be defined by AHRI. However, all scheduled values in the engineer’s documents shall be attained during the factory test. This includes temperatures, flow rates, pressure drops, and electrical efficiency (kW/ton).

C. The chillers shall be factory performance tested under full load conditions in an AHRI certified test facility. The manufacturer shall supply a certified test report to confirm performance as specified. Proper AHRI certification documents for the test loop shall be made available upon request from the manufacturer for inspection. The performance test shall be conducted in accordance with AHRI Standard 550/590 procedures however tolerances will not be allowed as discussed above.
   1. The performance test shall be run with clean tubes in accordance with AHRI Standard 550/590 to include the following:
      a. A downward temperature adjustment shall be made to the design leaving evaporator water temperature to adjust from the design fouling to the clean tube condition.
      b. An upward temperature adjustment shall be made to the design entering condenser water temperature to adjust from the design fouling to the clean tube condition.
      c. There shall be no exceptions to conducting the performance test with clean tubes and with temperature adjustments in (1) and (2). The manufacturer shall clean tubes, if necessary, prior to test to obtain a test fouling factor of .0000 hr. sq. ft. F/BTU.

2. The factory test instrumentation shall be per AHRI Standard 550/590, and the calibration of all instrumentation shall be traceable to the National Institute of Standards and Technology (formerly NBS).
3. The owner or his representative shall be notified 14 days in advance to witness the factory performance test. If the owner or his representative desires to witness the performance test, all travel expenses will be the owner's responsibility.
4. The following must be referenced:
   a. There shall be no tolerance on capacity, as defined by AHRI Standard 550/590 for full and part load points.
   b. There shall be no tolerance on efficiency, as defined by AHRI Standard 550/590 for IPLV/NPLV, full load and all part load test points.
5. A certified test report of all data shall be submitted to the Contracting Officer prior to completion of the project. The factory certified test report shall be signed by an officer of the manufacturer's company. Preprinted certification will not be acceptable; certification shall be in the original.
6. The equipment will be accepted if the test procedures and results are in conformance with the engineer's documents. If the equipment fails to perform within allowable tolerances, the manufacturer will be allowed to make necessary revisions to his equipment and retest as required. The manufacturer shall assume all expenses incurred by the owner or his representative to witness the retest. In the event that these revisions do not achieve submitted performance, the following penalties will be imposed:
   a. CAPACITY PENALTY: For each ton below the allowable capacity, $1000 per ton will be deducted from the contract price.*Allowable capacity = [(1 - tolerance) x design capacity].
   b. POWER CONSUMPTION PENALTY: All load points and the Power Consumption Penalty (P.C.P.) shall be based upon the tolerances specified above. The P.C.P. shall be calculated based upon the following formula: P.C.P. = [Measured kW - (Measured tons x ALLOWABLE kW/ton*)] x $2000/kW.*Allowable kW/ton = [(1 + tolerance) x design kW/ton].
   c. TOTAL PERFORMANCE PENALTY: The total performance penalty will be the sum of the CAPACITY PENALTY AND THE POWER CONSUMPTION PENALTY times the number of typical chillers, regardless if tested.
   d. Equipment manufacturer shall not invoice for the chillers(s) until successful completion of the performance test or acceptance of penalty deduction from the contract.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Trane Agility

B. Engineer Approved Equal such as Daikin, Carrier, or JCI

2.02 SUMMARY

A. Description: Factory-assembled and tested water chiller complete with compressor, evaporator, condenser, controls, starter or variable speed drive, interconnecting unit piping and wiring, indicating accessories, and mounting frame. Performance shall be per specification section 3.03 schedule.

B. On site labor or a premanufactured equipment factory shall install centrifugal water chillers as shown and scheduled in the plans and specifications. The units shall produce the specified tonnage per the scheduled data in accordance with the latest revision of AHRI 550/590. The unit shall bear the AHRI certification label as applicable.

2.03 COMPRESSOR AND MOTOR

A. The compressor shall be centrifugal with multiple stages.

B. Chiller should be able to unload to 25% of design tonnage with constant entering water temperature. Chiller should be able to unload to 10% of design tonnage with AHRI relief

entering water temperature. The minimum unloading point shall be demonstrated at the time of the factory performance test. The machine shall be modified to include hot gas bypass if the minimum load cannot be met.

C. The chiller must provide backup power to the magnetic bearings with a UPS system that provides power conditioning, to completely isolate the magnetic bearing system from utility power, enabling error-free operation during surges, sags, spikes, and other power anomalies.

D. The motor shall be hermetic and either; suction, interstage, or liquid refrigerant cooled. Hot gas motor cooling is not acceptable. Open drives are not acceptable due to the potential for refrigerant and oil leakage associated with the mechanical shaft seal and the coupling between an open motor and the compressor.

E. The impellers shall be fully shrouded and made of a high strength aluminum alloy.

2.04 EVAPORATOR AND CONDENSER

A. The evaporator and condenser shall be built in accordance with ANSI/ASHRAE 15-2001 Safety Code for Mechanical Refrigeration and ASME section VIII as applicable.

B. The evaporator and condenser tubes shall be internally and externally enhanced with a **0.75"** outer diameter. The tubes shall be securely supported at intermediate supports and physically expanded into both ends of the tube sheets. The evaporator tubes must also be removable from both ends to provide easy access for tube cleaning. The minimum evaporator tube wall thickness, root-to-root across the entire tube length shall be **0.025".** The minimum condenser tube wall thickness, root-to-root across the entire tube length shall be **0.028".**

C. The evaporator and condenser water piping connections shall be grooved.

D. Provide evaporator water box designed for 150 psig maximum waterside working pressure, with grooved pipe water connections. Waterside shall be hydrostatically tested at 1.5 times design working pressure.

E. Provide condenser water box designed for 150 psig maximum waterside working pressure, with grooved pipe water connections. Waterside shall be hydrostatically tested at 1.5 times design working pressure.

F. The evaporator and condenser shall both have a flow turndown of 2:1

G. The evaporator water boxes shall be standard non-marine type with connections per the schedule.

H. The condenser water boxes shall be standard non-marine type with connections per the schedule.

I. Insulation will be 3/4" insulation and cover all low-temperature surfaces to include the evaporator, water boxes, suction elbow, and economizer if applicable.

J. Units with multi-stage compressors shall incorporate an interstage "economizer". All units with single stage compressors shall have the condensers circuited for liquid subcooling and controlled through the use of condenser liquid level control.

K. Adjustable or float type refrigerant metering devices and thermal expansion valves (TXV) shall be inspected and adjusted by the manufacturer annually for the first five years of operation to assure equivalent reliability to an electronic expansion valve (EXV) system. A written report shall be forwarded to the owner each year over the first five years to confirm completion of calibration.

2.05 REFRIGERANT CIRCUIT

A. All units shall have 1 refrigerant circuit with a single compressor. If manifolded compressors are provided, then individual compressor warranties must be provided for each compressor motor.

B. An electronically controlled expansion valve (EXV) is provided to maintain proper refrigerant flow.

C. Chiller shall be able to unload to 10% of capacity with AHRI relief and 25% with constant entering condenser water temperature.

2.06 **CONTROLS**

A. The chiller shall be controlled by a unit mounted, stand-alone Direct Digital Control (DDC) system. A dedicated chiller microprocessor control panel is to be supplied with each chiller by the chiller manufacturer.

B. Enclosure shall be unit mounted NEMA 250 Type 1

C. A color, touch sensitive liquid crystal display (LCD) shall be unit mounted and a minimum of 12.1" diagonal. The display shall be fully adjustable in height and viewing angle. Animated graphical representations of chiller subsystem operation shall be used to enhance the user interface.

D. Display shall consist of a menu driven interface with easy touch screen navigation to organized sub-system reports for compressor, evaporator, condenser and motor information as well as associated diagnostics. The controller shall display all active diagnostics and a minimum of 20 historical diagnostics.

E. Control authority must be capable of handling at least four conditions: Off, local manual at the chiller, local automatic at the chiller and automatic control through a remote source.

F. Capability to connect a laptop to service utility with applicable software from manufacturer and obtain enhanced set-up and diagnostics.

G. The front of the chiller control panel shall display the following in clear language, without the use of codes, look-up tables, or gauges
   1. Run time
   2. Number of starts
   3. Current chiller operating mode
   4. Chilled water set point and set point source
   5. Electrical current limit set point and set point source
   6. Entering and leaving evaporator water temperatures
   7. Entering and leaving condenser water temperatures
   8. Saturated evaporator and condenser refrigerant temperatures
   9. Evaporator and condenser refrigerant pressure
   10. Compressor motor current per phase
   11. Compressor motor percent RLA
   12. kW energy consumption and power factor
   13. Compressor motor winding temperatures per phase

H. The chiller control panel shall provide password protection of all setpoints

I. The chiller control panel shall provide individual relay outputs to start/stop the evaporator and condenser water pumps. The condenser water pump relay output can be used to enable the cooling tower temperature controls.

J. The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature.

K. The chiller control panel shall be capable of displaying system data in I-P or SI units.

L. The chiller manufacturer shall include a pressure, non-mechanical based unit mounted flow switch that is of the thermal dispersion type for each evaporator and condenser to verify flow through the unit.

M. Safeties - the chiller control panel shall provide the following safeties:
   1. Low chilled water temperature
   2. Low evaporator refrigerant temperature or pressure
   3. High condenser refrigerant pressure
   4. Evaporator and condenser water flow status
   5. High motor winding temperatures
   6. High motor current

7. AFD function faults
8. Sensor faults
9. Unit controls operation
10. The chiller control panel or starter shall incorporate advanced motor protection to safeguard the motor throughout the starting and running cycles from the adverse effects of:
    a. Current phase loss
    b. Current phase unbalance
    c. Current phase reversal
    d. Under/Over voltage
    e. Motor current overload
    f. Distribution fault protection with auto restart consisting of three-phase current sensing devices that monitor the status of the current
    g. AFD communication-control failure

N. The chiller control panel shall be capable of providing short cycling protection.

O. The chilled water controller of each chiller shall include variable water-flow capability to allow the chiller to respond quickly to accelerating or decelerating water, and have the following features:
    1. Shall allow control of the leaving chilled water temperature to within +/- 1.0°F (0.3°C) at a water flow rate change of 10% per minute and will stay online at a water flow rate change of 30% per minute.

P. The chiller and controller shall include factory mounted transducers to read the differential evaporator water pressure (psid) and condenser water pressure (psid). The following parameters shall be displayed on the unit control display:
    1. Evaporator differential pressure (psid)
    2. Condenser differential pressure (psid)
    3. Evaporator flow rate (GPM)
    4. Condenser water flow (GPM)
    5. Evaporator capacity (Tons)

Q. The chiller, upon power loss restoration, must be able to start the compressor within 65s seconds. The chiller time to fully load up to 80% shall be no longer than 4 minutes. The manufacturer shall supply documentation to support their ability to do this
    1. If the documentation is not adequate, the manufacturer must demonstrate this in the factory on an AHRI certified loop
    2. See Section 2.13 for more information on restart demonstration

R. The chiller control panel shall provide a relay output that shall energize whenever the compressor is running.

S. The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.

T. The chiller control panel shall provide a relay output that shall energize whenever the chiller is operating at maximum capacity.

U. The chiller control panel shall provide a head relief request relay output to indicate that the chiller is in condenser limit mode and thereby requesting condenser water temperature relief.

V. The chiller control panel shall provide an analog [2 - 10VDC] [4 - 20mA] output signal that shall indicate the Compressor Motor Percent RLA.

W. The chiller should have a condenser pressure output signal of [0 - 10VDC] [4 - 20mA] that may be used for head pressure control if required.

X. The chiller control panel shall allow for an analog input for a chilled water setpoint and an electrical current limit set point. These setpoints can be in the form of 4-20 mA or 2-10 Vdc signals from a remote source (i.e. generic building automation system).

Y. The chiller control panel shall provide an analog output signal that shall indicate the condenser refrigerant pressure or condenser/evaporator differential refrigerant pressure.

Z. The chiller controller must be able to communicate directly to a building automation system using Modbus protocol (RTU-RS 485). The chiller operation shall be fully intergrated to the Campus BMS.

AA. Digital communication to BAS system shall consist of a LonMark certified LonTalk interface supporting all standard and optional points in the LonMark chiller profile. Certification by LonMark it only acceptable if listed on the lonmark.org web site. All information available within the chiller control module shall be accessible at the BMS central station interphase.

2.07 **VARIABLE SPEED DRIVE (VSD), UNIT MOUNTED**

A. The water chiller shall be furnished with a variable speed drive (VSD) as shown on the drawings. The VSD shall be factory mounted on the chiller and shipped completely factory assembled, wired and tested.

B. The VSD will be specifically designed to interface with the centrifugal water chiller controls and allow for the operating ranges and specific characteristics of the chiller. The VSD control logic shall optimize chiller efficiency by coordinating compressor motor speed and compressor inlet guide vane position to maintain the chilled water setpoint while avoiding surge. If a surge is detected, VSD surge avoidance logic will make adjustments to move away from and avoid surge at similar conditions in the future.

C. The VSD efficiency shall be 97% or better at full speed and full load. Fundamental displacement power factor shall be a minimum of 0.96 at all loads.

D. The VSD shall be solid state, microprocessor based pulse-width modulated (PWM) design. The VSD shall be voltage and current regulated. Output power devices shall be IGBTs.

E. Power semi-conductor and capacitor cooling shall be from a combination of liquid cooled heatsink and air flow.

F. The VSDs shall each be furnished in a metal enclosure having as minimum a short circuit withstand rating of 65,000 amps per UL 508A. It will include three phase input lugs plus a grounding lug for electrical connections, output motor connection via factory installed bus bars and all components properly segregated and completely enclosed in a single metal enclosure.
   1. Enclosure shall include a padlockable, door-mounted circuit breaker with a minimum AIC rating of 65,000 amps.
   2. The entire chiller package shall be UL/CUL listed.

G. The VSD panel shall be tested to ANSI/UL Standard 508A and shall be listed by a Nationally Recognized Testing Laboratory (NRTL) as designated by OSHA.

H. Compliance to IEEE 519-1992. The drive shall meet the IEEE 519 requirements for less that 5% total demand distortion TDD ***with the use of an input matrix*** **harmonic** filter mounted within the drive enclosure. The losses due the the filter, if applicable must be included in the chiller performance. If a remote harmonic filter is offered to meet the 5% TDD level, the performance of the chiller selection must include the filter losses. In addition if chiller factory performance testing is selected, the remote filter must be tested with the chiller in the factory.

I. Input shall be nominal 460 volts, three phase, 60 Hertz AC power, +/- 10 percent of nominal voltage.

J. Line frequency 60 Hertz (+/-5%)

K. The VSD shall include the following features:
   1. All control circuit voltages are physically and electrically isolated from power circuit voltage.
   2. Soft start, adjustable linear acceleration, controlled ramp-down to stop.
   3. Insensitivity to incoming power phase sequence.
   4. Adjustable current limiting and U.L. approved electronic motor overload protection.
   5. Output line-to-line short circuit protection.
   6. Line-to-ground short circuit protection.

7. Protection from phase loss at AFD input.
8. Protection from output phase reversal/imbalance.
9. Protection from over/under-voltage.
10. Protection from over-temperature.

L. The following VSD status indicators shall be available to the unit controller to facilitate startup and maintenance:
1. DC Bus voltage.
2. Output/load amps.
3. Fault.

M. Service Conditions:
1. Operating ambient temperature of 14°F - 104°F (-10°C - 40°C).
2. Room ambient up to 95% relative humidity.
3. Elevation to 3300 feet (1000 meters). For every 300 feet (90 meters) above 3300 feet, the rated output current shall be decreased by 4% up to 9900 feet.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide for connection to electrical service. If oil pump is electric include the connection of the electrical to the oil pump.

C. Provide elastomeric isolation pads to reduce vibration transmission.

D. On units without unit mounted starters provide for connection of electrical wiring between starter and chiller control panel, oil pump, and purge unit.

E. Furnish and install necessary auxiliary water piping for oil cooling units and purge condensers.

F. Arrange piping for easy dismantling to permit tube cleaning.

G. Provide piping from chiller relief valve to outdoors. Size as recommended by manufacturer.

3.02 MANUFACTURER'S FIELD SERVICES

A. All onsite Startup, maintenance and monitoring functions shall be performed by the manufacturer’s commercial agent to confirm, (in writing), that equipment has been correctly installed and passes specification checklist prior to equipment becoming operational and covered under OEM warranty.

B. Included OEM Factory Startup:
1. Water Cooled Magnetic Bearing Centrifugal Chiller

C. Applied Chiller manufacturers shall maintain service capabilities no more than 100 miles from the jobsite.

D. The manufacturer shall furnish an alternative price for 5 years.

E. The manufacturer shall furnish complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

END OF SECTION

SECTION 23 64 26.16

WATER COOLED ROTARY SCREW WATER CHILLER

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Semi-hermetic, direct drive, water-cooled rotary screw chillers with single or multiple compressors.

B. Acceptable refrigerants on which chiller performance is based on is R-134a. All proposals for chiller performance must include an AHRI approved selection for the specified refrigerant.

C. Chiller must be capable of operating in a geothermal application.

1.02 SUBMITTALS

A. Submit drawings indicating components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves, strainers, and thermostatic valves required for complete system.

B. Submit product data indicating rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.

C. Submit manufacturer's installation instructions.

D. Submit performance data indicating energy input versus cooling load output from 100 to 25 percent of full load with constant entering condenser water temperature.

1.03 OPERATION AND MAINTENANCE DATA

A. Include start-up instructions, operation data, maintenance data, controls, and accessories. Include trouble-shooting guide.

1.04 REGULATORY REQUIREMENTS

A. Conform to AHRI Standard 550/590 for rating and certified testing of Water Chilling Packages using the Vapor Compression Cycle.

B. Conform to UL 1995 - Standard for Heating and Cooling Equipment, Safety Standard. In the event the unit is not UL approved, the manufacturer shall, at manufacturer expense, provide for a field inspection by an UL representative to verify conformance to UL standards. If necessary, contractor shall perform modifications to the unit to comply with UL, as directed by the UL representative.

C. Conform to ASME SECTION VIII Boiler and Pressure Vessel Code for construction and testing of unfired pressure vessels.

D. Conform to ANSI/ASHRAE STANDARD 15 safety code for mechanical refrigeration.

E. Unit shall bear the AHRI Certification Label for the specific type of water chiller as applicable.

F. Chiller manufacturer shall provide LEED-NC EA Credit Calculation for each chiller utilizing the factors specified by the U.S. Green Building Council based upon equipment life of 23 years.

1.05 DELIVERY, HANDLING AND STORAGE

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Unit will ship with shrink wrap covering the entire unit.

1.06 WARRANTY

A. Provide a full parts, labor, and refrigerant warranty for 5 years from start-up or 66 months from shipment, whichever occurs first.

1.07 MAINTENANCE SERVICE

A. All inspections and service of units shall be accomplished by factory trained and authorized servicing technicians.

B. All labor for leak checking the chiller according to the manufacturer's IOM and documentation must be included.

C. In conjunction with and supporting Factory warranty OEM shall furnish complete factory authorized service and maintenance of Applied Chillers for 2 years from Date of Substantial Completion. All work shall be done by manufacturer's commercial warranty agent.

D. Service contract shall be an add alternate to base price

E. OEM shall provide and report quarterly, semiannual, and annual maintenance in compliance with or better than ASHRAE Standard 180-2008.

F. Include maintenance items as recommended in manufacturer's operating and maintenance data.

G. Submit copy of service call work orders and summary report to the Owner, including description of work performed, operating performance status and noted exceptions.

1.08 **VERIFICATION OF CAPACITY AND EFFICIENCY**

A. All proposals for chiller performance must include an AHRI approved selection method. Verification of date and version of computer program selection or catalog is available through AHRI.

B. Customer inspection of unit at factory prior to shipment.

PART 2 - PRODUCTS

2.01 **SUMMARY**

A. The contractor shall furnish and install rotary screw water chillers as shown and scheduled in the plans. The units shall be installed in accordance with this specification and produce the specified tonnage per the scheduled data in accordance with AHRI Standard 550/590. The unit shall be AHRI certified as applicable.

2.02 **COMPRESSOR AND MOTOR**

A. Construct chiller using semi-hermetic helical rotary screw compressors with independent circuits.
   1. Statically and dynamically balance rotating parts.
   2. Provide oil lubrication system with oil charging valve and oil filter to ensure adequate lubrication during starting, stopping and normal operation.
   3. Provide compressor with automatic capacity reduction equipment consisting of capacity control slide valve (rotary). Compressor must start unloaded for soft start on motors.
   4. Provide compressor heater to evaporate refrigerant returning to compressor during shut down. Energize heater when compressor is not operating.

B. Chiller should be able to unload to 25 percent of full load tonnage with constant entering condenser water temperature.

C. Provide constant speed 3600 rpm for 60Hz compressor motor, suction gas cooled with robust construction and system design protection, designed for across-the-line or wye-delta starting. Furnish with starter.

2.03 **EVAPORATOR**

A. The evaporator shall be built in accordance with ANSI/ASHRAE 15- Safety Code for Mechanical Refrigeration. Design, test, and stamp evaporator refrigerant side for 200 psig working pressure in accordance with ANSI/ASME SEC VIII.

B. Evaporator tubes shall be internally and externally enhanced. The tubes shall be securely supported at intermediate supports and physically expanded into both ends of the tube sheets. The evaporator tubes must also be removable from both ends to provide easy access for tube cleaning.

C. Water boxes shall be designed for 150 psig maximum waterside working pressure. The water boxes shall have grooved-type water connections for easy field chilled water and condenser water connections and have proper orientation as referenced in the scheduled drawings.

D. Adjustable or float type refrigerant metering devices and thermal expansion valves (TXV) shall be inspected and adjusted by the manufacturer annually for the first five years of operation to assure equivalent reliability to an electronic expansion valve (EXV) system.

E. Factory insulation will be 1.5" insulation Armaflex II or equal (k=0.28) and cover the evaporator for environments with high humidity. Factory installed foam insulation will be used on the motor housing, suction line, liquid level sensor and oil return system assembly.

2.04 **WATER COOLED CONDENSER**

A. The water-cooled condenser shall be built in accordance with ANSI/ASHRAE 15 Safety Code for Mechanical Refrigeration. Design, test, and stamp condenser refrigerant side for 300 psig working pressure in accordance with ANSI/ASME SEC VIII.

B. Condenser tubes shall be internally and externally enhanced. The tubes shall be securely supported at intermediate supports and physically expanded into both ends. The condenser tubes must also be removable from both ends to provide easy access for tube changeouts or tube cleaning.

C. Water boxes shall be designed for 150 psig maximum waterside working pressure. The water boxes shall have grooved-type water connections for easy field chilled water and condenser water connections and have proper orientation as referenced in the scheduled drawings.

D. Optimized compressors, oil cooler and high condenser temperature control panel allows for leaving condenser water temperatures up to 140ºF. This option allows for entering condenser water temperatures above 95ºF. Condenser leaving water temperature control option is required; the setpoint range is 80ºF to 140ºF.

2.05 **REFRIGERANT CIRCUIT**

A. All units shall have 2 independent refrigerant circuits, each with a separate single compressor. If manifolded compressors are provided on a circuit, then individual compressor warranties must be provided for each compressor on the circuit.

B. Chiller shall be able to unload to 25% of capacity with AHRI relief and constant entering condenser water temperature.

C. Provide for each refrigerant circuit:
1. Suction service valve
2. Discharge service valve
3. Liquid line shutoff valve
4. Refrigerant pressure relief valves for low side and high side
5. Electronic expansion valve
6. Removable core filter
7. Charging port
8. Oil separator

D. The chiller shall be configured with single relief valve on both the high pressure side and low pressure side of each refrigerant circuit.

2.06 **CONTROLS**

A. The chiller(s) shall be controlled by a microprocessor-based, proportional and integral controller to show water and refrigerant temperatures, refrigerant pressures and diagnostics. A dedicated chiller control panel with a non-coded display is to be supplied with each chiller by the chiller manufacturer. The controller shall provide chiller capacity control in response to the leaving chilled water temperature.

B. The chiller control panel shall utilize an Adaptive Control Microprocessor which will automatically take action to prevent unit shutdown due to abnormal operating conditions associated with: evaporator refrigerant temperature, high condensing pressure and motor current overload.

C. If the chiller runs in any of the abnormal operating conditions, the chiller will continue to run, in an unloaded state, and will continue to produce chilled water in an attempt to meet the cooling

load. However, if the chiller reaches the trip-out limits, the chiller controls will take the chiller off line for protection, and a manual reset is required. Once the "near trip" condition is corrected, the chiller will return to normal operation and can then produce full load cooling.

D. The chiller control panel shall provide control of chiller operation and monitoring of chiller sensors, actuators, relays, and switches. The panel shall be a complete system for stand-alone chiller control and include controls to safely and efficiently operate the chiller.

E. Manufacturer shall provide a compressor that is capable of unloading to an infinite amount of positions in order to provide water temperature accuracy of +/- 0.5ºF. In the event that the compressor unloads to finite steps, the manufacturer shall provide eight (8) or more steps of unloading on each compressor or provide hot gas bypass (HGBP).

F. The chiller control panel is to be provided with the following digital type pressure readouts:
   1. Evaporator refrigerant pressure
   2. Condenser refrigerant pressure

G. The front of the chiller control panel shall be capable of displaying the following clear language as standard:
   1. Entering and leaving evaporator water temperature
   2. Entering and leaving condenser water temperature
   3. Chilled water setpoint
   4. Electrical 3 phase current limit and percent RLA setpoint
   5. Electrical 3 phase amp draw
   6. Chiller operating mode
   7. Condenser refrigerant temperature
   8. Elapsed time and number-of-starts counter
   9. Chiller compressor run status relay
   10. Diagnostics with time and date stamp
   11. A relay output to start the condenser water pump and/or enable the cooling tower temperature controls.
   12. The control panel display shall identify the fault, indicate date, time, and operating mode at time of occurrence, and provide type of reset required and a help message. The historic diagnostic report shall display the last 20 diagnostics with their times and dates of occurrence
   13. A relay output that shall energize whenever an alarm is active.
   14. A relay output that shall energize whenever the unit is operating in a limit mode for an extended time period.
   15. A relay output that shall energize whenever a compressor is running.
   16. A relay output that shall energize whenever the chiller is operating in Adaptive Controls due to high head pressure.

H. The chiller control panel shall provide a programmable soft load to prevent the chiller from achieving full capacity during the pulldown period by imposing a ramped current limit, or a temperature pulldown rate. Either can be adjusted to limit how fast the chiller can load after an initial startup.

I. The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature.

J. The chiller shall have factory mounted and tested controls that provide dual chilled water setpoint control for ice-making application.

K. The chiller control panel shall provide a chilled water pump output relay that closes when the chiller is given a signal to start.

L. The chiller control panel shall have the ability to operate in variable evaporator flow applications. The chiller control must be able to operate with evaporator flow rate changes up to 10% during a 1 minute time period while maintaining 0.5ºF water temperature accuracy. The chiller control must also be able to operate with evaporator flow rate changes up to 30% during a 1 minute time period while maintaining 2ºF water temperature accuracy.

M. The chiller control panel shall have the ability to control the leaving condenser fluid temperature setpoint through the user interface or via a 0-10 Vdc signal from a building automation system.

N. Digital communications to building automation system shall consist of a BACnet open standard communication protocol. BACnet shall be capable of communicating MS/TP using RS-485 hardware.

O. The chiller control panel shall output head pressure via a 0-10 Vdc signal to control a condenser water flow modulating device.

P. The chiller control panel shall output percent RLA via a 2-10 Vdc signal.

Q. The chiller control panel shall have the ability to control the leaving condenser fluid temperature setpoint through the user interface or via a 0-10 VDC signal from a building automation system. The control system allows for a condenser leaving temperature range of 80ºF to 105ºF with a standard condenser and 80ºF to 140ºF.

R. Chiller provides an output signal to indicate the refrigerant pressure differential between the evaporator and condenser in psid. A BAS or other intermediate control is required to achieve condenser refrigerant differential pressure control.

2.07 STARTERS (LOW VOLTAGE)

A. Starters shall be unit mounted with ventilating louvers.

B. Motor starters shall include incoming line provisions for the number and size cables shown on the drawings. Incoming line lugs shall be copper mechanical type. Connection directly to the contactors is not permissible.

C. Contactors shall be sized properly to the chiller full load and locked rotor currents. Contactors shall have double break main contacts with weld resistant silver cadmium faces. Auxiliary interlocks that interface with the control panel shall be low resistance having palladium silver contacts.

D. Each motor starter shall include a control power transformer with fused primary and secondary. Current transformers of the proper size, ratio and burden capacity shall be provided to provide a signal to the control panel and optional devices. Control relays shall be provided within the motor starter to interface with the control panel.

E. Each starter shall include an advanced motor protection system incorporating electronic three phase overloads and current transformers. This electronic motor protection system shall monitor and protect against the following conditions:
   1. Three phase overload protection
   2. Overload protection during start-up
   3. Phase imbalance
   4. Phase loss
   5. Phase reversal
   6. Low voltage

F. Alternately the advanced motor protection system can be furnished in the chiller control panel.

G. Each starter/control shall be designed and able to operate in temperatures up to 104ºF.

H. All field supplied wires, bus bars, and fittings shall be copper only.

I. Provide in the starter panel:

J. The motor starters shall be Wye-Delta. Motor starters shall have a UL 1995 enclosure. Enclosure shall be constructed of 14 gauge steel minimum.

K. Factory installed control power transformer shall also be capable of providing 115V power for field-installed water regulating valve.

L. Under/over voltage protection.

M. Circuit Breaker - Starter shall contain a circuit breaker. The disconnect handle shall be capable of being padlocked in the off position.

N. Single point power connection.

2.08 **SOUND**

A. Acoustics: Manufacturer must provide sound pressure data in decibels. Sound pressure data per AHRI 575 must be provided at full load.

B. If manufacturer cannot meet the noise levels, sound attenuation devices must be installed to meet this performance level.

C. Factory provided sound attenuating wrap for compressors, discharge lines, and oil separators.

2.09 ACCESSORIES

A. Factory installed IFM flow switch.

B. 4" 150 psi 2-way water regulating valve

PART 3 - EXECUTION

3.01 **INSTALLATION**

A. Install in accordance with manufacturer's instructions.

B. Provide for connection to electrical service. If oil pump is electric include the connection of the electrical to the oil pump.

C. Provide elastomeric isolator to reduce vibration transmission.

D. On units without unit mounted starters provide for connection of electrical wiring between starter and chiller control panel, oil pump, and purge unit.

E. Furnish and install necessary auxiliary water piping for oil cooling units and purge condensers.

F. Arrange piping for easy dismantling to permit tube cleaning.

G. Provide piping from chiller relief valve to outdoors. Size as recommended by manufacturer.

H. Proof of flow shall be provided by the equipment manufacturer, mechanically installed and electrically wired, at the factory of origin.

I. Proof of flow shall be provided by the equipment manufacturer, mechanically installed and electrically wired, at the jobsite by the contractor.

J. Proof of flow shall be provided, mechanically installed and electrically wired, by the contractor at the jobsite.

3.02 **SERVICE AND STARTUP**

A. Startup - Provide all labor and materials to perform startup. Startup shall be performed by a factory-trained technician from the original equipment manufacturer (OEM). Technician shall confirm that equipment has been correctly installed and passes specification checklist prior to equipment becoming operational and covered under OEM warranty. This shall be done in strict accordance with manufacturer's specifications and requirements. Third-party service agencies are not permitted.

B. A start-up log shall be furnished by the factory approved start-up technician to document the chiller's start-up date and shall be signed by the owner or his authorized representative prior to commissioning the chillers.

C. Chiller manufacturer shall maintain service capabilities no more than 50 miles from the jobsite.

D. Provide local service agent with direct access to factory support on equipment.

END OF SECTION

SECTION 23 65 00
COOLING TOWERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Section 230500 and other Division 1 Specification Sections, apply to this Section.

1.02 WORK INCLUDED

A. Furnish and install all cooling towers, in the type, capacity and quantities indicated, including all connection points for make-up, overflow and drains to make a complete and operational system.

B. All systems shall be installed in accordance with local codes including drain and overflow discharge termination points.

C. Secure all permits and local/state approval for the installation of all components included under this Section.

1.03 RELATED SECTIONS

A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

1.04 REFERENCES

A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.

B. Material standards shall be as specified or detailed hereinafter and as follows:
1. ABMA STD 9 – Load Ratings and Fatigue Life for Ball Bearings.
2. ABMA STD 11 – Load Ratings and Fatigue Life for Roller Bearings.
3. ASME PTC 23 – Atmospheric Water-Cooling Equipment.
4. ASTM A 123 – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Sheet Products.
5. ASTM A 653/A 653M – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot Dip Process.
6. ASTM E 84 – Test Method for Surface Burning Characteristics of Building Materials.
7. CTI ATC – 105 – Acceptance Test Code for Water Cooling Towers; Cooling Tower Institute.
8. CTI STD-2-201 – Certification Standard for Commercial Water Cooling Towers; Cooling Tower Institute.
9. NEMA MG 1 – Motors and Generators.

1.05 SUBMITTALS

A. See Section 230500 and General Conditions for additional requirements.

B. Product Data: Provide rated capacities, dimensions, weights and point loadings, accessories, required clearances, electrical requirements and wiring diagrams, and location and size of field connections. Submit schematic indicating capacity controls.

C. Shop Drawings: Indicate suggested structural steel supports including dimensions, sizes, and locations for mounting bolt holes.

D. Manufacturer’s Instructions: Submit manufacturer’s complete installation instructions.

E. Manufacturer’s Certificate: Certify that cooling tower performance, based on CT1 ATC-105, CT1 STD-201, or ASME PTC 23 meet or exceed specified requirements and submit performance curve plotting leaving water temperature against wet bulb temperature.

F. Operation and Maintenance Data: Include start-up instructions, maintenance data, parts lists, controls and accessories.

G. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.06 **QUALITY ASSURANCE**

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum five years of documented experience.

B. Installer Qualifications: Company specializing in performing work the type specified in this section, with a minimum of five (5) years of documented experience and approved by manufacturer.

1.07 **DELIVERY, STORAGE AND HANDLING**

A. Factory assembled. For shipping, disassemble into as large as practical sub-assemblies so that minimum amount of field work is required for re-assembly. Provide a list of field installed equipment and an estimate on assembly time.

B. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

1.08 **WARRANTY**

A. Provide a one (1) year extended warranty to include coverage for corrosion resistance cooling tower structure, cooling tower package, fan drive, and motor including all labor and materials.

PART 2 - PRODUCTS

2.01 **INDUCED DRAFT COOLING TOWERS**

A. General
   1. Acceptable manufacturers subject to compliance with the specifications shall be as follows:
      a. Marley
      b. Baltimore Air Coil
   2. Cooling towers shall be induced draft, vertical discharge, package cross-flow type, direct drive with screened air inlets. Cooling towers shall be factory assembled, induced draft, vertical discharge, and cross-flow type as shown on the plans.
   3. Casings shall be heavy mill stainless steel sheets.
   4. Fan shall be cast aluminum alloy, with adjustable pitch blades.
   5. Fill and drift eliminator material shall be non-corrosive and non-ferrous. Fill shall consist of vertical sheets of polyvinyl chloride with three-pass, integral eliminators. Drift loss shall be limited to 0.005% of the water circulated.
   6. Access panels shall be provided on both end walls for access to the eliminator and plenum section. A heavy gauge, stainless steel wire, grille type fan guard shall be provided over each fan cylinder.
   7. All bolts, nuts and washers shall be stainless steel. All steel used in the construction of the cooling tower shall be stainless steel.

B. Performance:
   1. Thermal rating shall be certified by the Cooling Technology Institute. The performance shall not be less then that scheduled.
   2. Acoustical Performance
      a. Sound level for a single cell shall not exceed 74 dBA 5 ft from the air inlet.

C. Performance Warranty:
   1. CTI Certification notwithstanding, the cooling tower manufacturer shall guarantee that the tower supplied will meet the specified performance conditions when the tower is installed according to plan.

D. Design Loading

1. The tower and all its components shall be designed to withstand a wind load of 45 psf, as well as a .3g seismic load. It shall be designed to withstand shipping and hoisting loads of 2g horizontal and 3g vertical. The fan deck and hot water basin covers shall be designed for 50 psf live load or a 200 lb. concentrated load. Handrails, where specified, shall be capable of withstanding a 200 lb. concentrated live load in any direction, and shall be designed in accordance with OSHA guidelines.

E. Cooling tower shall be equipped with:
   1. S/S Basin
      a. The cold water basin shall be heavy-gauge Series 300 stainless steel, and shall include the number and type of suction connections required to accommodate the outflow piping system. The basin shall include a depressed center section into which accumulated silt can be flushed and overflow standpipes shall be removable to permit flush-out cleaning of the basin. The basin floor adjacent to the depressed section shall slope toward the depressed section to prevent build-up of silt under the fill area. All steel items which project into the basin (columns, diagonals, anchor clips, etc.) shall also be made of stainless steel.
      b. The cold water basin shall be equipped with PVC sweeper piping with plastic nozzles. The piping shall be factory installed under the fill and designed to force all dirt and debris to the depressed section of the collection basin.
   2. S/S Hot Water Basin
      a. Two stainless steel open basins (one above each bank of fill) shall receive hot water piped to each cell of the tower. These basins shall be installed and sealed at the factory, and shall be equipped with removable, stainless steel covers capable of withstanding the loads described. All components of these basins, with the exception of the nozzles, shall be stainless steel.
      b. Open gravity type distribution basins shall be made of 304 stainless steel with plastic diffusing type metering orifices. Flanged connections shall be provided to be connected to piping distribution provided by the Mechanical Contractor, including cast iron flow control valves if shown on plans. Removable basin covers shall be factory installed and shall be made of 304 stainless steel. Pressurized spray-type distribution systems are not acceptable. If the winter duty (GPM) is less than half of the summer duty, provide hot water basin dams to accommodate for flow reduction.
   3. Make up
      a. Provide an electric motorized valve to control the make up water:
         1) Shall be 120 V and slow acting.
         2) Suitable for 150 PSIG
         3) Provide one for each cell
      b. Five (5) probe electric level control in each cell
         1) In each cell, provide a probe-type electric water level sensor system. The five-probe assembly shall contain a relay for make-up, high-level alarm, and a low-level alarm.
   4. Internal Walk with stainless steel supports
      a. Provide a stainless steel bar grating walkway extending from one endwall access door to the other endwall. This walkway shall be supported by a stainless steel framework, and the top of the grating shall be at or above the cold water basin overflow level.
   5. Internal Ladder and Platform to Access Motor and Drive
      a. Elevated mechanical platform - An internal ladder shall extend upward from the plenum walkway to an elevated stainless steel bar grating platform convenient to the care and maintenance of the tower's mechanical equipment. The platform shall be surrounded by a sturdy handrail and kneerail system.
   6. OSHA compliant external ladder and access door platform, each tower from roof level to top of tower
      a. Provide a vertical ladder attached to the tower casing and extending from the base of the tower to the top of the fan deck platform handrail.

b. Provide a ladder extension for connection to the foot of the ladder attached to the tower casing. This extension shall be long enough to rise from the roof (grade) level to the base of the tower. The installing contractor shall be responsible for cutting the ladder to length; attaching it to the foot of the tower ladder; and anchoring it at its base.
c. A heavy gauge galvanized steel safety cage shall surround the ladder, extending from a point approximately 7'-0" (2.134m) above the foot of the ladder to the top of the handrail surrounding the fan deck.
d. There shall be an access platform at the base of the tower (as shown on drawings) extending from the vertical ladder to the endwall access door. The platform shall be stainless steel bar grating, supported by stainless steel framework attached to the tower. The platform shall be surrounded by a handrail, kneerail, and toeboard.

7. Fan Deck Hand Rail and Toe Guard
   a. The top of the tower shall be equipped with a sturdy handrail, complete with kneerail and toeboard, designed according to OSHA guidelines. Handrails and kneerails shall consist of 1.66" O.D. x 15 gauge
   b. vanized structural tubing, the handrail of which shall be capable of withstanding a 200 pound concentrated live load in any direction. Posts are 2" x 2" square structural tubing and shall be spaced on centers of 8'-0" or less. A 1'-6" wide aluminum ladder with 3" I-beam side rails and 1.25" diameter rungs shall be permanently attached to the endwall casing of the tower, rising from the base of the tower to the top of the handrail.
8. Tower Air Inlet Screens Each Cell
   a. Air inlet screens are to be full height, one inch square by .063" welded wire mesh, stainless steel after welding. Screens shall be factory installed.
9. Tower Outlet Screens Each Cell
   a. The casing and fan deck shall be heavy-gauge stainless steel, and shall be capable of withstanding the loads described. The top of the fan cylinder shall be equipped with a conical, non-sagging, removable fan guard, fabricated of welded 5/16" (8 mm) and 7 gauge rods, and hot dip galvanized after fabrication.
10. Fan Deck Extension
    a. Provide extensions on the fan deck with handrails.
11. Gear Drive
    a. Fan(s) shall be driven through a right angle, industrial duty, oil lubricated, geared speed reducer that requires no oil changes for the first five (5) years of operation. Speed reducers employing pulleys and belts will not be accepted. Gear drive shall be suitable for VFD drive.
    b. A neoprene and stainless steel oil line shall extend from the gear reducer(s) to a point on the fan deck of each cell. The oil level in the gear reducer shall be readable at that point by means of a dip stick.
12. Bottom Side Outlet Anti Vortex Sump with Screen Each Cell
    a. The cold water basin shall be heavy-gauge Series 300 stainless steel, and shall include the number and type of suction connections required to accommodate the outflow piping system shown on the plans. The outlet connection shall be a depressed, stainless steel sump, including trash screen and anti-vortex plate if required by manufacturer. Flange shall be 14”.
13. Provide flanged bottom equalizer connection in each cell.
14. Provide bottom 4” drain and overflow connections for each cell.
    a. A 4" (102mm) diameter PVC pipe overflow shall be provided in each cell of the tower. The basin shall include a depressed center section into which accumulated silt can be flushed and overflow standpipes shall be removable to permit flush-out cleaning of the basin. The basin floor adjacent to the depressed section shall slope toward the depressed section to prevent build-up of silt under the fill area.
15. Basin Heaters
    a. Provide a system of electric immersion heaters and controls for each cell of the tower to prevent freezing of water in the collection basin during periods of shutdown. The

system shall consist of one or more stainless steel electric immersion heaters installed in threaded couplings provided in the side of the basin. A NEMA 4 enclosure shall house magnetic contactors to energize heaters; a transformer to provide 24-volt control circuit power; and a solid-state circuit board for temperature and low water cut-off. A control probe shall be located in the basin to monitor water level and temperature. The system shall be capable of maintaining 40°F water temperature at an ambient air temperature of 0 °F.

b. Provide all controls, safeties, contacts, and relays in a NEMA 4 enclosure, one for each cell.

16. Bottom Inlet Return Connection
    a. Each cell of the tower shall include a single hot water inlet connection located as shown on the plans. An internal system of piping shall deliver water equally to the distribution basins without the need for balancing valves. This internal piping shall be Schedule 40 stainless steel pipe located such that it does not interfere with normal maintenance access or tower equalization.
17. Motor
    a. Motor(s) shall be Premium efficiency, TEFC, 1.15 service factor, variable torque, and specially insulated for cooling tower duty.
    b. Speed and electrical characteristics shall be 1800 RPM, single-winding, 3 phase, 60 Hertz, 480 volts.
    c. Motor shall operate in the shaft-horizontal position, and nameplate horsepower shall not be exceeded at design operation.
    d. See Specification Section 230513 - Motors and Controllers.
    e. Furnish 2-speed, 1-winding fan motor(s).
    f. Furnish 2-speed, 2-winding fan motor(s).
18. Vibration Switch
    a. A vibration limit switch (one per cell) shall be installed on the mechanical equipment support assembly and wired into the control panel. The purpose of this switch will be to interrupt power to the motor in the event of excessive vibration. It shall be adjustable for sensitivity, and shall require manual reset.
19. Mechanical Equipment Removal
    a. Provide one portable/removable davit arm for rigging of motor or gear assembly to basin level.
    b. For each tower cell, provide pedestal support for mounting removable davit.
    c. Removable davit and pedestal support shall be designed to withstand/transfer load of the fan motor to cooling tower structure/frame.

F. Condenser water piping exposed to weather where indicated on the drawings shall be heat traced, insulated and covered with weatherproof insulation covering by the installing contractor. All condenser water piping shall be installed and supported independently from the towers on substantial steel supports as approved by the Architect.

PART 3 - INSTALLATION

3.01 COOLING TOWER

A. Install in accordance with manufacturer’s instructions.

B. Install tower on structural steel beams as instructed by manufacturer.

C. Install tower on vibration isolators and Seismic restraint. Refer to Section 230548.

D. Connect condenser water piping with flanged connections to tower. Pitch condenser water supply to tower and condenser water suction away from tower.

E. Connect make-up water piping with flanged or union connections to tower. Pitch to tower.

3.02 FIELD QUALITY CONTROL

A. Test for capacity under actual operating conditions in accordance with CT1 ATC-105 and verify specified performance.

3.03 STARTING EQUIPMENT AND SERVICES

A. Manufacturer shall inspect tower after installation and submit report prior to start-up, verifying installation is in accordance with specifications and manufacturer's recommendations.

B. Manufacturer shall supervise rigging, hoisting, and installation.

C. Manufacturer shall Start-up tower in presence of and instruct Owner's operating personnel. These activities shall be coordinated with and in concert with the project Cx and ECx agents.

END OF SECTION

SECTION 23 73 25
PRE-FABRICATED MEP CENTRAL PLANT SYSTEMS

PART 1 – GENERAL

1.01 DESCRIPTION

A. The following specification details the minimum requirements for equipment and structure for a complete factory assembled Packaged MEP Central Plant System.

B. The Packaged System shall be factory fabricated, tested and delivered to site by the manufacturer as a complete unit containing all the items listed under Products. Field fabrication of the Packaged System is not acceptable.

C. Basis of Design is Epsilon Industries.

D. Alternate acceptable manufacturer is EAS. Canariis Corporation may be considered as an alternative acceptable manufacturer based on validation of project specific capability.

E. Equal and alternate manufacturers must submit a request to bid in writing to the owner and the owner's MEP consultant prior to tender closing. Alternate bids must be entered with cost savings over base bid. The manufacturer must provide the following information for consideration prior to entering a bid:
   1. Equipment selection data.
   2. Equipment and piping arrangement drawings of the alternate's package in REVIT format demonstrating compliance with space considerations and coordination with elements of the MEP design outside of the plant room.
   3. Piping flow schematic of the alternate's package, including pipe sizes, flow rates, valves. Indicate guaranteed fluid pressure drops within the plant and guaranteed pressure at connections to the premanufactured plant.
   4. Confirmation of compliance with the project specification and a detailed explanation of all deviations to the specification.

1.02 PRODUCTS

A. All piping shall be manufactured in the United States or Canada to ASME and ASTM standards. All piping with one plant must be from the same manufacturer. A full fill of materials must be available for inspection upon request.

B. The following products are to be included as part of this Packaged Plant System. All components listed are to be supplied and installed by the Premanufactured Central Plant Manufacturer (see piping one-line drawing, schedules and/or balance of plant specifications for complete list required components. Manufacturers and model numbers are included within this section as a guide to acceptable components, the balance of plant specifications take precedent over the components listed below:
   1. Air & Dirt Separator, Centrifugal Type: Spirotherm Model V
   2. Air Vent (high capacity at air separator): Hoffman 792
   3. Air Vent (low capacity/ pipe bleed): Bell & Gossett Type 97
   4. Single Phase Low Voltage Power and Lighting Panel: Cutler Hammer 125A CBM118CU
   5. Ball Valves – Water Service, Isolation: Kitz Type 58, Brass
   6. Ball Valves – Natural Gas, Isolation: Kitz Type 400, Brass
   7. Ball Valves – Water Service, Drain & Cap: Kitz Type 68C, Brass
   8. Butterfly Valve (isolation): Bray Series 41. Gear operator on valves 8" and larger
   9. Check Valve, 2½" and under: Kitz type AK150YR, Cast Bronze
   10. Check Valve, 3" and over: Kitz type 78 (125FOC), Cast Iron
   11. Circuit Setter, 2" and under: Bell & Gossett CB
   12. Butterfly Control Valves: Bray Series 41 with Bray Series 70 Actuators
   13. Ventilation Air Damper: Ventex model 3965 c/w Honeywell Actuator
   14. Dielectric Fitting, 2" and below: Watts 3001A
   15. Access Doors: 16 ga insulated c/w Sargent type 3828 lockset
   16. Drip Pan Elbow: Apollo Valves model
   17. Exhaust Fan (ventilation and refrigeration evacuation): Loren Cook

18. Expansion Tank: Bell & Gossett Diaphragm or Bladder type
19. Flex Connector: Flex-Hose Flexzorber NND Double Sphere type, Flanged
20. Heat/ Cool Thermostat: Honeywell
21. Indoor Lighting: LED
22. Ventilation Louver: Ventex 6” Deep Storm Proof
23. Make-up Water PRV: Conbraco
24. Make-up Water Back-Flow Preventor: Conbraco RPZ
25. Make-Up Water Strainer: Conbraco
26. Pipe Support (chilled, hot water, geothermal and condenser water): Behringer below 10”, U-bolts 10” and greater
27. Pressure Indicator: Trerice Series D80 liquid filled, stainless steel case
28. Safety Relief Valves (water systems): Conbraco
29. Spring Isolators: Mason Industries type SLFH, subject to acoustical vibration analysis
30. Strainer (water service, 2” and under): Mueller Model 351M, Cast Bronze, Threaded
31. Strainer (water service, 2½” and over): Mueller Model 725, Cast Iron, Flanged
32. Suction Diffuser: Bell & Gossett, Flanged
33. Temperature Indicator: Trerice Model BX9
34. Structural steel base with all piping supported from the plant structure
35. Pumps and motors as specified by the engineer
36. Domestic and makeup water
37. Hot water boilers
38. Deaerators
39. Water softeners
40. Brazed Plate Heat exchangers:
41. VFDs: ABB ACH550
42. Combination starters
43. Switchboards
44. Pressure, flow, and/or temperature transmitters: Siemens
45. BAS interface: Siemens

C. All controls shall be Siemens and shipped to the factory for installation by the Central Plant Premanufacturer.

D. The Packaged System shall be designed for the heat transfer, generation, flow and total dynamic head as noted. It shall be arranged to fit the space allotted on the plans and allow for equipment service.

1.03 SUBMITTALS AND OPERATION MANUALS

A. Submittals shall include the following as a minimum:
1. Package dimensions and general arrangement drawing in three dimensions including overall 3D orthographic. REVIT model shall be provided using REVIT families specific to the project from the component manufacturer.
2. Electrical power diagram indicating all terminations and connections by others.
3. Equipment submittals for all major components including but not limited to: chillers, cooling towers, boilers, pumps and pump ancillary equipment, tanks, variable frequency drives and electrical switchgear.
4. Catalog information on valves, strainers, and piping components specific to this project.
5. Piping schematic of the Packaged System’s components showing equipment and valve tags, pipe sizes, connections types, gauges, piping specialties and instrumentation tags.
6. Enclosure details including wall, base, and/or any applicable roof construction.

B. Operation and maintenance manuals shall be coordinated with the Cx and ECx agenta and include the following as a minimum:
1. All of the items contained in the submittal section above.
2. Installation and maintenance manuals for OEM’s products integral to the Package.
3. Structural calculations as required by this section.

C. Submittals and operation and maintenance manuals shall be assembled in a neat and orderly manner and submitted in both physical and PDF form. All PDFs shall be fully indexed by type of equipment and subsection.

1.04 **QUALITY AND PERFORMANCE ASSURANCE**

A. PERFORMANCE CRITERIA: The following are to be used as selection criteria and are to be as specified: water flow rates, water temperatures, water pressure drops. The following are to be equaled or bettered: system electricity consumption (parasitic load), acoustical sound pressure levels, chiller, boiler and cooling tower, pump performance.

B. PERFORMANCE TEST: Plant must be fully assembled at factory prior to shipping and all piping must be pneumatically leak tested.

C. CONTROLS RESPONSIBILITY: The Packaged System manufacturer will factory mount and wire full controls system. Control system design and all panels and devices provided by ATC vendor (Siemens). Control Valves to be furnished and installed by packaged plant manufacturer.

D. ETL: The unit shall be ETL or UL certified as a package. Certification of only the components is not acceptable.

E. QUALITY ASSURANCE PROGRAM: The manufacturer shall have a quality assurance program in place, and have the quality assurance manual available for the owner upon request. The QA/QC program nust be reviewed by the Cx and ECx agents.

F. PRESSURE TEST: Once the Packaged System is fully assembled, all piping shall be pressure tested as per ASME B31.1 guidelines in the factory before shipping. Pressure testing of individual pipe spools or sub-assemblies is not acceptable.

G. STRUCTURAL [AND SEISMIC] REQUIREMENTS: The base, wall and roof steel framework, sheet metal enclosure [and integral tower support steel] shall be designed to meet or exceed the loading (wind, snow/ sand, live and dead loading, lifting) [and seismic] requirements outlined in the relevant parts of this section. The vendor must provide documentation demonstrating that this requirement will be met at the owner's request.

H. ACOUSTICAL REQUIRMENTS: The enclosure panels (if an enclosure is required) shall be acoustically rated at the sound transmission loss levels contained in this section to NRTL standards and listed by NRTL to be in accordance with ETL's procedures for acoustical testing. This listing shall be made available to the owner upon request. Further, as part of the O&M the manufacturer shall provide detailed calculations (when required) demonstrating that the sound pressure levels stipulated in this section for this Packaged System shall not be exceeded when the unit is fully operational.

I. WELDING: All pipe and structural steel shall be welded in accordance with the procedures outlined in this section – no exceptions. At the owner's request, the manufacturer shall provide certified documentation of both the procedures and the welder's certification for that procedure.

J. PAINTING: All bases, enclosure floors and exteriors are to be factory painted in accordance with this section. At the owner's request, submit the paint specification demonstrating that it will withstand 500 hour exposure to the salt spray test specified in ASTM B 117.

1.05 **WARRANTY**

A. The entire Packaged System shall be guaranteed for parts and workmanship for a period of 12 months from start-up or 18 months from shipment form the vendor's facility, whichever comes first.

PART 2 – PRODUCTS

2.01 **PACKAGER SCOPE:**

A. Furnish and install the following equipment as part of a factory assembled and tested Packaged System. The Packaged System enclosure shall match the dimensions indicated on the plans and coordinated with the project architect. All equipment shall have sufficient service clearance for equipment with special emphasis being placed on Human Factors Engineering (HFE). See

schedules for equipment performance. There is a single premanufactured package for this project having complete chilled water, hot water, geothermal, condenser water and plumbing systems (MU water and Natural Gas) to serve the HPR campus.

B. EXAMPLE PROJECT A
   1. Chilled water system
      a. Qty (XX) chilled water pumps with trim as noted on mechanical details on plans.
      b. Qty (XX) chilled water pump VFDs
      c. Qty (XX) butterfly manual isolation valves.
      d. Qty (XX) 2 way modulation control valves
      e. Qty (XX) system flow meter
      f. One set of flanged 16” chilled water connections to connect plant to main campus chilled water system with 2” drains lines and valves. Each connection to have 2 way/2 pos motorized control valve for safety shutoff.
      g. One set flanged 10” connections from plant to building.
      h. One set flanged 12” connections from plant to building.
      i. One set flanged 8” connections to feed CP MER equipment.
      j. One set flanged 6” connections to feed CP MER equipment.
      k. Factory installation of controls supplied by base building ATC. See controls details and specification for devices.
      l. Interconnection piping with sizes and layout as shown on M4-004.00
      m. Ball valves, air vents, check valves, balancing valves, blow down valves, pressure relief valves, etc as shown on piping one line and mechanical details.
   2. Hot water system
      a. Qty (XX) how water pumps with trim as shown on mechanical details on plans.
      b. Qty (XX) hot water pump VFDs
      c. Qty (XX) Brazed plate heat exchangers with trim as shown on mechanical details on plans.
      d. Qty (XX) 4 way back flush valves
      e. Qty (XX) butterfly manual isolation valves
      f. Qty (XX) 2 way modulation control valves
      g. Qty (XX) 2 way / 2 pos automatic isolation valves
      h. Qty (XX) system flow meter
      i. One set of flanged 12” hot water connections to connect plant to main campus hot water system with 2” drains lines and valves. Each connection to have 2 way/2 pos motorized control valve for safety shutoff.
      j. One set or 4” flanged connections to feed to building
      k. Two sets of 4” flanged connections to feed CP MER equipment.
      l. Factory installation of controls supplied by base building ATC. See controls details and specification for devices.
      m. Interconnection piping with sizes and layout as shown on M4-006.00
      n. Ball valves, air vents, check valves, balancing valves, blow down valves, pressure relief valves, etc as shown on piping one line and mechanical details.
   3. Plumbing system
      a. Qty (XX) triplex domestic water booster pumps
      b. Qty (XX) Duplex domestic water heaters
      c. Qty (XX) make up water feed with: isolation valves, strainer, flow meter, and RPZ backflow preventer. One for each triplex booster.
      d. Interconnection piping with sizes and layout as shown on P5-002.00
      e. Ball valves, air vents, check valves, balancing valves, blow down valves, pressure relief valves, PRV, etc as shown on piping one line and mechanical details.

C. EXAMPLE PROJECT B
   1. Chiller water system
      a. Qty (XX) chilled water pumps with trim as noted on mechanical details on plans.
      b. Qty (XX) condenser water pumps with trim as noted on mechanical details
      c. Qty (XX) pump VFDs

d. Qty (XX) modular chiller
e. Qty (XX) Brazed plate heat exchangers with trim as shown on mechanical details on plans
f. Qty (XX) butterfly manual isolation valves
g. Qty (XX) 3 way modulating valve for condenser water temperature control.
h. Qty (XX) 2 way / 2 pos automatic isolation valves
i. One set 10” flanged connections for connection to building condenser water system
j. Two sets of 6” connections for chilled water connection to building
k. Interconnection piping with sizes and layout as shown on M4-005.00
l. Ball valves, air vents, check valves, balancing valves, blow down valves, pressure relief valves, PRV, etc as shown on piping one line and mechanical details
m. Factory installation of controls supplied by base building ATC. See controls details and specification for devices.

2. Hot water system
   a. Qty (XX) hot water pumps with trim as noted on mechanical details on plans
   b. Qty (XX) hot water pump VFDs
   c. Qty (XX) Brazed plate heat exchangers with trim as shown on mechanical details on plans
   d. Qty (XX) manual butterfly isolation valves
   e. Qty (XX) 2 way / 2 pos automatic isolation valves
   f. Qty (XX) 2 way / 2 pos modulating control valves
   g. One set 4” hot water connections from building
   h. One set 2” hot water connections to feed AHU-7-1
   i. One set 4” hot water connection out to upper building
   j. Two sets 2.5” hot water connections out to upper building
   k. Interconnection piping with sizes and layout as shown on M4-007.00
   l. Ball valves, air vents, check valves, balancing valves, blow down valves, pressure relief valves, PRV, etc as shown on piping one line and mechanical details
   m. Factory installation of controls supplied by base building ATC. See controls details and specification for devices.
3. Plumbing system
   a. Qty (XX) duplex hot water heater with circulating pumps
   b. Interconnection piping with sizes and layout as shown on M4-007.00
   c. Ball valves, air vents, check valves, balancing valves, blow down valves, pressure relief valves, PRV, etc as shown on piping one line and mechanical details.

PART 3 - PACKAGE SPECIFICATIONS

3.01 STRUCTURAL STEEL BASE

A. The steel base shall consist of a structural steel perimeter with intermediate structural steel members at a minimum height of 6”. A 3/16” checkered plate floor shall be welded to the base and serve as an intricate part of the structure.

B. The base shall be designed for a maximum deflection of L/240 when the unit is fully operational and supported only at the perimeter and at unit splits.

C. The base frame shall be welded to a factory certified procedure that shall conform to the requirements of AWS D1.1.

D. If an enclosure is not required, then each skid base shall be equipped with lifting lugs.

3.02 DOUBLE WALL ACOUSTICAL ENCLOSURE

A. All mechanical and electrical equipment shall be housed inside a factory fabricated double wall enclosure. The enclosure shall be fabricated by the same manufacturer as the steel base, pipe work and pipe supports to ensure structural integrity of the entire Packaged System. The use of a self-framing or sheet metal building that does not incorporate a structural steel wall framework, structural steel roof framework, lifting lugs is not acceptable.

B. The components of the enclosure shall be:

1. Floor: shall be a minimum of 3/16” steel checker plate. When used with an enclosure, the perimeter of the floor shall be broken upward 1.5” to form a water dam and the corner seams shall be seal welded to form a watertight floor. The use of z-bar is permitted provided that the z-bar is continuously seam welded, not caulked.
2. Exterior Panels: Wall and roof panels shall be fabricated from 16ga. satin coat steel and sealed with an individual strip of ½” x 3/8” tape sealer. Wall panel shall be 2” thick with seams turned inward to provide flush exterior finish. Exterior roof panels shall be 4” thick. Wall and roof exterior panels shall wrap around wall and roof structural framework to ensure thermal break.
3. Structural Steel Base: When used with an enclosure, the perimeter members shall be, at a minimum, 8”x6”x0.188” hollow structural steel tube (HSS) and shall enable the installing contractor to shim the unit at 12 foot spans on site. The use of a c-channel or flanged steel perimeter is permitted provided the base is at least 12” deep.
4. Wall and Roof Structural Steel Framework: an integral structural steel framework of hollow structural steel shall support the walls and roof. The framework members shall be, at a minimum, 3”x3”x0.188” HSS at 10-foot centers. The roof steel shall also support all pipe in the Packaged System higher than four feet from the floor or base level. The framework shall be primed and finish painted using the paint system described in this section.
5. Roof Mounted Lifting Lugs: If an enclosure is required and the package is to be split for shipping, then the wall and roof structural steel framework will be extended through the roof of the enclosure and incorporate lifting lugs so that the entire package can be lifted from the roof – no exceptions.
6. Interior Wall Panels: Interior walls panels shall be a minimum of 2” thick fabricated from a minimum of 22 ga. galvanized steel. The wall interior panel joints shall run horizontal (or 90 degrees to the exterior panels) to provide an acoustic break, and overlapped to be suitable for washing with a pressure washer or steam cleaned without risk of wetting the insulation. The wall panel shall be installed over top of the floor water dam such that any water run-off will drip onto the water-tight floor.
7. Insulation: Wall and roof shall be insulated with no less than 4” of 4.5 Lb/cu.ft density rigid or semi-rigid board type insulation equivalent to R-16. Floor insulation thickness will be no less than (i) the smallest structural steel member used to support the floor or (ii) 4”, and shall have a minimum insulating valve of R-16. All insulation shall be rated non-combustible for continuous service at 1200F and shall be non-wicking with a moisture absorption rating of <1%.
8. Insulation: Elevated floor insulation shall meet the requirements of joist and framing construction with a minimum insulation value equivalent to R-30.
9. Floor Drain Pan: Fabricate floor drain pans as shown on the drawings at a minimum of 12”x18”x2” deep from 18 ga. stainless steel seal welded and covered with 3/4”x1/8” floor grating. The use of drain holes in the floor is not acceptable. Drain pans shall be sloped at a minimum of 1% to a drain ¾” hole that shall be piped to the exterior of the unit and finished with a ¾” male NPT thread.
10. Roof Covering: The roof covering shall be standing seam panels.

C. The enclosure shall have the following structural [and seismic] ratings:
   1. A minimum snow/ sand load rating of 40 pounds per square foot.
   2. A minimum wind load rating of 150MPH.
   3. Use seismic zone 1 as the minimum seismic requirement.

D. The enclosure panels shall be acoustically designed with a sound Transmission Loss (TL) rating. The TL values must be rated across the eight octave bands. Sound pressure levels shall be predictable from any distance from the enclosure when sound power levels from the sound generating equipment are known. Calculations that support the sound data shall be provided on request.

E. All bases, enclosure floors and exteriors are to be factory painted. Enclosure paint shall have weather resistant finish that will withstand 500 hour exposure to the salt spray test specified in ASTM B 117. Paint shall be applied and allowed to dry for a sufficient amount of time before shipping. The paint shall be a non-isocyanate enamel that produces a durable, chemically

resistant coating similar to urethane. The vehicle type shall be a cross-linked acrylic with an oxygenated and aromatic hydrocarbon solvent. All exterior surfaces shall be wiped down with thinners and prepared with a zero induction epoxy primer before applying paint. All interior surfaces shall be prepared with a high build epoxy primer before applying paint.

3.03 Pumps see section 23 21 23

3.04 Chillers see section 23 55 10

3.05 Heat Exchangers see section 23 57 00

3.06 VFDs see section 23 85 00

3.07 **VALVES, GAUGES AND PIPING ACCESSORIES**

A. Valves shall meet the material, fabrication and operating requirements of ASME B31.1. All valves shall be located such that the removal of their bonnets is possible. All flanged valves in horizontal lines with the valve stem in the horizontal position shall be positioned so that the valve stem is inclined one bolt hole above the horizontal position. Screw pattern valves placed in horizontal lines shall be installed with their valve stems inclined at an angle of a minimum of 30 degrees above the horizontal position. All valves must be of threaded or flanged type. All bronze and iron body gate and globe valves shall be the product of one manufacturer. Manufacturers of other types may not be mixed, i.e., all butterfly valves shall be of one manufacturer, all ball valves shall be of one manufacturer, etc. No yellow brass valves will be allowed. Wafer style valves (except check valves) are not allowed.

B. Butterfly valves shall be constructed with a stainless steel body, UHMWPE seat, stainless steel disc, stainless steel shaft, 316 stainless steel shell with PE liner bearings. Valves are to be Bray Resilient Seated Series 31. Valves 6” and smaller shall be provided with lever operators and valves 8” and larger shall be provided with hand wheel and gear operator.
   1. Exception: Main chilled water, hot water, and well field water supply & return shutoff valves located before piping leaves the central energy plant are to be Bray Series 41.

C. Ball valves shall be full port type, cast bronze body and cap, brass stem with double O-ring stem seals, forged brass ball and PTFE seat. Stem extensions shall be furnished for use on all ball valves to be insulated.

D. Check valves 2” and smaller shall be Y-pattern swing type, bronze body to ASTM B62 with forged brass cap and cast bronze disc. Check valves 2½” and larger shall be iron body, bronze disc and seat or non-slam lug or wafer type with stainless pins and springs and bronze plate.

E. Strainers 2” and smaller shall be constructed for 250 psig operating pressure at 406 degrees F and shall have a cast iron threaded body and 20 mesh Type 304 stainless steel screen. Strainers larger than 2” shall be constructed for 125 psig @ 150 degrees F and shall have a cast iron flanged body and a 3/64” perforated Type 304 stainless steel screen up to 3” and a 1/8” perforated Type 304 stainless steel screen on 4” and larger. Strainers 2” and smaller shall have straight thread and gasketed caps and plugged blow-off connections. Strainers larger than 2” shall include drain connections complete with ball valve, cap and chain.

F. Install thermometers so they can be easily read from floor level. If this cannot be accomplished, install remote reading units. Thermometers are to be installed in thermowells so that they can be replaced without draining the system. Thermometers shall have a 9” scale, cast aluminum case and adjustable angle stem.

G. Use one pressure gauge for each pump/ strainer assembly with connections upstream of the strainer, between the strainer and pump and on the discharge of the pump, all isolated with shut off valves.

H. Where three or more pumps share the same discharge or suction header install pressure gauges on a common gauge panel mounted next to the pump assembly. A manifold valve shall be used for each common pressure gauge allowing a manual selection of suction or discharge indication of individual pumps and headers. All sensing lines shall be stainless steel tubing and installed in aligning standoffs. Pressure gauges shall be liquid filled, 4” diameter, accurate to 1.5%.

I. See section 1.02 Products in this specification for acceptable manufacturers.

3.08 **PIPE AND PIPE SUPPORT**

A. All pipe used in the Packaged System shall be fabricated in accordance with this specification. The use of grooved mechanical connections is not acceptable.

B. Piping shall be Schedule 40 for pipe smaller than 12” and standard weight for pipe 12” and larger. All pipe shall conform to Standard ASTM Designation A53 grade A or B. All weld fittings shall conform to ASME/ ANSI B16.9, latest addition. All condensate and threaded pipe shall be Schedule 80 conforming to Standard ASTM Designation A53B.

C. Pipe welding shall be in accordance with ANSI/ASME B31.1 and ANSI/ASME Boiler and Pressure Vessel Code, Section IX. Ensure complete penetration of deposited metal with base metal. Manufacturer shall provide filler metal suitable for use with basemetal. Keep inside of fittings free from globules of weld metal. All welded pipe joints shall be made by the fusion welding process employing a shielded metallic arc process (SMAW) or gas metal arc welding process (GMAW/ MIG). Inside of pipe shall be free of excessive reinforcement. The use of backing plates is not acceptable. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during the welding operation.

D. In no cases shall Schedule 40 or standard weight pipe be welded with less than three passes including one stringer/ root, one filler and one lacer.

E. Each weld shall be uniform in width and size throughout its full length. In addition, the cover pass (final weld layer) shall be free of coarse ripples, grooves, overlaps, abrupt ridges and valleys/ under cut. The surface smoothness of the finished weld shall be suitable for the proper interpretation of non-destructive examination of the weld.

F. Each weld layer or pass shall be visually free of slag, inclusions, cracks, porosity and lack of fusion. Grinding to meet this criteria and elimination of defects and surface preparation of welds shall be done in a manner as not to gouge, groove or reduce the adjacent base material thickness below the minimum required.

G. All butt welds shall be full penetration with uniform crown, with reinforcement blending smoothly into the base material. Concavity on the root side of a single welded circumferential butt weld is permitted with the resulting thickness of the weld at least equal to the thickness of the thinner member of the sections being joined.

H. Socket welds shall have a gap of approximately 1/16" minimum to 1/8" maximum between the bottom of the socket and the end of the pipe prior to welding.

I. Visually inspect all welds for compliance with this section. Welds found to be lacking penetration, or containing excessive porosity or cracks must be removed and replaced with an original quality weld as specified herein.

J. All screw joints shall be made with tapered threads, properly cut. Joints shall be made with Teflon or dope applied to the pipe threads only and not to fittings. All threaded fittings shall conform to ASTM B16.3.

K. Copper pipe shall be fabricated of Type K conforming to ASTM specifications for copper water tube. Copper pipe shall only be joined using non-lead-solder such as 95-5 silver or antimony solder (95 percent tin and 5 percent silver or antimony).

L. All pipe shall be painted with a machine enamel in the Manufacturer’s standard color prior to assembly.

M. All piping for the Packaged System shall be sized for a maximum head loss of 4 feet W.C. per 100 feet equivalent pipe length or as noted on the mechanical drawings. Piping shall be supported independently of connections to equipment. If an enclosure is used all pipe higher than four feet from the floor or base level must be supported from the roof framework to provide clear access to equipment. The only exception is where pipe is supported from a vibration isolation base as part of a pump assembly.

N. Piping shall be installed to facilitate drainage and/or condensate management. Install drain valves at low points in piping, at equipment and at section isolating valves. Install air vents at high points in each piping system.

O. Pipe supports shall be Behringer Pipe Clamps to support pipe under all conditions of operation and prevent excessive stresses and vibration from being introduced into pipe work or connected equipment.

P. Shop fabricate equipment supports not provided by equipment manufacturer from structural grade steel. Provide removable angle iron blocking and bracing to prevent movement of pipe work and equipment during shipping.

Q. Insulation and pipe identification shall be within the packagers scope of work.

3.09 VIBRATION ISOLATION

A. Pumps mounted on concrete 4” vibration inertia bases. Concrete field poured by on site labor supervised by the Packaged Plant manufacturer..

B. Chillers mounted on 4” spring isolators with static deflections calculated by the project acoustician.

C. Flexible pipe connectors shall be installed on pump and chiller connections to piping. Flex connectors shall designed for 125 psig service, or as appropriate for the static head plus system head, and 200 degrees F. The flexible connector shall be constructed of rubber or tetrafluoroethylene resin. The flexible section shall be suitable for intended service with end connections to match connecting piping. The use of reducing flexible connectors is not allowed. Connectors shall be flanged and equipped with limit bolts, rods or cable to restrict maximum travel.

D. All pipe and HXs are hung with Behringer pipe clamps without isolators.

3.10 ELECTRICAL FABRICATION

A. All Electrical fabrication work shall be in compliance with N.E.C.

B. All service, feeder, branch or control circuit conductors shall be housed in Electrical Metallic Tubing

C. All conductors used shall have a minimum temperature rating of 90 degree C

D. Separate EMT conduit is used to house power, control and signal conductors

E. Package supplied with three points of power
   1. 480v panel to service all normal/emergency loads. All such loads are to be factory wired to this panel.
   2. 120v power for controls.

F. All wiring shall be factory complete. 120v power and controls will be 100% factory wired with quick connect plugs across shipping splits. 480v wires that cross shipping splits will be factory terminated and then pulled back, coiled, and zip tied for shipment. Pulling and terminating theses wired in the field points are to be performed by on site labor fully overseen and approved by a factory representative.

3.11 LOW VOLTAGE PANELBOARD DISTRIBUTION

A. General
   2. The panelboard shall be constructed to meet or exceed the requirements within UL 67 panelboards, cabinets and boxes UL 50 NEC, CSA , NEMA Standard PB1 . The panelboard shall be designed, manufactured, and tested in facilities registered to ISO9001 quality standards.
   3. All circuit breakers within the panelboard shall be UL listed under UL 489.

3.12 CONTROLS

A. Package to come complete with factory installed and wired DDC control system.

B. All control valves supplied by Siemens and installed by packager. All controls and end devices shall be similarly supplied by Siemens for factory installation.

C. Controls programming, engineering, start-up, and commissioning by Siemens. Supervision from packager only for commissioning, enhanced commissioning and monitoring based commissioning.

3.13 MECHANICAL / ELECTRICAL ROOM VENTILATION

A. Chiller plant ventilation will be provided by a H&V unit which will be provided with heating coil to maintain a minimum space temperature of 55°F. The ventilation rate shall be a minimum of 0.5 CFM/SQ. FT and be capable of providing sufficient make up during refrigerant purge.

B. A refrigerant purge system shall be sized for the mass of refrigerant in the largest chiller and shall be ducted to an exhaust fan. The refrigerant exhaust system shall have a duct drop at each chiller and shall terminate 18” above the finished floor with a wire mesh screen.

C. The boiler plant shall be provided with an H&V unit which will provide ventilation to the boiler plant. The unit shall be provided with a heating coil and maintain a minimum space temperature of 55°F. The minimum ventilation shall be 2 CFM/BHP and shall comply with local mechanical code.

D. Exhaust fans shall be provided to properly to properly ventilate the boiler and chiller plant, the space shall be maintained under 104°F.

E. Main electrical distribution rooms will be cooled (to 85°F) using chilled water fan coil units. Fan coil units shall not be located within the electric rooms. Ductwork from the fan coil unit to the electric rooms will be provided.

F. Locker rooms and control rooms will be heated and cooled (to 72°F) using four pipe (hot water and chilled water) fan coil units. Ventilation air will be provided by the heating and ventilation unit (H&V) serving the chiller plant

PART 4 - PACKAGE VALIDATION AND SHIPPING

4.01 INSPECTION AND TESTING

A. Include all test data and reports as required by this section as part of the Operation and Maintenance manual, including:
1. Vendor’s Inspection and Test Report verifying compliance with this specification on an item by item basis.
2. NEC, UL and OSHA certified compliance report.
3. Hydrostatic pressure test results.
4. Structural [and seismic] calculations as required.
5. Factory supplied special inspections complying with the requirements of the 2020 New York State Building section 102.7 exception 1 and section 1704.

4.02 SHIPPING PERPARATION

A. Piping shall be provided with external painting to provide corrosion protection. Interior of piping shall be flushed with a water-soluble corrosion inhibitor and then drained to prevent freezing.

B. All equipment and components shall be identified with equipment number specified or as shown on the shop drawings to assist field assembly and erection. Equipment numbers will be marked by the Buyer on the approved shop drawings. All items shipped shall be accompanied by instructions for storing and protecting in English.

C. All equipment shall be sealed to prevent entry of water, dirt or other foreign matter. Seals used in nozzles shall not affect threads, weld preparation or flange faces. Each section of the Packaged System shall be entirely shrink wrapped with a minimum 10 mil plastic shrink wrap. Shrink wrapping only open ends of the enclosure is not acceptable. All equipment and components shipped loose or on skids shall be properly packaged to withstand recommended method of shipment without damage. Each package shall be clearly labeled on the outside as to its contents.

D. Include a complete packing list and bill of material.

E. Provide consumables required during the installation for all equipment furnished including, but not limited to, flange bolts, sheet metal screws, rubber roofing for unit splits, roofing glue and caulking.

PART 5 – EXECUTION

5.01 EXECUTION

A. The Manufacturer shall provide on-site supervision for the following for the following:
1. Removal of protective wrapping such as shrink-wrap, wood crating, and packing.
2. Receiving (including interior and exterior inspection).
3. Inspect interior and exterior and report any obvious damage, or equipment shifting that may have taken place between the time the unit left the factory and arrived at job curb.
4. Roof preparations: contractor is responsible for supplying, and installing all roofing materials including caulking, and sundry items needed to accept unit into place. Roofing equipment can consist of, but is not restricted to roof curb, sleepers, structural beam, vibration rails with springs. It is the contractor's responsibility to confirm roofing equipment to be supplied by Vendor.
5. Hoisting and rigging the section(s) into final location as per the instructions supplied with the unit.
6. Join the sections (if shipped in sections) following the instructions enclosed with the unit.
7. Re-install any equipment, pipe, stacks or enclosure trim shipped loose due to shipping constraints.
8. Leveling, shimming as needed, and as per manufacturer's instructions.
9. Tighten all mechanically fastened connections that may have vibrated loose during shipping.
10. Re-align and level equipment including pumps.
11. Insulate all piping and equipment that is required.
12. Flushing and filling the system.
13. Install all life safety equipment as needed.
14. All field connections to the unit including piping, electrical, and drainage.
15. Connect all utilities needed for the mechanical system including domestic water, drainage, gas and electricity.
16. Make all hydronic connections (leading to and away from) the Packaged System and the Campus, geothermal field, exterior air source heat pumps, boilers and cooling towers.
17. Field installed equipment including pressure/temperature transmitters, flow meters and their associated wiring to the unit (a list field installed equipment will be supplied, along with installation instructions).
18. Touch up and paint scratches and minor dents occurred during hoisting and rigging.
19. Permits and inspections needed to start system up.
20. Startup of system with the full supervision of manufacturer's personnel.
21. Connection to Gas piping.

END OF SECTION

SECTION 25 90 00
SEQUENCES OF OPERATION

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Section 250500 and other Division 1 Specification Sections, apply to this Section.

1.02 WORK INCLUDED

A. Furnish and install temperature controls.

1.03 RELATED SECTIONS

A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

1.04 SUBMITTALS

A. See Section 250500 and General Conditions for additional requirements.

B. Product Data: Provide data for materials.

C. Prepare and submit sequences and drawings.

D. Manufacturer’s Installation Instructions.

1.05 QUALITY ASSURANCE

A. All sequences shall be made functional.

PART 2 – PRODUCTS

2.01 EXHAUST AIR FANS/SUPPLY AIR FANS

A. For all exhaust fans and ventilating supply fans, which are not located in AHU's or EAHU's, furnish for installation by the HVAC Contractor, automatic supply and/or discharge air dampers and interlock with fans to "open/close" when fans are "on/off". For fan designations and areas served by each fan, see schedule on drawings.

2.02 VARIABLE SPEED PUMPING SYSTEMS (VFD)

A. VFD's shall be furnished and installed by the HVAC Contractor. The Electrical Contractor shall provide power to each VFD. The ATC Contractor shall provide all control wiring for each VFD.

B. ATC Contractor shall provide a differential pressure sensor for each VFD controlled pumping system. The ATC Contractor shall furnish and the HVAC Contractor shall install all sensors. Provide a differential pressure sensor, with adjustable set point, reporting to the DDC panel, valve(s) and pump(s) to maintain a constant pressure differential (psi) set point between the supply and return piping mains, to automatically bypass water and compensate for pressure fluctuations in the system. All pressure sensors for the system shall have an accuracy of +/- 0.25% of full scale or better. The pressure sensor shall have sensing tips in the supply and return water lines. The location of the differential pressure sensor shall be coordinated by the ATC Contractor in the field. The D.P. sensor shall be located in the major piping branch.
   1. Campus Chilled Water System: One (1) Valve each system.
   2. Plant Chilled Water System: One (1) Valve each system.
   3. Campus Hot Water System: One (1) Valve each system.
   4. Plant Hot Water System: One (1) Valve each system.
   5. Wellfield System: One (1) Valve each system.
   6. Open Loop Condenser Water System: One (1) Valve each system.
   7. Closed Loop Condenser Water System: One (1) Valve each system.

C. The VFD shall vary the speed of the pump to maintain the differential pressure setpoint at the D.P. sensor located in the major piping branch. D.P. sensor shall be wired to the local DDC control panel where the system control logic resides. Across the network communications of

the system differential pressure shall not be allowed. Final system differential pressure setpoint shall be determined by the Balancing Contractor. The ATC Contractor shall allocate sufficient time to work with the Balancing Contractor to provide the necessary BAS support to determine the optimal system differential pressure setpoint (adjustable). The Balancing Contractor shall determine the lowest possible differential pressure control setpoint possible for all variable speed pumping systems and for all differential pressure bypass control valves. In systems that have both variable speed pumping and a differential pressure bypass valve, the Balancing Contractor shall assure, in conjunction with the ATC Contractor, that a minimum of 3 psig difference in setpoints is maintained between the two control settings with the differential pressure setpoint for the variable speed pumping system being the lower of the two settings.

D. The bypass valve shall remain closed during normal operation of systems that have both variable speed pumping and a differential pressure bypass valve. The bypass valve shall be modulated to maintain system differential pressure setpoint (+) 3 PSI (adjustable). If the system differential pressure rises above setpoint, the differential pressure valve shall be modulated open to maintain setpoint. Upon a drop is system differential pressure below setpoint the reverse shall occur.

E. Upon failure of the D.P. sensor feedback to the DDC panel, the bypass valve and/or pump(s) speed shall remain in the last known state. An alarm shall be generated at the BMS.

F. The pumps shall be programmed for lead/lag operation to maintain equal runtime. The runtime for each pump shall be totalized by the BAS system. Lead pump shall be selected as the pump with the least amount of runtime. Lead pump shall also be alternated monthly if required to maintain equal runtime.

G. Upon a failure of the lead pump, the lag pump shall be started automatically within 10 seconds (adjustable).The pumps shall be staged ON to maintain system differential pressure setpoint. Upon enabling the system to start the lead pump shall be started and ramped up to maintain system differential pressure set point. If the lead pump speed exceeds 95% (adjustable) the lag pump shall be started. Both pumps shall operate in parallel to maintain system differential pressure. The pumps shall be staged OFF by determining the pump with the greatest runtime to disable. With two pumps operating below 45% speed (adjustable) for greater than 10 minutes (adjustable) then the operating pump with the greatest runtime is disabled.

H. The position of the VFD bypass switch shall be monitored by the BAS system and an alarm generated at the BAS system when the VFD'S are switched to the bypass position.

2.03 **FAN COIL UNITS (WITH ECM MOTORS)**

A. The unit shall be enabled by manual command or time of day schedule both from the BAS. For equipment rooms initial time of day program shall provide for continuous operation of the system. For public spaces the BAS Contractor shall coordinate with the Owner the hours for occupancy with initial default being 7am to 7pm. When the system is energized by the DDC panel, the fan shall be started at a minimum speed of 20%. Fan status shall be proven via the current switch at 15% speed. If the fan fails to prove status, an alarm shall be generated at Facilities.

B. The BAS Contractor shall coordinate the Room Temperature Setpoints with the Owner. The default setpoint shall be as follows:

	Occupied
Cooling	75 Degf
Heating	70 Degf

C. Occupied Mode:
1. Cooling: With the fan operating at minimum speed, if the room temperature rises above the room temperature setpoint the cooling coil valve shall modulate open to maintain the room temperature. On a continued rise in room temperature the fan speed shall modulate to full speed. On a drop in room temperature the reverse shall occur.

2. Heating: With the fan operating at minimum speed, if the room temperature falls below the room temperature setpoint the heating coil valve shall modulate open to maintain the room temperature. On a continued drop in room temperature the fan speed shall modulate to full speed. On a rise in room temperature the reverse shall occur.

D. Unoccupied Mode:
1. Cooling: If the room temperature rises above the Unoccupied room temperature setpoint the fan shall modulate to minimum speed and the cooling coil valve shall modulate open to maintain the room temperature. On a continued rise in room temperature the fan speed shall modulate to full speed. On a drop in room temperature the reverse shall occur. When the room temperature falls into the deadband range the fan shall modulate down to zero speed and the valve shall be closed.
2. Heating: If the room temperature falls below the Unoccupied room temperature setpoint the fan shall modulate to minimum speed and the heating coil valve shall modulate open to maintain the room temperature. On a continued drop in room temperature the fan speed shall modulate to full speed. On a rise in room temperature the reverse shall occur. When the room temperature falls into the deadband range the fan shall modulate down to zero speed and the valve shall be closed.

E. In addition to the points referenced in the sequence above, all monitoring points, virtual points, networked points, setpoints etc. as defined in the point list shall be displayed on the system graphic. All adjustable setpoints shall be adjustable from the graphic interface

F. The BAS Contractor shall monitor the moisture sensor in the FCU cooling coil drain pan. On a high level alarm as indicated by the moisture sensor the cooling coil valve shall close and an alarm shall be generated.

2.04 FAN COIL UNITS (NON-ECM MOTORS)

A. The unit shall be enabled by manual command or time of day schedule. For equipment rooms initial time of day program shall provide for continuous operation of the system. For public spaces the BAS Contractor shall coordinate with the Owner the hours for occupancy with initial default being 7am to 7pm. When the system is energized by the DDC panel, the fan shall be started. Fan status shall be proven via the current switch, if the fan fails to prove status, an alarm shall be generated at Facilities.

B. The BAS Contractor shall coordinate the Room Temperature Setpoints with the Owner. The default setpoint shall be as follows:

	Occupied
Cooling	75 Degf
Heating	70 Degf

C. Occupied Mode:
1. Cooling: If the room temperature rises above the room temperature setpoint the cooling coil valve shall modulate open to maintain the room temperature. On a drop in room temperature the reverse shall occur.
2. Heating: If the room temperature falls below the room temperature setpoint the heating coil valve shall modulate open to maintain the room temperature. On a rise in room temperature the reverse shall occur.

D. In addition to the points referenced in the sequence above, all monitoring points, virtual points, networked points, setpoints etc. as defined in the point list shall be displayed on the system graphic. All adjustable setpoints shall be adjustable from the graphic interface

E. The BAS Contractor shall monitor the moisture sensor in the FCU cooling coil drain pan. On a high level alarm as indicated by the moisture sensor the cooling coil valve shall close and an alarm shall be generated.

2.05 CABINET UNIT HEATERS/PROPELLER UNIT HEATERS

A. At each unit heater, the ATC Contractor shall provide remote mounted thermostats and interlocking to modulate the 2-way hot water normally open control valve and energize the fan to satisfy the room temperature setting. When heat is not available the fan will remain off, provide aquastat.

2.13 **ENERGY METERS**

A. The ATC Contractor shall furnish, receive, mount and wire meters and all control devices associated with each energy meter/recording system. (Typical for chilled water supply/return, hot water system supply/return and electric service meters each having KW and KWH meters). The electricity metering shall be accomplished by monitoring current transducers and pulsed outputs provided by the Electrical Contractor in the switchgear. Provide conversion/calibration software as required.

2.14 **CHILLED WATER SYSTEM**

A. Chiller and condenser system as specified below shall be controlled by a dedicated DDC controller. Control of other major systems (i.e., air handling units, heat exchangers, etc.) on this DDC controller shall not be acceptable.

B. The ATC Contractor shall provide all interlocking wiring to the integral chiller control panel(s) provided by the chiller manufacturer to activate/deactivate chiller(s), as hereinafter specified as specified in the chiller specification section. The chiller plant shall be programmed through the DDC system to operate fully automatically as described in the following description of operation. Minimal DDC system manual operator intervention shall be required for normal plant operation. The chilled water plant shall be programmed so that manually manipulating the chilled water plant will not adversely affect operation or damage equipment. The program shall be structured to offer the DDC system operator flexibility in the selection of online equipment should the need arise to take a piece of equipment out of service. All remote sensors, differential pressure switches, differential pressure transmitters, water flow stations and other control devices furnished as part of this control system shall be provided by the ATC Contractor. The HVAC Contractor shall install wells, etc., as directed by the ATC Contractor. Refer to the Division 25 point schedules for additional points to be provided by the ATC Contractor.

C. The chiller control system shall provide all sequences for chiller(s), cooling tower(s) and their respective chilled water and condenser water pump(s). The ATC Contractor shall interlock each chiller, cooling tower(s) and pump(s) to the DDC control system. Chillers, condenser water pumps, chilled water pumps, and the cooling towers can run in multiple quantities and configurations.

D. Provide vapor tight flow switches for each chilled water pump and condenser water pump and interlock to the chiller to prevent chiller operation until both the chilled water and condenser water pumps are operating to provide flow through the chiller. Provide flow switches at the outlet of each chiller. Sensors used for chilled water and condenser water temperature measurement are to be “matched”. All temperature sensors for the system shall have accuracy within +/- 0.1°C (+/-0.2°F) or better. All pressure sensors for the system shall have an accuracy of +/- 0.25% of full scale or better.

E. Provide all sensors, relays and other control devices necessary for a complete and workable chilled water system. Coordinate the entire chilled water control installation with the chiller manufacturer. ATC Contractor shall review all “Chiller Plant” sequences of operations with the Chiller Manufacturer prior to final programming and system startup.

F. Chillers shall be controlled as follows:
   1. For any chiller plant function to be operational, the CHILLER PLANT ENABLE point must be turned on. When CHILLER PLANT ENABLE is off, the plant will be off. If the outside air temperature is greater than 55°F (adjustable) and/or any of the air handling units are calling for cooling (chilled water control valve open and discharge air temperature greater than 2°F (adjustable) above the supply air setpoint) for greater than 20 consecutive minutes (adjustable), the chilled water plant shall be automatically enabled. The chilled

water plant shall be automatically disabled when the outside air temperature is 3°F (adjustable) below the enable setpoint and all the air handling units chilled water automatic control valve(s) position are 0% open (adjustable). agitated

2. When a chiller is enabled to start, the associated cooling tower isolation valves, associated condenser water isolation valves and associated chiller isolation valves open and the condenser water pump and the chilled water pump start. Both the condenser water and chilled water flow through the chiller are monitored with flow switches that must close before the chiller can start. Subsequently if the flow switch does not sense water flow within 60 seconds (adjustable), the failed pump(s) and associated chiller will shut down and the back-up pump(s) and chiller shall be started. The chilled water pump and the associated condenser water pump shall start via the DDC system. When flow is established in both circuits by flow switches, the chiller will start.
3. Upon initial startup of the chilled water plant, the cooling tower bypass valve shall be positioned to bypass the cooling tower cells and circulate the condenser water through the chillers. The lead chiller shall not be allowed start until the supply condenser water temperature exceeds the chiller manufacturer's minimum supply condenser water temperature set point. The ATC Contractor shall coordinate with the Chiller Manufacturer to determine the minimum supply condenser water temperature set point. When the supply condenser water temperature exceeds the chiller manufacturer's minimum supply condenser water temperature set point, the lead chiller shall be started and the bypass valve shall be slowly modulated open to the tower to control for the optimal supply condenser water temperature set point.
4. When a chiller is enabled to start, a ten-minute program timer (adjustable) is started. If the compressor does not start or shuts down within ten consecutive minutes (adjustable) and the chilled water temp is above set point for ten consecutive minutes (adjustable), a LOCKOUT point will be enabled, the chiller will shut down and a back-up chiller will start. The failed chiller LOCKOUT alarm shall be activated at the ATC workstation. The LOCKOUT point must be manually commanded off at the DDC system for the chiller to be re-enabled for automatic operation. The LOCKOUT point shall automatically release to the readied automatic state.
5. The differential pressure across each chiller condenser bundle shall be monitored by the ATC Contractor. Transmitter piping wells shall be provided by Division 23. Transmitter shall be provided, installed and calibrated by the ATC Contractor. The pressure sensing device shall be equal to Setra Model 230 Wet/Wet Pressure Transducer with 3 valve manifold and have an accuracy of +/-0.25% of full scale. Transmitter range shall be coordinated with chiller manufacturer. The BAS shall control pump speed (via VFD) as required to maintain minimum differential pressure setpoint across the condenser bundle of each active chiller. If the condenser water bundle differential pressure falls below setpoint, the pump speed shall be increased to maintain setpoint. If the condenser water bundle differential pressure rises above setpoint, the pump speed shall be decreased to maintain setpoint. Each chiller shall have an individually adjustable condenser water bundle differential pressure setpoint. Condenser water pump(s) shall control for the lowest of the operating chillers differential pressures. The Refrigerant Differential Pressure (RDP) shall be monitored for each operating chiller via integration to the integral chiller control panel(s) provided by the chiller manufacturer. ATC Contractor shall coordinate with the chiller manufacturer to determine the low limit RDP setpoint for each chiller. If the RDP falls below this low limit setpoint the BAS shall slowly reset the condenser water bundle differential pressure setpoint downward, through PID control, as required to maintain RDP minimum setpoint. If the RDP rises above this low limit setpoint the BAS shall slowly reset the condenser water bundle differential pressure setpoint upward, through PID control, as required to maintain RDP minimum setpoint. Each condenser water bundle differential pressure setpoint shall have a low limit, to be determined by the chiller manufacturer. The condenser water bundle differential pressure shall not be allowed to drop below the low limit setpoint.
6. The chillers shall be programmed for lead/lag operation to maintain equal runtime. The runtime for each chiller shall be totalized by the DDC system. When the plant is started,

each chillers totalized run time is looked at by the program and the chiller with the least run time will start. The chiller with the most run time is started last. When chillers are being shed, the chillers with the greatest run time shall be shut down. The chiller plant shall also be programmed to allow the DDC system operator to arrange the lead/lag order of equipment manually. Manually arranging the lead/lag order of equipment while the plant is operating shall have no effect on the plant operation until a machine is added, a machine is shed, or the plant is shut down and re-started.

7. Additional chillers shall be staged ON based on the chilled water system flow. If the secondary chilled water system tonnage demand is greater than 95% (adjustable) of the operating chiller(s) total capacity and the primary chilled water supply temperature exceeds setpoint by 2°F (adjustable), for twenty consecutive minutes (adjustable), the next chiller in line shall be enabled to start. Chillers shall be staged OFF based on the secondary chilled water system tonnage demand and the primary chilled water temperature. The chiller sequencing software shall consider stopping another chiller whenever the load on operating chillers drops to a level low enough so that a chiller can be turned off and the remaining chiller(s) can carry the load and the primary chilled water supply temperature is within setpoint by 3°F (adjustable), for ten consecutive minutes (adjustable). The chiller with the greatest runtime will be stopped.
8. The chiller plant control system shall determine the optimum number of chiller(s) required at any time to meet the cooling load and minimize energy consumption. The differential pressure across each chiller evaporator shall be monitored by the ATC Contractor. Transmitter piping wells shall be provided by Division 23. Transmitter shall be provided, installed and calibrated by the ATC Contractor. The pressure sensing device shall be equal to Setra Model 230 Wet/Wet Pressure Transducer with 3 valve manifold and have an accuracy of +/-0.25% of full scale. Transmitter range shall be coordinated with chiller manufacturer.
9. The ATC Contractor shall coordinate with the Chiller Manufacturer to correlate the chiller evaporator differential pressure to water flow through the chiller. The ATC Contractor shall work with the Testing and Balancing Contractor to correlate the secondary chilled water system pumps speed to water flow. This shall be accomplished by determining the secondary chilled water pump(s) speed that produces water flow equal to the primary chilled water pump(s) water flow. Additional chillers shall be staged ON if the return chilled water temperature is greater than the design primary chilled water return temperature 58°F (adjustable) for greater than 20 minutes (adjustable) and the secondary chilled water flow is greater than or equal to the primary chilled water system flow. Stage lag chiller OFF when the return chilled water temperature is 50% of the design primary chilled water return temperature 58°F (adjustable) for greater than 20 minutes (adjustable) and the secondary chilled water flow is less than or equal to the primary chilled water system flow.
10. When a chiller is enabled to run, it shall run for a minimum of 30 consecutive minutes (adjustable) before being allowed to stop. Once stopped, additional chillers shall not be staged on for a minimum of 30 consecutive minutes (adjustable). All respective chilled water and condenser water optimization routines should be disabled for a period of 15 consecutive minutes (adjustable) during the chiller start-up and shut down sequences. The chiller staging software shall not shutdown a chiller pump until all chiller compressors are proven off.
11. The chilled water pumps, and condenser water pumps shall be programmed for lead/lag operation to maintain equal runtime. The runtime for each pump shall be totalized by the DDC system. Lead chilled water pump, secondary chilled water pumps and condenser water pump shall be selected as the pump with the least amount of runtime.
12. Pump status shall be monitored by the ATC system via analog current sensors. The ATC Contractor shall determine the minimum pump motor amperage that correlates with pump running status. A pump failure alarm is sent to the operator work station if a pump is commanded ON but the minimum pump motor amperage is not sensed within 30 second (adjustable) to verity pump operation. The LOCKOUT point will be enabled and the next available pump will be started. The failed pump LOCKOUT alarm shall be activated at the

ATC workstation. The LOCKOUT point must be manually commanded off at the DDC system for the pump to be re-enabled for automatic operation. The LOCKOUT point shall automatically release to the readied automatic state.

13. The secondary chilled water pumps shall be staged ON to maintain system differential pressure setpoint. Upon enabling the system to start, the lead pump shall be started and ramped up to maintain system differential pressure set point. If the lead pump speed exceeds 95% (adjustable) for greater than 10 consecutive minutes (adjustable) the lag pump shall be started. Both pumps shall operate in parallel to maintain system differential pressure. The pumps shall be staged OFF by determining the pump with the greatest runtime to disable. With two pumps operating below 45% speed (adjustable) for greater than 10 consecutive minutes (adjustable) then the operating pump with the greatest runtime is disabled.
14. The VFD shall vary the speed of the pump to maintain the differential pressure setpoint at the D.P. sensor located in the major piping branch. D.P. sensor shall be wired to the local DDC control panel where the system control logic resides. Across the network communications of the system differential pressure shall not be allowed. Final system differential pressure setpoint shall be determined by the Balancing Contractor. The ATC Contractor shall allocate sufficient time to work with the Balancing Contractor to provide the necessary BAS support to determine the optimal system differential pressure setpoint (adjustable). The Balancing Contractor shall determine the lowest possible differential pressure control setpoint possible for all variable speed pumping systems.
15. Upon failure of the D.P. sensor feedback to the DDC panel, the pump(s) speed shall remain in the last known state. An alarm shall be generated at the BMS.
16. At no point shall the secondary chilled water system be allowed to “over pump” the primary chilled water system. During steady state operation, the secondary chilled water pumps shall not over pump the primary chilled water pumps. ATC Contractor and Balancing Contractor shall determine secondary pump GPM versus VFD speed relationship. ATC Contractor to vary VFD speed (i.e. GPMs) to ensure the primary chilled water flow is maintained greater than the secondary chilled water flow. During transient operations provide a 20 minute time delay (adjustable) when switching from one (1) to three (3) chiller operation, it is acceptable to allow the secondary chilled water flow to exceed the primary chilled water flow by no more than 20%.
17. Provide a pressure sensor, reporting to the DDC panel and valve to control the VFDs to compensate for pressure fluctuations in the systems. Pressure sensor shall have sensing tips in the supply and return water lines. During conditions where the secondary chilled water pumps/VFDs are controlled in the hand mode, operate the normally closed differential bypass valve to automatically bypass water and compensate for pressure fluctuations in the secondary chilled water system.

G. Equipment Service and Maintenance Shutdown
   1. Each piece of equipment shall be programmed with an associated MSD point. By commanding an MSD point on, the program recognizes the equipment is unavailable and seeks an alternate piece of equipment. When the MSD point is commanded ON, the equipment shuts down immediately and the back-up equipment will start. If the piece of equipment to be serviced is already off, then the MSD point can be commanded off without consequence.
   2. MSD points shall be programmed for each Chiller, Primary Chilled Water Pump, Secondary Chilled Water Pump, Condenser Water Pump and Cooling Tower.

H. Chiller System Operator Interface - The Chiller Plant Control Program shall include at a minimum the following operator interface elements:
   1. Chiller Plant Control Application Operational Status Screen to include:
      a. Chiller System Status (Off/Soft Start/Normal/Ambient Lockout/Shutdown in Progress)
      b. Chiller Plant Supply Water Setpoint
      c. Chilled Water System Supply Water Temperature
      d. Chilled Water System Return Water Temperature

e. Prediction chiller addition / subtract status messages (i.e Next Chiller to Add will be added if the system supply water temp [40.1] exceeds [41.5] degrees for [15] minutes. OR Next Chiller to Subtract will be subtracted if there is no add request and the actual system Delta T [12.7] degrees is less than [10.2] degrees for [15] minutes.)
f. Individual Chiller Failure Reset (Push Button)
g. All Chiller Failure Reset (Push Button)
h. System Pump Failure Reset (Push Button)
i. Manual Addition of Chiller (Push Button)
j. Manual Subtraction of Chiller (Push Button)
k. Manual Rotation of Chiller Sequence (Push Button)

2. Chiller Plant Control program shall include a screen(s) that allows editing of the following data without entering program code editor:
a. Supply Water Setpoint
b. System Soft Loading Setpoints
c. Ambient Lockout Setpoints
d. Chiller Addition Setpoints
e. Chiller Subtraction Setpoints
f. Auto Rotation Setpoints
g. Alarm Handling Setup
h. Security Setup

3. Individual Chiller Status Graphic Screen(s)
a. Chiller Name
b. Chiller Operating Mode
c. Chilled Water Setpoint
d. Chiller RLA %
e. Chiller Number of Starts
f. Chiller Run Hours
g. Entering Chiller Water Temperature
h. Leaving Chilled Water Temperature
i. Evaporator Flow Status
j. Condenser Flow Status
k. Purge Unit Status (Low pressure machines only)
l. Purge Compressor Daily Run Time (Low pressure machines only)
m. Compressor Phase Voltages 1/2/3
n. Compressor Phase Amperages % of FLA 1/2/3
o. Compressor Motor Winding Temperatures 1/2/3

2.15 COOLING TOWER AND CONDENSER WATER PUMPS

A. The BAS shall select one of the cooling tower cells as the lead tower cell on a monthly basis. The tower cell with the lower total run time shall be selected as lead tower. The BAS shall select the lead condenser water pump similarly.

B. The lead chillers, chilled water and condenser water isolation valves shall be proofed open before any lead equipment is energized. After the tower water level probe system shows proof of the tower being full of water, and after chilled water flow is established, the lead condenser water pump shall start after a predetermined time delay as suggested by the chiller manufacturer. The lead condenser water pump shall start with the lead chiller's condenser water isolation valve open. Approximately one (1) second (adjustable) after the lead chillers condenser water isolation valve is proofed, the lead chiller's condenser water pump shall be energized. The lag chillers condenser water pump shall be energized with the lag chillers condenser water isolation valves closed. Approximately one (1) second after the lag equipment has been proofed the lag chillers condenser water isolation valves shall be opened slowly.

C. Condenser water pump status shall be as determined by a current transducer. A readable flow meter shall indicate the condenser water flow for each chiller at the BAS.

D. The tower fill system must maintain a full status, the condenser water pump proof must remain made and the Condenser water flow shall be verified for a minimum of five (5) minutes before chiller is energized.

E. The cooling tower shall maintain a condenser water supply temperature of 85^0F (adjustable) to the chiller's condenser. The 85^0F shall be adjustable from the BAS. A temperature transmitter located in the main condenser water supply pipe shall sense the condenser water supply water temperature to the chiller and cycle the cooling tower cell fan speed through the BAS.

F. Each tower fan is equipped with a VFD for fan speed control. Automatic start/stop of the Tower fans shall be via the VFD start/stop terminals. The cooling tower fan shall cycle from "OFF" to "ON" with the fan starting on "Low" speed and modulating to "High" speed through the VFD to maintain the condenser water supply temperature set point. The BAS shall control each online cooling tower fan at the same speed to maintain condenser water supply temperature (CWST) in the common CW pump suction header at set point.

G. The BAS will deactivate the cooling tower fans when the chiller system is in the deactivated mode.

H. The cooling tower cells utilize a central bypass system that is controlled by a modulating two way motorized automatic control valve. The cooling tower bypass valve shall be open when the chillers are first started during low outside air temperature conditions in order to maintain a minimum 70^0F (adjustable) set point temperature as sensed by a temperature transmitter. As the condenser water supply temperature increases, the bypass control valve shall modulate to a closed position and increase the condenser water flow to the cooling tower. This process shall continue with full flow over the tower until maximum set point temperature is reached. The cooling tower cell bypass system is controlled by the BAS in order to maintain a minimum set point temperature of 70^0F (adjustable).

I. The BAS will activate the Tower Water Make up System when the outside air temperature is above 40^oF (adjustable) and there is a call for cooling. The BAS shall give a "Full" signal when the Tower water level is at an acceptable level before the chiller, primary chilled water pump and the condenser water system is energized. The BAS will allow activation of the Tower filtration system when the condenser system is "Full". Level sensor shall maintain the proper level in the cooling tower basin section by addition of make-up water.

J. If cooling tower is drained for service, the Operator shall report tower off-line status via the BAS input screen. Basin heater shall be disabled under this condition.

K. Vibration switches shall shut down the fans and signal an alarm. If the outside air temperature is colder than 40° (adj.) the fan that was in vibration alarm shall be set to reverse fan direction for (2) minutes (adj.), then restarted at low speed. These switches shall be independently wired and monitored by the BAS.

2.22 VARIABLE SPEED DRIVES

A. For each VFD, provide the following through the PLC:
   1. Motor run feedback points to provide run status in both VFD and bypass mode.
   2. Provide mode feedback (VFD and bypass mode).
   3. Speed control output signal to VFD.
   4. Feedback indicating speed (Hz) and amperage.
   5. General alarm from VFD.
   6. Start/stop output to VFD.
   7. Control ramp up rate.
   8. Control ramp down rate.
   9. Adjust and set minimum speed.

2.23 CHEMICAL TREATMENT

A. Chemical treatment systems shall be provided by the HVAC Contractor for all water systems. The ATC Contractor shall provide wiring between all components of the chemical treatment systems.

2.24 REFRIGERANT DETECTION AND PURGE SYSTEM

A. General
1. The ATC Contractor shall furnish and install a refrigerant detection system for the mechanical/chiller room as manufactured by MSA, or approved equal. The detection system shall have:
   a. Multiple point scanner type, suitable for continuous monitoring of four (4) locations throughout the mechanical equipment room for refrigerant R-134a concentrations between 9-and 1000 ppm.
   b. The refrigerant monitor shall draw room air through an infrared, photo-acoustic sensing device allowing accurate measurement of refrigerant vapors with minimum interference from other chemicals in the vicinity.
   c. The refrigerant analyzer shall be calibrated at the factory for R-134a and be capable of measuring refrigerant concentrations as low as 1 ppm.
   d. Provide 1/4" copper tubing to draw air samples from locations indicated on drawings. Provide sample filters for each sensing point. The refrigerant monitor shall signal alarm levels at three (3) concentration levels, plus a unit trouble alarm that indicates internal problems with the instrument. Provide lights to indicate the alarm location and alarm level. Provide separate dry contacts for remote monitoring of Level 1, Level 2 and Level 3 and unit trouble alarms.
   e. Provide NEMA 4 enclosure for wall mounting and all components necessary for periodic calibration. The refrigerant monitor shall be suitable for operation with 115 volt, 60 hertz, 1 phase electric power.

B. Operation
1. Whenever the refrigerant leak detection senses a refrigerant above its preset alarm limit, respectively, an alarm condition shall be initiated. Limits shall be set at:
   a. Alarm 1 set at 10 ppm.
   b. Alarm 2 set at 30 ppm.
   c. Alarm 3 set at 300 ppm.
2. Emergency Warning (Alarm 1 and/or Alarm 2)
   a. Once Alarm 1 and/or Alarm 2 condition is initiated, the following shall occur:
      1) Two (2) alarm horn/strobe lights shall be energized, (1) in the chiller room and (1) outside of the chiller room (in the boiler room) adjacent to the Attendant’s Office.
3. Emergency exhaust shall be provided for local hardwired control.
   a. Once Alarm 3 condition is initiated, the alarm will energize the exhaust fan to 100% and supply/makeup fan. The exhaust/return dampers shall be set to full exhaust, and the supply/makeup fan outside/return dampers shall be set to 50% outside air, thus, creating a negative pressure in the chiller equipment room during a refrigerant emergency.
      Note: This system is being provided by normally operating PH ventilation unit.

2.25 SYSTEM AND NORMAL/EMERGENCY POWER MONITORING

A. Power Management System Monitoring - Provide connections to the BAS to monitor the Electrical Power Management System (PMS) controllers. The Electrical Contractor shall retain and bear the cost of developing computer drivers for each of the PMS's. The ATC Contractor shall integrate the drives information into the campus automation system and extend all necessary cabling to interconnect with the PMS driver outputs.

B. Normal/Emergency Power Monitoring System - Provide DI points to sense the transfer of building power from normal-to-emergency and emergency-to-normal, plus the loss of power and normal testing. Each automatic transfer switch requires three (3) digital inputs as follows:
1. DI Undercurrent relay
2. DI Loss of normal power
3. DI Loss of emergency power

2.26 SMOKE DAMPER

A. Typical: Smoke damper shall close on signal from a smoke detector located in the duct or within 5 feet of the damper. The fire alarm system shall be capable of overriding this control and opening the damper remotely.

2.27 **FIRE SMOKE DAMPER**

A. Trip-on temperature.

B. Typical: Smoke damper shall close on signal from a smoke detector located in the duct or within 5 feet of the damper. The fire alarm system shall be capable of overriding this control and opening the damper remotely.

2.28 **PUMP-FAN AND EQUIPMENT ALTERNATION**

A. All lead/lag/stand-by pumps, fans and equipment shall be programmed and sequenced to alternate on a bi-weekly (ADJ) basis. The alternation logic for all lead/lag/stand-by function shall be based upon total run time and unit cycling providing for equal run time for all fans, pumps and equipment.
   1. Sequencing for the lead/lag/stand-by function of all pumps, fans and equipment shall not cause loss of flow, pressure, fire/smoke dampers and/or building pressurization.
   2. All lead/lag/stand-by function sequencing and programming logic shall be review and confirmed by the Architect & Owner prior to final software programming is implemented.

B. Additional programming for sequencing requirements of fan system that are utilized for life safety and/or special conditions shall be incorporated to operate on a monthly (ADJ) basis. Each system shall operate for a minimum of 15 minutes (ADJ) to verify system function and operation.
   1. Systems to be include but not limited to shall be as follows:
      a. Chiller Refrigerant Purge Fan(s)
   2. All life safety and/or special conditions function sequencing and programming logic shall be review and confirmed by the Architect & Owner prior to final software programming is implemented.

C. Pump-Fan and Equipment Alternation Checkout
   1. System Adjustments
      a. Once the above controls sequences have been verified by the ATC Contractor to by operating properly and the system has been balanced, the ATC Contractor shall carry an additional 120 hour allowance for program modifications to fine tune the space pressurization modes of operation

END OF SECTION

SECTION 25 10 00
DIRECT DIGITAL/AUTOMATIC TEMPERATURE CONTROLS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Section 250500 and other Division 1 Specification Sections, apply to this Section.

1.02 WORK INCLUDED

A. Furnish and install a complete system of direct digital controls to make a fully operational and controllable building HVAC system.

B. The work shall include but not be limited to all labor, materials, special tools, equipment, enclosures, power supplies, software, software licenses, Project specific software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, Warranty, specified services and items required by the Contract for the complete and fully functional Controls Systems.

C. The system shall be all electric DDC (direct digital control).

D. All system components shall be installed in accordance with local and State codes.

E. Secure all permits and local/State approval for all components and installation as specified under this Section.

F. Provide complete commissioning for all control system components and sequences of operation.

G. Preparation and submission of shop drawings.

1.03 RELATED SECTIONS

A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

B. Section 019113 General Commissioning Requirements

C. Division 21

D. Division 22

E. Division 23

F. Division 25

G. Division 26

1.04 REFERENCES

A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.

B. Material standards shall be as specified or detailed hereinafter and as follows:
1. NFPA 70 – National Electric Code.
2. UL-916 – Energy Management Systems.
3. UL-873 – Temperature Indication and Regulating Equipment.
4. FCC; Part 15, Subpart J – Class A computing Equipment.
5. UL-864 – Fire and Smoke Control.

1.05 SYSTEM DESCRIPTION

A. Furnish and install, as hereinafter specified, a combination direct digital/ electric/electronic temperature control system and Building Automation System (BAS). The system shall be comprised of a network of various independent Stand-alone Direct Digital Controllers,

electric/electronic control equipment, thermostats, sensors, controllers, valves, dampers, actuators, panels and related hardware, software and other accessory equipment, along with a complete system of electrical control wiring, and software generation to fill the intent of the specifications and provide for a complete and operable system.

B. The Building Automation System (BAS) shall be composed of PC-based setup and programming workstations, programming and configuration software tools, operator workstations, web server user interface software and hardware, and microcomputer-based controllers of modular design providing distributed processing capability, and allowing future expansion of both input/output points and processing/control functions.

C. The Building Automation System (BAS) shall be designed in accordance with ASHRAE's BACnet standard, 135-2010, to provide interoperability between different building subsystems. All physical controller components of the Building Automation System – network controllers, application controllers, unitary controllers, input output extension modules, network resident sensors, etc. shall be listed in conformance with the BACnet Testing Laboratories (BTL) established testing standards, as described for each component in this specification. Contractor shall provide manufacturer's Protocol Implementation Conformance Statement (PICS) for every controller model installed under this contract. BACnet over ARCNET shall not be accepted. No BACnet gateways shall be used for communication to Building Automation System controllers furnished under this section unless approved by owner. BAS controllers which are not BTL listed are not acceptable.

D. The primary user interface for the Building Automation System shall be via standard PC web browser as described in this document. The Building Automation System shall include web server hardware and software to provide graphical, web-based operator interfaces for instant access to any system data through a standard PC web browser, such as Microsoft Internet Explorer, without the need for any added manufacturer's software installed loaded on the PC.

E. All Building Automation System server machines and appliances, PC workstations and notebook PCs, and all other user interface devices shall conform to IT (Information Technology) industry accepted standards and specific requirements as described in this document.

F. The BAS shall be engineered, programmed and installed by competent controls mechanics and electricians regularly employed by the manufacturer of the BAS control equipment. All BAS control equipment, user interface server software and configuration/programming software tools shall be the products of one (1) manufacturer and all components shall be capable of interfacing with the HVAC equipment using BACnet protocols. The Contractor must maintain adequate factory trained staff and offer standard services to fully support the owner in the timely maintenance, repair, and operation of the control system. Contractors who do not maintain such staff and offer services or must develop some for this project are not acceptable.

G. Bids from franchised dealers or others whose principal business is not the manufacture, installation and service of the Building Automation Systems will not be acceptable.

H. The Contractor shall submit a copy of the manufacturer's standard software and firmware licensing agreement for the owner's signature. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets constrained within such software.

I. All products of the Building Automation System shall be provided with the following agency approvals. With the submittal documents, verification that the approvals exist for all submitted products shall be provided. Systems or products not currently offering the following approvals are not acceptable.
   1. UL-916; Energy Management Systems
   2. UL-873; Temperature Indication and Regulating Equipment UL-864; Subcategories UUKL, QVAX, UDTZ; Fire and Smoke Control Systems
   3. UL-864; Subcategories UUKL, QVAX, UDTZ; Fire and Smoke Control Systems where used for smoke control applications as described in this document and/or indicated on the drawings.
   4. FCC; Part 15, Subpart J, Class A Computing Devices

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

K. HVAC/Smoke Control System Operation:
1. On/Auto/Off switches and status indicators (LEDS) shall be provided by the Fire Alarm Contractor for monitoring and manual control of each fan, damper, HVAC control unit, stairwell pressurization fan, space pressurization and smoke exhaust fan. To ensure compliance, where used for smoke control applications as described in this document and/or indicated on the drawings, the Building Automation Systems controllers supplied shall meet the following **UL categories: UUKL, PAZX, UDTZ, QVAX** as well as the requirements of NFPA 90A, HVAC, and NFPA 92A & 92B, Smoke Control. The control system shall be field programmable for either 90A operation or 92A/B operation to allow for future use and system expansion.
2. All devices shall be UL 864 and UUKL listed, where used for smoke control applications as described in this document and/or indicated on the drawings.

1.06 **SUBMITTALS**

A. See Section 230500 and General Conditions for additional requirements.

B. Product Data: Provide data for each system component and software module.

C. Shop Drawings.
1. Control damper and control valve schedules, including the size, pressure drop and location for intended use.
2. Terminal unit schedules shall be provided on a floor by floor basis and must include at a minimum but shall not be limited to room numbers, sizes, contract drawing tag id's, capacity values of minimum/maximum along with modes of operation (Occ/Unocc/Purge etc.), calibration values, etc.
3. Provide a Control Systems Network Riser diagram. This shall incorporate the following:
a. The riser shall show on a floor by floor basis the BAS controllers and the communication Tier that the controllers reside on.
b. The communication Tiers should be identified and qualified (Ethernet, RS-485, etc.) along with the cabling type.
c. All Tier 1 devices along with 3rd party interfaces and gateways shall be shown including workstations, servers, controllers, printers, etc.
d. Tier 2 and 3 devices can be grouped by type provided a total quantity of devices is indicated. An example of grouping for Tier 2 and 3 would be for terminal equipment showing VAV's with the quantity separate from Fan Coils with a quantity, etc.
e. All routers, switches, bridge, modems, etc shall be shown.
f. If a separate Network is required to achieve any smoke control or life safety functions to comply with UL-864 requirements the riser shall be segregated accordingly.
4. Provide Electrical load calculations for the entire BAS system as follows.
a. Electrical Load calculation sheets shall be provided as part of this submittal package. Provide on a panel by panel basis grouping the loads by floor providing a total VA load for the floor.
b. This shall also apply to VAV box loading when utilizing step down transformers for 24VAC distribution.
c. The BAS contractor shall review the Electrical power plans for the dedicated BAS circuits and indicate in the initial submittal the panels/controllers that will be on each circuit with the panel and circuit number depicted.
d. The KVA and Electrical Panel/Circuit number will also be shown on the BAS controller Network riser diagrams showing totals for panels and totals for floors.
e. If additional circuits are required, the BAS contractor shall indicate this in the submittal and demonstrate by the load calculations the quantity of additional circuits that are required.
f. The Electrical Load Calculations shall be updated and submitted with the final as-built documents.

5. Electrical panel enclosure layouts and wiring diagrams to numbered terminal blocks shall be provided as part of the submittal documentation for all BAS panels. The layouts shall depict all components and the wiring diagrams must be in ladder logic diagram format.
6. Unique individual control flow diagrams shall be provided for all systems. These shall show all input and output system components in their correct locations and orientations. Typical diagrams are allowed providing the systems are truly identical but the unit numbers for major systems are clearly listed. For terminal units the drawing number for the “typical” must be indicated on the terminal unit schedules. All control diagrams shall be provided with their associated points schedules.
7. List connected data points, including connected control unit and input device.
8. Indicate all system graphics for all controlled systems including all air handling systems, hydronic pumping systems, monitored systems, data (connected and calculated) point addresses and operator notations.
9. Show system configuration with peripheral devices, batteries, power supplies, diagrams, modems and interconnections.
10. The sequence of operation for each HVAC system and the associated control diagrams shall be provided. The sequence should include normal operation along with failure modes of operation detailing any software lockouts that require user intervention and any time delays or specialty interfaces. All equipment and control labels shall correspond to those shown on the contract documents.
11. Develop and provide emergency, fire, smoke management control and device response matrices in an MS Excel spreadsheet format.
12. Show electronic ranges for each valve, damper, inlet vanes actuators etc., (i.e. 4 – 20 ma or 0-10 vdc).
13. All control logic and controllable components shall be depicted and identified within each matrices developed.
14. Furnish PICS and BTL listing information for each BACnet compliant device.
15. All UUKL components shall be depicted and identified.

D. Manufacturer’s Installation Instructions: Indicate manufacturer’s installation instructions for all manufactured components.

E. Submit brochures that contain only that information which is relative to the particular equipment or materials to be furnished. Do not submit catalogs that describe several different items other than those items to be used unless irrelevant information is marked out and relevant material is clearly marked.

F. Specifications Compliance Statement
1. The manufacturer shall submit a point by point statement of compliance with the specifications.
2. The statement of compliance shall consist of a list of all paragraphs (line by line).
3. Where the proposed system complies fully, such shall be indicated by placing the word “comply: opposite the paragraph number.
4. Where the proposed system does not comply, or accomplishes the stated function in a manner different from that described, a full description of the deviation shall be provided.
5. Where a full description of a deviation is not provided, it shall be assumed that the proposed system does not comply with the paragraph in question.
6. Submissions which do not include a point by point statement of compliance as specified shall be disqualified.

G. Project Record Documents: Record actual locations of control components, including control units, thermostats and sensors, trunk cable routing, junction boxes, transformers, VAV terminal box power circuiting, box addresses.
1. Revise shop drawings to reflect actual installation and operating sequences.
2. Include submittal data in final “Record Documents” form.
3. All start-up/checkout documentation shall be initialed and signed by the on-site control technician with intimate knowledge of the project.

4. Provide start-up/checkout documentations for all DDC controllers connected to the BAS network. Documentation shall include all controller points used and unused (spare). Furthermore, all final settings, calibration, coefficient values, K factors, spanning, actual spring ranges, etc., shall be documented and indicated for all active points in use.
5. Revise all control sequences of operation. Sequences of operation that restate the Design Engineer's sequences will not be acceptable. Complete details will be given within the sequences of operation provided by the Contractor. Details shall include, but not be limited to, the following items: Control strategy, timers, delays, logic sequencing, start/stop, end devices involved, sensors involved, set points, globally commanded values, shared data between panels and controllers.
6. Provide a separate drawing with detailed operation sequence for each UL category UUKL smoke control system. This means if there are four pressurized stairs each has its own drawing and sequence specific to that system. No system shall be a duplicate.
7. VAV controller startup/commissioning documentation shall include as a minimum but not limited to the following final as-built information:
    a. Min/max CFM settings.
    b. Controller volume tracking differential.
    c. Box size and area multiplier.
    d. Box K factor as determined by BAS and TAB.
    e. Controller network master address.
    f. Controller address on master.
    g. Auto-zero enabled/disabled.
    h. Auto-zero scheduled time.
    i. Communications priority (life safety, critical, normal).
    j. Tstat set point override range (+/- 5°F).
    k. Rom set point (base).
    l. Generic additional points added to controller.
    m. Controller box identifier shall match mechanical tag as called out on mechanical plans.
    n. When used for smoke control unit shall be UL category UUKL.

H. Operations and Maintenance Data:
1. Include interconnection wiring diagrams for completed field installed systems with identified and numbered system components and devices.
2. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
3. Include inspection period, cleaning methods, cleaning materials recommended and calibration tolerances.

1.07 **QUALITY ASSURANCE**

A. Perform work in accordance with NFPA 70 and Divisions 26, 27 and 28 specifications.

B. Manufacturer Qualifications: The BAS manufacturer shall be a recognized national manufacturer, installer and service company specializing in manufacturing the Products specified in this section with minimum ten (10) years of documented experience.

C. Installer Qualifications: The Building Automation System (BAS) shall be engineered, programmed, and installed by controls mechanics and electricians regularly employed by the manufacturer of the BAS control equipment. Company specializing in performing the type of work specified in this section with minimum ten (10) years of documented experience and approved by manufacturer. Bids from independent or franchised dealers or others whose principal business is not the manufacture, installation and service of Building Automation Systems will not be acceptable.

D. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. and testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.08 **WARRANTY**

A. See Section 230500 and General Conditions for additional requirements.

B. The system specified herein and shown on the drawings shall be guaranteed to be free from original defects in both material and workmanship for a period of twelve (12) months of normal use and service, excepting damages from other causes. This guarantee shall become effective starting the date the Contract work is accepted as complete by the Owner and in accordance with the General Provisions/Conditions.

C. Provide five (5) year manufacturer's warranty for field programmable micro-processor based units.

D. Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.09 **MAINTENANCE SERVICE**

A. Provide service and maintenance of energy management and control systems for one (1) year from Date of Substantial Completion/Acceptance of System by Owner.

B. Provide two (2) complete inspections during the first year, one (1) in each season, to inspect, calibrate and adjust controls as required and submit written reports.

1.10 **PROTECTION OF SOFTWARE RIGHTS**

A. Prior to delivery of software, the Owner and the party providing the software shall enter into a software license agreement with provisions for the following:
   1. Limiting use of software to equipment provided under these specifications.
   2. Limiting copying.
   3. Preserving confidentiality.
   4. Prohibiting transfer to a third party.
   5. Bid shall include cost for no more than 10 licenses.

1.11 **GENERAL**

A. Acceptable manufactures subject to compliance with the specifications
   1. Siemens Building Technologies
   2. Johnson Controls

B. The entire system and all control components shall be powered with emergency power.

C. All electrical work shall comply with Divisions 26, 27 and 28 Specifications.

PART 2 - PRODUCTS

2.01 **ELECTRIC LOW VOLTAGE WIRING**

A. All wiring shall comply with the requirement of Division 26. This section shall add additional requirements for the installation of the Building Automation System.

B. Furnish all labor and material to install the necessary wiring to accomplish the successful and complete operation of the new Building Automation System.

C. All electric wiring, wiring connections and all interlocking required for the installation of the temperature control system, as herein specified, shall be provided by the Contractor, unless specifically shown on the Electrical drawings or called for in the Electrical specifications.

D. Furnish all labor and material to install necessary relays, general purpose enclosures and appurtenances to control designated devices relative to the DDC.

E. All wiring throughout shall be concealed where possible.

F. All conduit used shall be EMT, 3/4" minimum size or larger. Conduit sizes shall be large enough to permit the individual conductors to be readily installed or withdrawn without damage to the conductors or their insulation. Splicing of wires will be permitted only in junction boxes or pull boxes. Conduit shall be rigid up to 8'-0″ AFF in mechanical rooms.

G. Conduit shall never to be relied upon for a fault current and safety ground return conductor.

H. All UL category UUKL portions of the system shall be in conduit.

I. All UL category UUKL portions of the system shall be powered from emergency power.

J. 2-Hour Fire Rated Mineral Insulated (MI) Conductors
   1. General
      a. This section includes 2 hour fire rated type MI mineral-insulated metal-sheathed cable with multiple, twisted copper conductors within a seamless copper sheath, cable connectors and connections.
      b. The following control circuits shall be 2 hour fire rated type MI mineral-insulated metal-sheathed cable where not installed within 2 hour fire rated rooms, closets, enclosures and/or shafts:
         1) Fire alarm conductors traveling between fire zones
         2) Control wiring to all stairwell pressurization systems and associated equipment.
         3) Engine start circuit from each automatic transfer switch to the generator.
   2. References
      a. NFPA 72 – National Fire Alarm and Signaling Code
      b. International Building Code (IBC) Section 909 - 2009
      c. ANSI/NFPA 70 - National Electrical Code
      d. FM 3D0Q9.AM 8/1997
      e. UL Category FHIT – Classified Electrical Circuit Integrity System with a 2 hour fire rating, 12/2012.
   3. Qualifications
      a. Manufacturer shall be a company specializing in manufacturing products specified in this Section with minimum ten years documented experience.
      b. Cable shall not off gas or propagate smoke.
   4. Regulatory Requirements
      a. Cable shall conform to requirements of ANSI/NFPA 70.
      b. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.
   5. Project Conditions
      a. Verify that field measurements and conditions are as shown on Drawings.
      b. Cable routing shown on Drawings is approximate. Route cable as required to meet project conditions.
      c. Where cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.
   6. Coordination
      a. Coordinate work specified in this section with work provided under other electrical work and the work of other trades.
      b. Determine required separation between cable and other work.
      c. Determine cable routing to avoid interference with other work.
   7. Manufacturer
      a. Pentair Thermal Management/Pyrotenax System 1850 2-hour fire rated.
   8. Mineral-Insulated Metal-Sheathed Cable
      a. Description: ANSI/NFPA 70, Type MI
      b. Conductor: Copper
      c. Insulation Voltage Rating: 300 volts.
      d. Insulation Material: Magnesium oxide refractory mineral.
      e. Metal-sheath Material: Seamless soft-drawn copper.
      f. Fire Rating: Cable assembly, including factory splices and supports shall have a 2 hour fire rating as listed and classified by Underwriters Laboratories, Inc.
      g. Overjacket:
         1) If installed interior to the building: none required
         2) If installed direct buried, PVC or manufactured extruded jacket.
      h. Cable sheath shall be marked with conductor size, voltage and UL fire resistant classification number.
      i. Each components of the cable assembly shall contain less than 300 ppm of lead, and shall meet the requirements of LEED for Healthcare MR Credit 4.2.

9. Wiring Connectors And Terminations
    a. Cable Termination:
        1) Pentair Thermal Management/Pyrotenax Model PyroPack – Multi-conductor (Installation PTM document #545E) and fire alarm twisted pair cables (PTM document #578E).
    b. Cable Splice:
        1) All cable spices of MI cable required due to length of conductor shall be factory installed and have 2 hour fire rating equivalent to the conductor itself. Field spices shall not be allowed unless installed within 2 hour fire rated rooms. Field spices within 2 hour fire rated rooms shall be Tyco Thermal Controls/Pyrotenax Model Installation Sheet 550.
10. Examination
    a. Verify that cable end factory temporary seals have remained intact, that the insulation has not been exposed to air, and that no moisture has entered cable insulation.
    b. Verify that work of other trades likely to damage cable has been completed.
11. Storage
    a. Cables shall be shipped from the manufacturer with ends temporarily sealed against moisture ingress.
    b. When cables are cut in the field, the end shall be sealed using standard sealing compound and PVC tape.
    c. Cable shall be stored in a clean dry location.
12. Handling
    a. Cable shall be uncoiled by rolling or rotating supply reel. Do not pull from coil periphery or center.
    b. Take precautions necessary to prevent damage to cable from contact with sharp objects, including pulling over foreign material or sheaves.
13. Wiring Methods
    a. Fire Rated Locations: Use only fire rated cable.
    b. Use wiring methods indicated on Drawings and as specified herein.

K. The ground system shall not be used as a current carrying conductor except for faults and noise suppression. The grounding system shall be used to control noise and transients which might affect the operation of the automation system. As such, the ground requirements shall be in excess of a grounding system used solely for physical protection minimum (Code requirement).

L. In all cases, the bond to ground shall be as short as possible. A ground point shall be derated by one (1) point (in order of preference) for each 50’-0″ of conductor run between it and the automation equipment to be grounded. Therefore, a water pipe bond located 10’-0″ away will be preferable to a structural steel bond located 150’-0″ away.

M. Set screw connectors shall be galvanized or plated steel. White metal cast type will not be permitted.

N. Flexible conduit shall be used at field devices, i.e., pressure switches, flow switches, temperature devices, etc. Convolutions shall be steel, interlocked continuously. Aluminum will not be permitted. "Liquidtight" shall be used in wet locations. Flexible connector shall be a minimum of 18" long.

O. Only core drilling is permitted to pierce the floors in the electrical closets and elsewhere. The use of water for drilling shall be controlled by a suitable vacuum system, using proper dams to prevent damage to floors below. The BAS Contractor shall be responsible for providing a suitable sleeve in all core drilled holes as specified herein.

P. All wiring shall be run in EMT as noted below:
1. Sensor to Panel (Block Wall): In Wall Conduit (EMT)
2. Sensor to Panel (Stud Wall): In New Conduit (EMT)
3. Sensor to Panel (Mechanical Room): In New Conduit (EMT)
4. Panel to Front End Workstation: In New Conduit (EMT)

5. Front End: In New Conduit (EMT)

Q. Wiring
1. Type THHN solid #18 AWG for control wiring in dry location up to 194°F.
2. Type THWN in wet location up to 167°F (solid #18 AWG).
3. Twisted shielded pair (18 gauge), with PVC cover, Belden #8760 or approved equal.
4. Conduit is not considered as a shield.
5. All wiring associated with the control signals to the smoke damper control/sequence must be in approved conduit.
6. All signal wiring to all field devices shall be run with no splices, separately from any wiring having voltage greater than 30 volts.

R. The Contractor shall install all shielded cable and ground systems in accordance with Division 23. The installation of ground loops shall not affect any sensing or control circuits.

S. All devices and equipment shall be mounted in minimum NEMA 1 enclosures.

T. In addition to the requirements specified above, all communication wiring cables shall include a minimum of (1) individually 100% shielded pair ([2] conductors) as unused spare conductors. Where the number of conductors and specific cable specified above for each type of communication wiring will not meet this requirement for spare conductors, Contractor shall provide approved equivalent product of Belden or other manufacturer with the necessary number of conductors and which meets the requirements specified above.

U. Low Voltage Control Wiring (30 VAC or Less)
1. Low voltage control wiring shall be minimum 16 gauge, or heavier if required, twisted pair, 100% shielded with PVC cover Belden #9316 or approved equivalent product of other manufacturers run in conduit with no splices, separate from any wiring above 30 volts.

V. Coordination of Interfacing/Interlocking
1. The Contractor shall be responsible for coordinating all required interface/interlocking software, software logic, sequencing and wiring necessary to provide a fully automated and fully functional operable system to meet or exceed the intent of the Design Engineer's Sequence of Operation. Coordination may include but not limited to the following at no additional cost to the Owner. Variable frequency drive (VFD) interlocking and wiring logic including software, relays factory/field installed wiring and/or VFD drive modifications. This would include coordination of miscellaneous points as specified under the point list in this specification. Systems to include all points, analog, digital, sensors wiring, software, wiring, communications gateways, etc., to connect and communicate to any Fire, Plumbing, HVAC, Lighting, BAS, Security, World Wide Web (Internet) systems installed under this project.

2.02 **BUILDING AUTOMATION SYSTEM ARCHITECTURE**

A. General
1. The Building Automation System shall consist of a number of Nodes and associated equipment connected by industry standard network practices. All communication between Nodes shall be by digital means only. The BAS shall provide control, alarm detection, scheduling, reporting and information management for the entire facility, and Wide Area Network (WAN) if applicable, from a single ODBC-compliant database.
2. The system shall be designed with a top-level minimum 100 Mb Ethernet network, using the BACnet/IP protocol. 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:
   a. BACnet MS/TP for 3rd party equipment,
      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.

b. BACnet IP over Ethernet (virtual routing)
   1) Application specific controllers for smaller single zone, supplemental or special system can reside on the BACnet/IP network or subnetwork.
c. Modbus.
d. Floor level controllers, terminal units, package AC units, auxiliary equipment, VFDs, or meter shall reside on one of the subnetworks above.
e. Controllers and software shall be BTL listed at the time of bid.
f. The system shall meet peer-to-peer communication services such that the values in any one BC or AAC level controller can be read or changed from all other controllers with 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
g. 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

3. The Building Automation System network shall at minimum comprise of the following:
   a. Operator Workstations – fixed and portable.
   b. Network processing, data storage and communication equipment including file server and web server hardware and software.
   c. Routers, bridges, switches, hubs, modems and the like communications equipment.
   d. Active processing Nodes including field panels.
   e. Intelligent and addressable elements and end devices.
   f. Third-party equipment interfaces.
   g. Other components required for a complete and working Building Automation System.
4. The Building Automation System shall be accessible via Enterprise Intranet and high speed Internet browser with security protection for user access.
5. The PC Workstations, File servers and principal network equipment shall be standard products of recognized major manufacturers available through normal PC vendor channels. These devices shall exceed all of the BAS manufacturer's minimum performance specifications, including operating system software, server software, database management software, storage memory, processing memory, and processing speed and power. "Clones" are not acceptable.
6. Provide all of the PC and server operating system software, communications software, server software, database management software, and all BAS manufacturer's user interface, system configuration, setup, and programming software tools. Provide licenses for all software residing in the Building Automation System and transfer these licenses to the Owner prior to completion.

B. Network
1. The Building Automation System shall incorporate a primary Tier 1 and Tier 2 networks. At the Contractor's option, the Building Automation System may also incorporate integrated tertiary Tier 3 networks.
   a. The Tier 1 portion of the Network shall comprise the Operator Workstations, Network File Servers, Network Application Nodes (NAN), Network Application Controllers (NAC), Web Servers and IP based Integration Controllers. This shall be the main backbone of the system which shall be an Ethernet LAN/WAN, using BACnet/IP as the communications protocol; minimum speed shall be 100Mb.
   b. The Tier 2 portion of the Network shall comprise the various Unitary Application Controllers (UAC). These shall communicate via BACnet MS/TP field buses managed by the NAN/NAC's. Minimum speed shall be 76.8kbps. The Level 2 field bus consists of an RS485, token passing bus.
2. The Building Automation System Network shall utilize an open architecture capable of:
   a. Utilizing standard Ethernet communications of 10/100 Mb/sec with a minimum speed of 100 Mb/sec. This shall be the Tier 1 level of the Network.
   b. Connecting and communicating via BACnet/IP.

3. The Building Automation System network shall support both copper and optical fiber communication media. As a minimum provide CAT 6E cabling within the building for Tier 1 communication. For any connections between buildings, fiber optic cabling shall be utilized.

C. Third-Party Interfaces
1. Building Automation System Contractor shall integrate real-time data from systems supplied by other trades as required.
2. The Building Automation System shall include necessary Building Automation System hardware equipment and software to allow data communications between the Building Automation System and systems supplied by other trades.
3. The trade contractor supplying other systems will provide their necessary hardware and software and will cooperate fully with the Building Automation System Contractor in a timely manner and at their own cost to ensure reliable communications and the complete data integration as required in this document.
4. The Building Automation System Contractor shall provide all necessary coordination with vendors, contractors, owners, engineers, and other representatives at no additional cost to the Owner. Provide a completed fully functional, operational, integrated and seamless communicating infrastructure system.

D. Power Fail / Auto Restart
1. Provide for the automatic, orderly and predefined shutdown of parts or all of the Building Automation System following total loss of power to parts or all of the Building Automation System.
2. Provide for the automatic, orderly and predefined startup of parts or all of the Building Automation System following total loss of power to those parts or all of the Building Automation System. Archive and annunciate time and details of restoration.
3. Provide for the orderly and predefined scheduling of controlled return to normal, automatically time scheduled, operation of controlled equipment as a result of the auto restart processes.
4. Maintain the Building Automation System real-time clock operation during periods of power outage for a minimum of 72 hours.

E. Downloading and Uploading
1. Provide all BAS manufacturer software tools necessary to generate Building Automation System software-based sequences, database items and associated operational definition information and user-required revisions to same on designated Operator Workstations and the means to download same to the associated Application Nodes.
2. Provide the capability to upload Building Automation System operating software information, database items, sequences and alarms to the designated Operator Workstations with automatic archiving of same on the Operator Workstations. The functions of this Part shall be governed by the codes, approvals and regulations applying to each individual Building Automation System application.
3. The entire control system shall be approved and listed by UL 916 - Energy Management.
4. All DDC panels shall be powered through uninterruptible power sources (UPS) with sufficient capacity to ride through a (2) minute power interruption between transfers from normal to emergency power. UPS’s and wiring shall be provided by the BAS Contractor.
5. Uploading or downloading functions performed at any location shall not affect controllers, communications, inputs, outputs at any location or address within the Building Automation Control Architecture nor shall any controller level functions be disrupted in any manner.

F. Network Automation Nodes (NAN)
1. (NAN) Network Automation Nodes shall be stand-alone, multi-tasking, multi-user, real-time digital controllers complete with all hardware, software, and communications interfaces, power supplies. The Building Automation System shall provide high speed browser access and connectivity over the customer Enterprise-Wide Network and I.T. infrastructure, and/or over the Internet. NANs shall communicate with each other and share their data over the Enterprise-Wide Network using BACnet IP to accomplish coordinated global control and

energy management strategies as required. NAN's shall communicate with the BAS Server over the Enterprise-Wide Network using BACnet/IP or IT standard Web Services. The NAN's shall be designed, packaged, installed, programmed and commissioned in consideration of their specific service and prevailing operating conditions. The Network Automation Nodes shall be designed, manufactured, and supported by the same BAS manufacturer that manufactures and supplies the Network Automation Controllers, the Unitary Automation Controllers, the BAS server software, and the setup, configuration and programming software tools. The NAN's shall be proven standard products of their original manufacturer and not a custom product for this Project.

2. A failure at a Network Automation Node shall not cause failures or non-normal operation at any other system Network Automation Node other than the possible loss of active real-time information from the failed Network Automation Node.
3. Ancillary Network Automation Node equipment, including interfaces and power supplies, shall not be operated at more than 80% of their rated service capacity.
4. NANs shall provide both standalone and networked direct digital control of mechanical and electrical building system controllers as required by the Specifications. The primary NAN shall support a minimum of [5,000] field points together with all associated features, sequences, schedules, applications required for a fully functional distributed processing operation.
5. NANs shall monitor and report communication status to the Building Automation System server. The BAS shall provide and record a system advisory upon communication failure and restoration.
6. All NANs shall include all necessary internal server software to provide a complete graphical user interface via a Browser connection, either via the Enterprise-Wide Network or directly via a local port on the NAN. This user interface will provide the ability to view, monitor, and/or override any data point or object in the NAN's database, to view equipment and area schedules and override stop/start times, to view, acknowledge, or discard system alarms, and/or to view point trending data.
7. All NAN shall be provided with face mounted LED type annunciation to continually display its operational mode, power and communications.
8. The NAN's shall be tested and listed by the BACnet Testing Laboratory (BTL) as BACnet Building Controllers (B-BC).
9. Each NAN shall be provided with the necessary un-interruptible power facilities to ensure its continued normal operation during periods of line power outages of, at minimum, 1-minute duration. Normal functionality shall include all normal software processing, communication with powered field devices and network communications with other powered Controls Systems NAN, Data Servers and OWS. Each NAN shall report its communication status to the BAS server Application. The BAS server Application shall provide and record a system advisory upon communication failure and restoration. Each NAN shall retain program, control algorithms, and setpoint information in non-volatile memory in the event of a power failure, and shall return to normal operation upon restoration of power.
10. Each NAN shall have sufficient memory to support its operating system, database, and program requirements, including the following:
    a. Data sharing.
    b. Device and network management.
    c. Alarm and event management.
    d. Scheduling.
    e. Point data trending.
    f. Energy Management.
11. Each NAN shall support firmware upgrades without the need to replace hardware. Each NAN shall have a minimum of 15 percent spare capacity of memory secondary system controllers, point capacity and programming functions as indicated in the NAN's built-in self-diagnostics tools.

12. Each NAN shall continuously perform self-diagnostics, communication diagnosis, and provide both local and remote annunciation of any detected component failures, low battery condition; and upon failure shall assume the predetermined failure mode.
13. Each NAN shall monitor the status of all overrides and inform the operator that automatic control has been inhibited, and allow the operator to manually override automatic or centrally executed commands. The NAN shall include an internal audit record of any and all operator command overrides.
14. The BAS shall provide all necessary BAS manufacturer's software tools to generate and modify and archive the Controls Systems Application software-based sequences, database elements, associated operational definition information and user-required revisions to same at any designated Workstation together with the means to download same to the associated NAN's NAC's and UAC's.
15. In the event of loss of normal power, there shall be orderly shutdown of the controllers to prevent the loss of database or software programming. When power is restored flash memory, battery backup or super capacitor will be automatically loaded into non-volatile flash memory and shall be incorporated for all programming data.

G. Network Application Controller (NAC)
1. The Network Application Controller (NAC) shall provide all of the same abilities described for the NAN, including communications over Ethernet and the Enterprise-Wide Network and the built-in web server and ability to serve a graphical user interface to a standard PC Browser application. The main differences will be in a lower controller count for the Tier 2 network and the NAC shall have direct hardwired input/output capabilities. The NAC's shall be tested and certified by the BACnet Testing Laboratory (BTL) as Building Controllers (B-BC).
    a. Each NAC shall have a minimum of 24 hardwired input/output points.
    b. Each NAC shall have an integral Input/Output communication bus for point expansion. The input/output expansion modules shall be for point IO only and all control processing algorithms shall reside in the NAC.
    c. The NAC's shall be utilized for large systems control and the contractor shall provide an NAC for each of the following systems:
        1) Air Handling Unit
        2) Chiller Plant (based on the size of the plant, more than a single controller may be required for redundant operation).
        3) Boiler plant (based on the size of the plant, more than a single controller may be required for redundant operation).
        4) Heat Exchanger Systems for Processed Chilled Water, Reheat/Radiation/Radiant Hot Water, etc.

H. Unitary Application Controller (UAC)
1. Unitary Application Controller (UAC) shall be a fully user-programmable for both standalone and networked direct digital control of HVAC systems. The UAC's shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Advanced Application Controllers (B-AAC) or as BACnet Application Specific Controllers (B-ASC), depending on the control application.
2. The B-AAC listed UAC versions shall be used for critical application where a real time clock is required and the ability to directly sample and record data status or value, manage real time equipment or system schedules, and execute and manage alarm sequences. The B-ASC listed UAC versions shall be used for simple terminal and unitary HVAC equipment. A dedicated UAC shall be configured and provided for each terminal HVAC system (VAV Box, Unit Heater, Fan Coil Unit, CV Box)
3. Each UAC shall be able to retain program, control algorithms, setpoints, logic and command information through the use of non-volatile memory (flash, EEPROM). For B-AAC listed UAC versions, other information such as trend data, historical data schedules will be maintained for at least 72 hours in the failure and shall return to normal operation upon restoration of power.

4. Each UAC shall report its communication status to the Building Automation System. The Building Automation System shall provide a system advisory upon communication failure and restoration.
5. Each UAC shall support firmware upgrades without the need to replace hardware and shall have a minimum of 15 percent spare capacity of I/O functions. The type of spares shall be in the same proportion as the implemented functions on the controller, but in no case there shall be less than one point of each implemented I/O type.
6. Provide a means to prevent unauthorized personnel form accessing setpoint adjustments and equipment control functions.
7. The UAC shall provide the ability to download and upload configuration data, both locally at the Node and via the FMS communications network.
8. Each UAC shall be a dedicated controller without the need to use expansion modules to accomplish the entire primary control sequences. Sharing controller, sensor, input/output data over any high level or low level network to accomplish the specified control sequences is unacceptable. Global sharing of general data such as OA-T, OA-RH OA-CO^2 levels between controllers over the BMS network is acceptable as long as speed of transmitting the data does not impact the UAC controller ability to perform in any mode of operation.
9. If it is determined that the UAC controller cannot perform specified sequence of operation because of dependency for shared information that Contractor shall provide a higher level controller at no additional cost. This change shall be identified by separate submittal to Design Engineers.

2.03 PORTABLE OPERATOR'S TERMINAL

A. Acceptable Manufacturers subject to compliance with the specification:
   1. Dell
   2. Acer
   3. Toshiba
   4. HP

B. Provide one (1) portable operator terminal with a minimum LCD display of 80 characters by 25 lines and a full featured keyboard. The portable operator’s terminal shall be hand-held and plug directly into individual distribution control panels as described below. Provide a user friendly, English language prompted interface for quick access to system information, not codes requiring look-up charts.

C. General
   1. Furnish portable operator’s terminal for system. Portable operator’s terminal shall allow for local accessing of program information.
   2. Laptop terminal portable operator’s terminal shall have the following features:
      a. Intel Pentium Core 2 Duo 2.53 GHz w/3 MB cache
      b. Full active matrix color display with minimum 1024 x 680 resolution, 15".
      c. AC adapter
      d. Battery pack / battery charger
      e. 250 GB fixed disk drive
      f. 3.0 GB of RAM
      g. 8X DVD +/- RW drive
      h. Internal modem
      i. Audio built in
      j. Latest version of Microsoft Windows
      k. Internal Ethernet Adapter Card with UTP/BNC connector
      l. Equipped with both 1 Type III or 2 Type II PCMCIA Slots
         1) Type III 4
         2) Type II PCMC1A Slots
      m. Integrated pointing device

D. Functionality of the portable operator's terminal connected at any high or lower level controller:
   1. Access all controllers on the network.

2. Backup and/or restore controller data bases for all system panels, not just the DDC controller.
3. Display all point, selected point and alarm point summaries.
4. Display trending, historical and totalization information.
5. Add, modify, and/or delete any existing or new system point.
6. Command, change setpoint, enable/disable any system point vertical or physical.
7. Program and load custom control sequences as well as standard energy management programs.

E. Connection of a POT on controller to a distributed control processor shall not interrupt nor interfere with normal network operation in any way, prevent alarms from being transmitted or preclude centrally-initiated commands and system modification.

F. Portable operator terminal access to controller shall be password-controlled and menu-driven.

2.04 OPERATOR INTERFACE WORKSTATION (TYPICAL FOR [1])

A. The Contractor shall provide all the necessary hardware and software to interface with the existing Central Facility Management System. A gateway between each system provided under this section and the CFMS system shall be provided by the BAS Contractor. The gateway shall allow the following:
1. Monitoring and commanding of all points of each system. Limited point sharing between the OCC and native systems is not acceptable except when using bundled point technology to control terminal equipment (e.g. VAV box, RHC). The bundle point information may be passed to the CFMS via a virtual terminal direct connection. This connection shall be over the Ethernet data highway and shown on the CFMS PC as an inset window on the screen. Each bundled point shall be unbundled to continuously pass the actual value of the controlled variable (e.g. room temperature, face velocity) and the controlled variable setpoint. If a virtual terminal connection is not possible, the BAS Contractor shall pass the bundled point through the gateway shall unbundle the information for display. Bundled points shall not be allowed for primary HVAC equipment (e.g. AHUs, EAHUs, heat exchangers).
2. Trend reports shall be compiled by the CFMS; however, point information and format shall be provided to the CFMS from the native system as directed.
3. The CAD drawings for the native system shall be capable of being located into the CFMS for the purpose of making dynamic graphics.

B. Transmission of the native system to the CFMS shall be via Ethernet. All necessary labor and material to tie into the existing campus Ethernet data highway shall be provided under this section.

C. Each native system shall have a CFMS gateway unless otherwise provided for in the specification.

D. The cost to develop the gateway shall be provided under this section. The labor to check out and verify each developed gateway shall be included under this section. The gateway operation must be verified in the presence of and signed-off by the Owner’s CFMS representative.

E. The cost to create graphics, check out, program and any other work necessary to provide a fully functioning CFMS interface with the new Building Automation System control systems shall be included under this section.

F. Provided with a UPS system with one hour backup.

2.05 OPERATOR WORKSTATION

A. Basic Interface Description
1. Command Entry/Menu Selection Process: Operator Workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software. The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. Users shall be

able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

2. Graphical and Text-Based Displays: At the option of the user, Operator Workstations shall provide consistent graphical or text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all workstations.

B. Computer System Access Operation Control Stations (OCS) Description: This system access workstation is also referred to as the Building Automation System “Front end”.

C. Provided Workstation with:
1. Workstation shall be general purpose, commercially available, personal computer with sufficient memory and processor capacity to perform all functions described in this specification.
2. Sufficient hard drive memory storage shall be provided to accommodate all fully configured point data bases, all application databases, all graphics data bases, all user-defined reports, and all historical data archival as described in this specification.
3. Each shall include the following:
   a. Intel Core 2 Duo 3.0 GHz, 6 MB cache with 4 GB DDR2 SDRAM memory.
   b. 19" color LCD monitor 1280x1024
   c. SVGA video output (256 MB RAM).
   d. 750 GB fixed disk.
   e. HI-RES bus mouse.
   f. (1) Printer for alarms, minimum 240 characters/seconds.
   g. (1) Printer for reports, minimum Laser printer similar to HP 4000.
   h. 16X DVD +/- RW drive
   i. Telephone modem (56K)
   j. Ethernet network interface card
   k. Server type platform shall have at a minimum a RAID level 1 array with multiple fixed hot swappable disks for redundancy. Provide minimum two fixed disks.
4. The operator functions provided by the system access Operator Terminal shall include, but not be limited to, the following:
   a. Start and Stop Points
   b. Modify Setpoints
   c. Modify PID Loop Setpoints
   d. Override PID Control
   e. Change Time/Date
   f. Add/Modify Start/Stop Weekly Scheduling
   g. Add/Modify Setpoint Weekly Scheduling
   h. Enter Temporary Override Schedules
   i. Define Holiday Schedules
   j. View Analog Limits
   k. Enter/Modify Analog Warning Limits
   l. Enter/Modify Analog Alarm Limits
   m. Enter/Modify Analog Differentials
   n. View Point History Files
5. UPS system with one hour backup.
6. The workstation shall provide access to all real or calculated points in the controller to which it is connected, or any other controller in the network. This capability shall not be restricted to a subset of predefined "global points", but shall provide totally open exchange of data between the operator terminal and any DDC panel in the network.
7. Provide English language prompting to eliminate the need for the user to remember command formats or point names. Prompting shall be provided consistent with a user's password clearance and the types of points being displayed, to eliminate the possibility of operator error. Operator shall not require the use of special templates for navigation.

8. On-line, interactive user's "Help" manuals and tutorials shall be provided. Based upon operator request, the "help" function shall provide general system operating instructions, and specific descriptions of commands available in the currently displayed menus.
9. Identification for all real or calculated points shall be consistent for all network devices.
10. In addition to instantaneous summaries, the Operator's Terminal shall allow a user to view a Point History file for system points. Point History files shall provide a record of value of analog points over the last 24 hours, at 30 minute intervals, or a record of the last (10) status changes for binary type points.

D. Provide Server with:
1. PC Hardware – The Workstation/Server computer shall be configured as follows:
   a. Memory – 4 GB
   b. CPU– Intel® Xeon®, 2.8 GHz, 8M Cache,
   c. Hard Drive – 500 GB each for RAID level 1 array
   d. Hard drive backup system –DVD +/- RW
   e. Ports – (1) Serial, (2) USB ports
   f. Keyboard – 101 Keyboard and 2 Button Mouse
   g. CRT configuration
      1) 17” LCD Flat Panel Monitor 1280 x 1024 resolution minimum
      2) 16 bit or higher color resolution
   h. LAN communications – Ethernet communications board; 100Mbps Min
2. Operating System Software
   a. Windows XP Professional, IIS Version 5.1, .Net Version 2.0, SQL server 2005 Express software with SP2 or <Alternately> Microsoft Windows Server 2003 OS with SP2, IIS Version 6.0, .Net version 2.0 and SQL Server 2005 with SP@
   b. Provide required software and hardware required for integration of computing hardware on enterprise IT network.

E. Database Configuration
1. Provide database configuration for each hardware and software point.
2. Specific point parameters, such as alarm limits, alarm message, point name and point description shall be as approved by the Owner.

F. Trends
1. Provide real time and historical trends for hardware and software points as directed by the Owner.
2. Archiving or transfer of trend and historical data information shall not interfere, reduce communication throughout stow network speed or reduce local controller operation by any measure, due to trend or historical data capture rates and storage routines.

G. Internet / Intranet Browser
1. A multi-user color graphics and textual interface shall be provided that allows customers to access their Building Automation System data via the Internet or Intranet. This interface shall use HTML-based pages to send and receive data from a Building Automation System to a web browser.
2. Browser shall:
   a. Automatically reflect any changes made to the Building Automation System without additional programming.
   b. When installed behind a corporate firewall, shall work in conjunction with other security measures that have been implemented.
   c. Allow the user to navigate and command the Building Automation System using the same format as the Operator Workstation.
   d. Be an industry-standard browser
   e. Provide user password access control.
   f. Provide the means by which the user can create, edit and view groups of FMS data points.
   g. Provide navigation tools for moving between the views. In addition, it shall provide tools for gaining access to help and for logging out of the system.

H. Remote Notification
   1. Provide as part of the project automatic remote notification for personnel of user defined Building Automation System events in the form of alphanumeric paging, email and text messaging. Communication protocols for support of this shall include but not be limited to the following:
      a. SMTP (Simple Mail Transfer Protocol)
      b. SMS (Short Message Services)

I. Reports
   1. Provide real time reports for hardware and software points as directed by the Owner.
   2. The BAS Contractor shall program and test all alarming and alarm report routing to final devices such as printer, computers, pagers, monitors, cell phones, www, etc. Alarming requirements and routing shall be coordinated with the Owner by first compiling and all points listing for Owner's review prior to any programming.

2.06 **DYNAMIC COLOR GRAPHIC DISPLAYS: COLOR GRAPHICS SHALL BE PROVIDED AS SPECIFIED IN THE EXECUTION PORTION OF THIS SPECIFICATION TO OPTIMIZE SYSTEM PERFORMANCE ANALYSIS AND SPEED ALARM RECOGNITION**

A. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration drill down scheme, menu selection, and text-based commands.

B. Dynamic Data Displays: 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.

C. Windowing: The windowing environment of the workstation shall allow the user to simultaneously view several graphics at the same 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.

D. Graphics Definition Package: Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.
   1. The Contractor shall 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. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:
      a. Define symbols
      b. Position and size symbols
      c. Define background screens
      d. Define connecting lines and curves
      e. Locate, orient and size descriptive text
      f. Define and display colors for all elements
      g. Establish correlation between symbols or text and associated system points or other displays.
   3. 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. To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC panels, including application specific controllers used for DDC unitary or VAV terminal unit control.

E. Graphic
   1. Provide graphic screens each system for this project.
   2. Provide the following as a minimum:
      a. Each air handling unit and exhaust air handling unit.
      b. Chilled water system.

c. Condenser water system.
d. Process chilled water system.
e. Hot water system.
f. Each heat exchanger.
g. Each chiller.
h. Each hot water system.
i. Each glycol system.
j. Each exhaust fan.
k. Process condenser water system.
l. Each piece of equipment.
m. Each controlled system.

3. Provide graphic representation of building's form and site plans locating all equipment and panels.
4. Each hardware point shall be represented on graphic screen.
5. Selected software points shall be represented on respective process system graph as determined by the Owner. Examples of these software points are:
   a. Control loop setpoint value.
   b. Control loop auto/manual selection.
   c. Lead/lag selection for pumps and other motors.
   d. Campus chilled water global points.
   e. Calculated points such as run time.
   f. Other vertical software points as required.

F. The Contractor shall coordinate all required graphical modes, features, binding, logic, etc., for a complete fully functional graphical operating system. All graphical schemes shall be submitted and approved by Architect/Engineer and Owner prior to programming.

2.07 **UNINTERRUPTIBLE POWER SUPPLY (UPS)**

A. Provide UPS backup for the following components of the BAS system:
   1. All field controllers (NAN, NAC and UAC types).
   2. All components of the BAS communication infrastructure.
   3. Workstations and Servers

B. The BAS contractor shall be responsible for sizing the UPS system/system's that will be required. All additional cabinets required for protection, cooling fans and filters shall be part of this projects scope. Load calculations shall be submitted for review.

C. The UPS shall provide the following:
   1. Sized for 125% of the connected load for the following durations:
      a. Workstations and Servers: 1 hour.
      b. Field Controllers and all network infrastructure components: 2 minutes.
   2. Designed to operate on Emergency Generator power.
   3. Utilizes double conversion online topology designed to protect equipment by supplying reliable, network-grade power providing extremely tight voltage and frequency regulation.
   4. Internal bypass and input power factor correction.
   5. The primary sections of the UPS are: input disconnect and filter stage, input PFC power stage, energy storage stage (DC bus capacitor bank), output power stage (inverter), bypass and a battery charger. The control of power module and fault detection logic is microcontroller-based providing the following:
      a. Input filter stages.
      b. Provide seamless transitions from battery to line and vice versa, as well as the low and high frequency power stages ripple.
      c. The output power (inverter) stage operates directly from the DC bus and produces a 120VAC output.
   6. Field-replaceable hot swappable battery modules allowing for replacement without the need to interrupt the connected load
   7. Either an optional dry contact to provide a battery low alarm or an integrated network card. If a network card is required, the BAS contractor shall own as part of this project the scope

required to install and monitor the UPS network and report the UPS alarms on the BAS network.

D. The BAS contractor shall include the UPS infrastructure on their Network Riser Diagram and submit for review. The UPS/UPS's shall be shown on the project coordination drawings.

E. Acceptable Manufacturer:
1. APC
2. Sola
3. Eaton

PART 3 - EXECUTION

3.01 PROJECT MANAGEMENT

A. The BAS Contractor shall designate a project manager who will be responsible for the following:
1. Construct and maintain project schedule.
2. On-site coordination with all applicable trades and subcontractors.
3. Authorized to accept and execute orders or instructions from Owner/Architect.
4. Attend project meetings as necessary to avoid conflicts and delays.
5. Make necessary field decisions relating to this scope of work.
6. Coordination/Single point of contact.

3.02 NUMBERING/NAMING CONVENTIONS

A. The Contractor shall collaborate with the Owner directly to determine the Owner's preference for naming conventions, etc. before entering the data in the system.

B. As a minimum the BAS Contractor shall submit to the Architect/Engineer and Owner the layout of the network, identifying all DDC controllers. Each controller will be identified by address and system being served. All physical and software generated objects, points and attributes shall be listed along with a description.

3.03 START-UP AND COMMISSIONING

A. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting and final field tests shall be completed by the installer. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.

B. Provide any recommendation for system modification in writing to Owner. Do not make any system modification, including operating parameters and control settings, without prior approval of Owner.

C. The BAS Contractor will provide industry standard checkout and startup checklists for each DDC controller installed for the project. If not standard is available, the BAS Contractor shall develop a spreadsheet in MS Excel format and submit to the Engineer for approval prior to system checkout.

3.04 INSTRUCTION AND ADJUSTMENT

A. The Contractor shall provide factory-trained instructor to give full instructions to the owner designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The Contractor shall provide all students with a student binder containing product specific training modules for the system installed. All training shall be held during normal working hours of 8:00 AM to 5:00 PM weekdays.

B. Upon completion of the project, the Contractor shall:
1. Fine-tune and "de-bug" all software control loops, routines, programs and sequences of control associated with the control system supplied.
2. Completely adjust and make ready for use, all transmitters, relays, damper operators, valves, etc., provided under this Section. This Contractor shall furnish copies of complete, detailed, calibrating checkout and commissionary documentation for reach controller.

Documentation shall list each procedure and shall be signed by the control specialist performing the service.

3. Furnish a complete set of system operation manual, including standard manufacturers' operating manuals, complete as-built installation diagrams, and complete software hardcopy documentation, as well as a magnetic media back-up.
4. Provide an on-site training program for the Owner's staff in the operation and use of the control system. Training shall include two (2) segments, as follows:
   a. Segment 1 shall include 16 hours of classroom and hands-on training. This segment shall instruct personnel in the system configuration, component characteristics, control strategy on each controlled system and all requirements for daily operation and use of the system. This segment shall give the Owner's representative a working proficiency in the day-to-day operational requirements (i.e., system monitoring, alarm acknowledgment, HVAC system troubleshooting techniques, setpoint and time schedule adjustments, manual override, etc.).
   b. Segment 2 shall include 6 hours of on-site training. This segment will be geared for the Owner's designated prime operator. An emphasis on overall software management and manipulation shall be made, to allow the prime operator(s) to make control strategy and overall facility and system management changes as required. Attendees shall have attended Segment 1.
   c. All training shall take place at the site and at times mutually agreed to between that BAS Contractor and the Owner. The BAS Contractor shall provide to the Owner's designated representative, at least three (3) weeks before each segment, a course syllabus outline and schedule. The BAS Contractor shall provide all training material, reference material and training aids, as required, all as part of his Contract cost.

3.05 MINERAL INSULATED (MI) METAL-SHEATHED CABLE

A. Install products in accordance with manufacturer's instructions.

B. Bending:
   1. Not less than five (5) times the cable diameter for cable not more than ¾ inch.

C. Pulling:

D. For all cables up to and including ½" diameter, use ten inch (250mm) or larger sheaves.

E. Splicing:
   1. All fire rated splices shall be made in the factory.
   2. In the event a field splice is necessary, it must be made within a 2 hour fire rated room, approved by the engineer and:
      a. Made in the field by manufacturer's field technician, or
      b. Made in the field by personnel trained by the cable manufacturer using manufacturer's components.

F. Terminations:
   1. Field made terminations shall be made with cable manufacturer's termination kits only. Stripping tools, crimping and compression tools available from the manufacturer shall be used for proper cable termination.
   2. Terminations must be completed immediately once started to avoid moisture ingress from surrounding air. Prior to completing each termination, test insulation resistance and follow manufacturer's drying procedures until insulation resistance reaches an acceptable level.

G. Exposed or Surface installations:
   1. Cable may be secured directly to fire rated building structure using an approved method such as one, or any combination, of the following:
      a. Straps: ½ inch (13mm) wide x 3 1/2 inch (38mm) long by 0.030 (0.75mm) thick stainless steel or copper straps. Each strap shall contain two ¼ inch (6mm) holes for securing with 3/16 inch (5mm) by minimum 1 3/4 inch (44mm) long steel anchors.
      b. Steel struts and cable tray: Use only the steel strut framing system and support recommended by Pyrotenax. Aluminum or other materials are not acceptable.
   2. Supports shall not exceed three (3) feet on center horizontally, or six (6) feet vertically.

3. Cables shall be installed perpendicular and parallel to building lines.

H. Embedded Installations:
   1. Protect against damage during pulling, and during concrete pouring or backfill and tamping.
   2. Where cables emerge from grade, provide PVC conduit, metal plate or angle iron. This protection shall minimally extend from 18 inches (460mm) below grade to 8 ft. (2.5m) above grade.
   3. Provide overall extruded polymer jacket over exposed copper cable sheath when embedded in corrosive environments.

I. Wall or floor penetrations:
   1. Provide sleeve to protect cable and penetration opening during pulling.
   2. Provide approved fire stopping of all penetrations.

J. Neatly train and lace cable inside boxes, equipment, and panelboards.

K. Field Quality Control
   1. Inspect cable for physical damage and proper connection.
   2. Measure tightness of bolted connections and compare torque measurements with manufacturer's recommended values.
   3. Verify continuity of each conductor.
   4. Prior to energizing cables, measure insulation resistance of each cable. Tabulate and submit for approval.

L. Provide certification from cable manufacturer that installation is in accordance with their requirements.

END OF SECTION

SECTION 26 13 10
MEDIUM VOLTAGE DISTRIBUTION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. All of the Contract Documents, as listed on the Table of Contents and including General and Supplementary Conditions and Division 01, General Requirements, shall be included in, and made part of, this Section.

1.02 DESCRIPTION OF WORK

A. The electrical Subcontractor shall furnish and install all medium voltage distribution equipment as specified herein and as shown on the Contract Documents.

B. The medium voltage distribution system and associated equipment shall have the electrical characteristics and arrangements as shown on the Contract Documents.

C. The following general systems and equipment shall be provided for the new building, as a minimum, but not necessarily limited to the following:
   1. Normal distribution system.
   2. Hoisting, rigging, setting of all medium voltage equipment.
   3. Testing, cleaning and adjusting.
   4. Power company related work and backcharges.
   5. Fees, permits, royalties, guarantees.
   6. Shop drawings.
   7. Power system studies and trip settings.
   8. Phasing of construction and power interruptions.
   9. Medium voltage metal clad switchgear.
   10. Fuses.

1.03 RELATED WORK

A. For work to be included as part of this Section, to be furnished and installed by the Electrical Subcontractor, refer to the Related Work section of Specification Section 26 0510.

B. Carefully examine all of the Contract Documents, criteria sheets and all other Sections of the specifications for requirements which affect work under this Section, whether or not such work is specifically mentioned in this Section.

1.04 REFERENCES

A. The equipment specified herein shall be designed, assembled, and tested and installed in accordance with latest applicable standards of NEMA, IEEE, ANSI and UL as follows:
   1. Medium Voltage Bus
      a. ANSI C37.23
   2. Medium Voltage Metal Clad Switchgear
      a. NEMA SG-4
      b. NEMA SG-5
      c. IEEE
      d. ANSI 37.20.2

1.05 QUALITY ASSURANCE

A. The manufacturers listed within this specification have been preselected for use on this project. No submittal will be accepted from a manufacturer other than specified.

B. To ensure system compatibility, all medium voltage distribution equipment and low voltage distribution equipment shall be the products of one manufacturer.

1.06 WARRANTY

A. Warranty shall be in effect for a period of (1) year from initial operation of the equipment but not more than (18) months.

1.07 **QUALIFICATIONS**

A. The manufacturer of the medium voltage distribution equipment shall be the manufacturer of the major components within the equipment.

B. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.08 **SEISMIC REQUIREMENTS**

A. The equipment and major components specified herein shall be suitable for, and certified by actual seismic testing to meet, all applicable seismic requirements of the 2006 International Building Code (IBC) Site Classification C.
   1. The following values shall be used:
      a. Site Coefficient, F_a = 1.3
      b. Site Coefficient, F_v = 1.5
      c. Spectral Response Acceleration, S_s 0.30 g
      d. Spectral Response Acceleration, S_1 0.06 g
   2. The test response spectrum shall be based upon a 5% damping factor, and a peak (S_{DS}) of at least 0.26 g's (3 -12 Hz) applied at the base of the equipment in the horizontal direction.
   3. The forces in the vertical direction shall be at least 66% of those in the horizontal direction.
   4. The tests shall cover a frequency range from 1 to 100Hz.

B. Guidelines for the installation consistent with these requirements shall be provided by the equipment manufacturer and based upon testing of representative equipment. Equipment certification acceptance criteria shall be based upon the ability for the equipment to be returned to service immediately after a seismic event within the above requirements without the need for repairs.

C. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.
   1. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed Civil Engineer in the project state. Mounting recommendations shall be provided by the manufacturer based upon the above criteria to verify the seismic design of the equipment.
   2. The equipment manufacturer shall certify that the equipment can withstand, that is, function; following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
   3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.09 **DELIVERY, STORAGE AND HANDLING**

A. Manufacturer's directions shall be followed completely in the delivery, storage, protection and installation. Promptly notify the Architect in writing of any conflict between any requirements of the Contract Documents and the manufacturer's directions. Obtain the Architect's written instructions before proceeding with the work. Should Electrical Subcontractor perform any work that does not comply with the manufacturer's directions or written instructions from the Architect, he shall bear all costs arising in correcting any deficiencies that should arise.

B. Equipment and materials shall be delivered to the site and stored in original sealed containers, suitably sheltered from the elements, but readily accessible for inspection by the Architect until installed. All items subject to moisture damage such as controls shall be stored in dry, heated spaces. Equipment such as switchgear with heater elements installed shall have the heater elements energized after the equipment is received by the Electrical Subcontractor.

C. The Electrical Subcontractor shall be responsible to fully inspect all shipments for damage and report damage to the manufacturer and the Architect.

D. Equipment shall be tightly covered and protected against dirt, water, and chemical or mechanical injury and theft. At the completion of the work, equipment and materials shall be cleaned and polished thoroughly and turned over to the Owner in a condition satisfactory to the Architect. Damage or defects that develop before acceptance of the work shall be made good at the Electrical Subcontractor's expense.

E. The Electrical Subcontractor shall make necessary field measurements to ascertain space requirements, for equipment and connections to be provided under his respective Trade and shall furnish and install such sizes and shapes of equipment to allow for the final installation to conform to the drawings and specifications.

F. The medium voltage distribution equipment shall be split into shipping groups for handling as directed by the Electrical Subcontractor or as the manufacturer’s limitations dictate. Shipping groups shall be designed to be shipped by truck, rail or ship. Shipping groups shall be bolted to skids. Accessories shall be packaged and shipped separately. Each switchgear shipping group shall be equipped with lifting eyes for handling solely by crane.

G. The medium voltage distribution equipment being stored prior to installation shall be stored so as to maintain the equipment in a clean and dry condition. If stored outdoors, indoor gear shall be covered and heated, and outdoor gear shall be heated.

1.10 ACCEPTABLE MANUFACTURERS

A. Eaton

B. Siemens

C. Square D

D. ABB

E. S&C Electric Company

1.11 SELECTIVE COORDINATION

National Electrical Code

A. All overcurrent protection devices shall be selectively coordinated with all upstream overcurrent protection devices, to meet the requirements of the 2017 National Electrical Code, based on the highest calculated value (from utility and/or generator) of available short circuit current, at the overcurrent protection device terminals, as follows:

2017 NEC

Distribution System:	Coordination Time, in Seconds	NEC Code Article
1. Emergency Distribution System	0.01	700.32
2. Legally Required Distribution System:	0.01	701.27
3. All Other Power Distribution Systems	0.10	240.12

B. The switchgear manufacturer shall be responsible to select appropriate overcurrent protective device, fuse and/or circuit breaker frame, sensor and trip sizes for all devices upstream of other devices for a completely coordinated system.

1.12 WITHSTAND AND INTERRUPTING RATINGS OF ELECTRICAL COMPONENTS

A. Calculated available 3 phase and single phase to ground short circuit currents indicated on the drawings are provided for information only, to assist in the selection of withstand and interrupting ratings and coordination of devices and equipment.

B. Prior to submission of shop drawings, the manufacturer shall perform short circuit calculations to determine actual available 3 phase and single line to ground short circuit current at each component in the system based on actual equipment, feeder lengths, impedances, etc. of the equipment proposed for this project. Failure to perform the study prior to submission of shop

drawings shall not relieve the manufacturer from providing devices that meet the requirements of the final study report.

C. Each component shall be UL listed and labeled and shall be fully rated to withstand and interrupt calculated available 3 phase and single phase to ground short circuit current levels. Series ratings will not be acceptable.

1.13 **SUBMITTALS**

A. Prepare and submit shop drawings in accordance with the requirements hereinbefore specified Submittal Procedures, in the manner described therein.

B. All shop drawings shall have clearly marked the appropriate specification number or drawing designation, for identification of the submittal.

C. Disposition of shop drawings shall not relieve the Electrical Subcontractor from the responsibility for deviations from drawing or specifications, unless he has submitted in writing a letter itemizing or calling attention to such deviations at time of submission and secured written approval from the Engineer, nor shall such disposition of shop drawings relieve the Electrical Subcontractor from responsibility for errors in shop drawings or schedules.

D. Power System Studies: Power system study report shall be submitted in advance, or in conjunction with distribution equipment shop drawings. If formal completion of the studies may cause delay in equipment manufacture, approval from the Architect may be requested to select device ratings and characteristics based on a preliminary submittal of the study using available data and reasonable assumptions. Any changes required as a result of the final power system study shall be made at no additional cost to the Owner.

E. Shop drawings shall include, but shall not be limited to, the following:
1. Medium voltage metal clad switchgear.
2. Equipment identification
3. Floor plans of all electric rooms housing electrical distribution equipment

Notes:
Shop drawings shall include floor plans of all electric rooms housing electrical distribution equipment, including, but not limited to; the incoming service electric room, substation rooms, floor electric rooms, etc. Floor plans shall be 3/8” = 1’-0” scale drawings indicating actual equipment dimensions, required Code clearances, etc. Acceptance of these shop drawings shall be obtained prior to installation of equipment and feeder conduits: Equipment shop drawings will not be reviewed without the room/equipment layouts. The Architect/Engineer reserve the right to rearrange equipment in electrical equipment rooms or spaces once final equipment dimensional information is known and prior to installation of the equipment. Install equipment in the final location selected by the Architect/Engineer at no additional cost to the Owner.

F. The switchgear manufacturer shall submit the following information with each submittal:
1. Master drawing index.
2. Front view elevation.
3. Floor plan.
4. Top view.
5. Single line.
6. Control schematics and wiring diagrams.
7. Nameplate schedule.
8. Component list/bill of material.
9. Conduit entry/exit locations.
10. Assembly ratings including:
    a. Short circuit rating.
    b. Information regarding series short circuit ratings.
    c. Voltage.
    d. Continuous current.
    e. Basic Impulse level for equipment over 600 volts.
    f. KVA.

11. Major component ratings including:
    a. Voltage.
    b. Continuous current.
    c. Interrupting ratings.
12. Cable terminal sizes.
13. Connection details between close-coupled assemblies.
14. Composite floor plan of close-coupled assemblies.
15. Impedance for transformers.
16. Manufacturer's catalog data sheets.
17. Test reports.
18. The following additional information shall be submitted to the Engineer:
    a. Busway connection.
    b. Key interlock scheme drawing and sequence of operations.
19. The following product information shall be submitted:
    a. Descriptive bulletins.
    b. Product sheets.

1.14 CLOSEOUT SUBMITTALS AND O & M MANUALS

A. The following information shall be submitted for record purposes, in a binder, prior to final payment:
   1. Final as-built drawings and information for items listed above.
   2. Operation and maintenance manuals with the following information:
      a. Instruction books and/or instruction leaflets
      b. Recommended renewal parts
   3. Wiring diagrams.
   4. Certified production test reports.
   5. Installation information.
   6. Seismic certification and equipment anchorage details.

PART 2 – PRODUCTS

2.01 MEDIUM VOLTAGE METAL CLAD SWITCHGEAR

A. Ratings
   1. The switchgear assembly ratings shall be as follows:
      a. Nominal System Voltage: 13.2 kV three phase, three wire
      b. Maximum Design Voltage 15 kV three phase, three wire
      c. System Grounding: high resistance
      d. Lightning Impulse Withstand Voltage: 95 kV Peak
      e. Continuous Current: 1200 Amperes
      f. Short Time Withstand Current: 50 kA rms Sym.
      g. Rated Voltage Range Factor: 1.0 K
      h. Frequency: 60 Hz
   2. Each circuit breaker shall have the following ratings:
      a. Nominal System Voltage: 13.2 kV three phase, three wire
      b. Maximum Voltage: 15 kV three phase, three wire
      c. Lightning Impulse Withstand Voltage: 95 kV Peak
      d. Continuous Current: 1200 Amperes
      e. Short Circuit Current at Rated Maximum Voltage: 50 kA rms Sym
      f. Voltage Range Factor: 1.0 K
      g. Maximum Symmetrical Interrupting and 2-Second Rating: 50 kA rms Sym
      h. Closing and Latching Capability: 139 kA Peak
      i. Rated Interrupting Time: Three cycles
      j. Frequency: 60 Hz

B. Construction
   1. The metal clad switchgear assembly shall consist of individual vertical sections housing various combinations of circuit breakers and auxiliaries, bolted to form a rigid metal-clad switchgear assembly. Metal side sheets shall provide grounded barriers between adjacent

structures and solid removable metal barriers shall isolate the major primary sections of each circuit. Two rear covers shall be furnished for each vertical section for circuit isolation and ease of handling.

2. The stationary primary contacts shall be silver-plated and recessed within insulating tubes. A steel shutter shall automatically cover the stationary primary disconnecting contacts when the breaker is in the disconnected position or out of the cell.
3. 4” infrared viewing windows with sliding cover to view each breaker termination shall be provided. Cover shall automatically close, by gravity, when not in use. Multiple windows shall be provided, if necessary, to ensure all cable terminations are visible.
4. Arc Resistant Switchgear
   a. When specified, the switchgear assembly shall be of arc resistant construction that provides Type-2B accessibility around the perimeter (front, sides, and rear) of the line-up in accordance with IEEE C37.20.7.
   b. Each individual vertical section of the switchgear shall include integral and top mounted pressure release flaps to facilitate a controlled upward release of arc created overpressures, smoke, and gasses. Individual vertical sections shall be of a unitized design to allow removal of a damaged vertical section after a fault incident, without requiring the removal of the adjacent vertical sections.
   c. An enclosed arc-chamber with arc duct exit shall be furnished for installation above the switchgear. Arc-duct exit location shall be as shown on the drawing. Arc exhaust shall be vented from the arc-chamber to the exit location via arc-duct as shown on the drawings. Field assembly of the arc-chamber and arc-duct shall be by installing contractor.

C. Bus
1. The main bus shall be copper and have fluidized bed epoxy flame retardant and track-resistant insulation. The bus supports between units shall be flame-retardant, track-resistant, glass polyester for 5 and 15 kV class.
2. The switchgear shall be constructed so that all buses, bus supports and connections shall withstand stresses that would be produced by currents equal to the momentary ratings of the circuit breakers.
3. Insulated copper main bus shall have provisions for future extension. All bus joints shall be plated, bolted and insulated with easily installed boots.
4. The bus shall be braced to withstand fault currents equal to the close and latch rating of the breakers.
5. The temperature rise of the bus and connections shall be in accordance with ANSI standards and documented by design tests.
6. Bus bars shall be arranged “A”, “B”, “C”, from front-to-back and/or top-to-bottom and/or left-to-right as viewed from the front of the equipment.
7. A ¼” x 2” copper ground bus shall extend the entire length of the switchgear.

D. Medium Voltage Circuit Breakers
1. The medium voltage circuit breakers shall be horizontal draw-out type, capable of being withdrawn on rails, and shall also include provisions to roll on the floor. Include a portable lifting device for removal of breaker from the rails. Breakers shall be interchangeable between top and bottom cells.
2. The breakers shall be operated by a motor-charged stored energy spring mechanism, charged normally by a universal electric motor and in an emergency by a manual handle. The primary disconnecting contacts shall be silver-plated copper.
3. Each circuit breaker shall contain three vacuum interrupters separately mounted in a self-contained, removable self-aligning pole unit. The vacuum interrupter pole unit shall be mounted on glass polyester supports for 5 and 15 kV class. A contact wear gap indicator for each vacuum interrupter, which requires no tools to indicate available contact life, shall be easily visible when the breaker is removed from its compartment. The current transfer from the vacuum interrupter moving stem to the breaker main conductor shall be a non-sliding design. The breaker front panel shall be removable when the breaker is withdrawn for ease of inspection and maintenance.

4. The secondary contacts shall be silver plated and shall automatically engage in the breaker operating position, which can be manually engaged in the breaker test position.
5. Interlocks shall be provided to prevent closing of a breaker between operating and test positions, to trip breakers upon insertion or removal from the stationary structure, and to discharge stored energy mechanisms upon insertion or removal from the stationary structure. The breaker shall be secured positively in the stationary structure between and including the operating and test positions.
6. Each main and tie and feeder breaker shall include one (1) auxiliary switch (MOC) to indicate breaker position for remote indication.
7. The circuit breakers shall be electrically operated by a control voltage of 120 volts AC close and AC capacitor trip. The AC control voltage shall be derived from a control power transformer mounted in the switchgear.
8. Each breaker shall be complete with control switch, and red and green indicating lights to indicated breaker contact position.
9. Main and tie circuit breakers shall include four (4) Spare, unused two (2) N/O and two (2) N/C contacts (MOC's) wired to terminal blocks.
10. Main and tie circuit breakers shall include four (4) Spare, unused two (2) N/O and two (2) N/C contacts (TOC's) wired to terminal blocks.

E. Protective Relays
1. The switchgear manufacturer shall furnish and install, in the metal-clad switchgear, the quantity, type and rating of protection relays as indicated on the drawings and described hereafter in this specification.
2. Overcurrent protection relays shall be multi-function microprocessor based with dual power supply (self-powered from CTs) and include the following ANSI device functions:
    a. Main Circuit Breaker
        1) 51/50, 51/50G, 87B and separate 86 and 86B lockout relays.
    b. Tie Circuit Breaker
        1) 51/50, 51/50G, 25 and separate 86 lockout relay.
    c. Feeder Circuit Breakers and provisions for future feeder circuit breakers
        1) Overcurrent Protection: 51/50, 51/50G, and separate 86 lockout relay.
        2) Transformer protection: 87T, 87GD, and 50/51G for neutral and 51/50 & 51N/50N for primary as well as secondary windings and separate 86 lockout relay.
        3) Motor protection: 27/47, 49, 50, 51, 46, 50G, 51G, 37, 38, 55, 66, 2/19, 74, 87 and separate 86 lockout relay.
    d. Generator protection relays
        1) 51/50, 51/50N, 67, 27, 59, 25, 47, 55, 40, 81 O/U, 67, 32, 24, 87, 49, 46, 50BF and include separate 86 lockout relay.
3. All voltage and current connections to relays shall be wired to test switches, via wiring harnesses, to allow removal of relay and field testing of relay.
4. Induction-Disk Type CO Overcurrent Relay.
    a. Provide an induction-disk type overcurrent relay mounted in a semi-flush flexitest universal case.
    b. Relay shall have low burden characteristics, high thermal capacity and negligible temperature error.
    c. All settings shall be readily visible and accessible from the front of the relay.
    d. Induction-disk shall be designed to compensate for spring wind-up throughout the travel of the moving contact to provide accurate pickup continuous "between tap" adjustment.
    e. Different style numbers of induction-disk relays shall be available with various families of IEEE inverse time current curves, including moderately inverse, very inverse and extremely inverse, ANSI Device 51.
    f. Induction-disk relays shall be equipped with ANSI Device 50 adjustable pick-up instantaneous coils.
    g. Induction-disk relay shall be furnished with targets to indicate relay operation.

F. Automatic Transfer Control System
   1. Provide an open transition automatic transfer control system within the switchgear to control the two (2) main breakers and one (1) tie breaker. System shall include sensing devices, logic control and auxiliary equipment. The logic of the transfer control system functions shall be provided via a microprocessor. The set points shall be field adjustable without the use of special tools.
   2. The transfer control system shall be provided with a local touchscreen display. The display shall show the status of the system as it is operating. When timers are functioning, the display shall show the timer counting down. All time delays shall be capable of being set from the front of the display using a password protected timer setting screen.
   3. The transfer control system shall include the following features:
      a. A local touchscreen local system display with the following:
         1) Main- Tie- Main one line diagram
         2) Main and tie breaker status (open, closed, tripped, out of cell)
         3) Readout marked “Source 1” and “Source 2” to indicate that respective source voltages are available
         4) Automatic/manual mode select pushbutton
         5) Two (2) manual breaker control pushbuttons. Pushbuttons may also be used to simulate loss of voltage on either source to test automatic transfer operation.
         6) Alarm information (loss of source, breaker trip)
      b. Line side voltage transformers with primary and secondary fuses to provide both sensing and control power.
      c. Two (2) relays for sensing voltage, reverse phase, and negative sequence conditions on each source.
      d. A PLC shall provide timing and logic to control opening and closing of circuit breaker.
      e. Lockout relays to lockout system in case of fault.
      f. Time delay to transfer on loss of Source 1, adjustable from 1 to 60 seconds.
      g. Time delay to transfer on loss of Source 2, adjustable from 1 to 60 seconds.
      h. Time delay re-transfer to Source 1, adjustable from 10 to 600 seconds.
      i. Time delay re-transfer to Source 2, adjustable from 10 to 600 seconds.
      j. Time delay neutral position (one main and tie open), adjustable from 0 to 10 seconds.
   4. Sequence of Operation – Automatic Mode
      a. Under normal conditions, both sources are energized, both main breakers are closed and the tie breaker is open.
      b. Loss of power to one source
         1) Upon phase loss or loss of phase-to-phase voltage on either main circuit breaker to between 80% and 100% of nominal, and after a time delay to override momentary dips and outages, the transfer control system shall open the affected main breaker and close the tie breaker.
         2) When normal voltage has been restored, and both sources are available:
            a) The transfer control system shall reset to manual mode, and restoration to normal operation (two main circuit breakers closed and tie circuit breaker open) shall be accomplished via manual intervention only. Refer to manual mode of operation below.
      c. Loss of power to the second source when carrying entire load
         1) If the second source should fail while carrying the entire load (one main breaker closed, the other main breaker open and tie breaker closed):
            a) No action shall be taken.
         2) When normal voltage has been restored to one source:
            a) The transfer control system shall immediately open the main of the de-energized source (if closed), open the tie breaker and close the main of the restored source (if open).
            b) After a neutral position time delay, the transfer control system shall close the tie breaker.
      d. Loss of power to both sources simultaneously
         1) If both sources should fail simultaneously:

a) No action shall be taken. Both mains breakers shall remain closed, tie breaker shall remain open

2) When normal voltage has been restored to one source:
   a) The transfer control system shall immediately open the main of the de-energized source (if closed), open the tie breaker (if closed) and close the main of the restored source (if open).
   b) After a neutral position time delay, the transfer control system shall close the tie breaker.
3) If both sources should be restored simultaneously:
   a) No action shall be taken. Both mains breakers shall remain closed, tie breaker shall remain open

5. Sequence of Operation – Manual Mode (Open Transition)
   a. While in manual mode, breakers shall be capable of being opened and closed using control switches or pushbuttons on the transfer control system display. Electrical interlocking shall be provided to prevent the closing of both mains and the tie simultaneously.
6. If the main or tie breakers trip due to a fault, the transfer control system shall be reset to manual mode and manual operation of that breaker shall be prevented until the respective overcurrent trip switch is reset.
7. Automatic transfer system accessories
   a. Provide a control power transformer for each source with control power transfer scheme.
   b. Provide electrically operated main and tie circuit breakers.
   c. Provide a programmable logic controller with 24 volts DC ride-through power supply.

G. Miscellaneous Devices
1. Key Interlocks
   a. Key interlocks shall be provided between the switches in each medium voltage selector switch, medium voltage selector switch and corresponding secondary main breaker and between the two (2) secondary main breakers in the secondary switchgear and the tie breaker.
2. Current Transformers
   a. Ring type current transformers shall be furnished as required. The thermal and mechanical ratings of the current transformers shall be coordinated with the circuit breakers. Their accuracy rating shall be equal to or higher than ANSI standard requirements. The standard location for the current transformers on the bus side and line side of the breaker units shall be front accessible to permit adding or changing current transformers without removing high-voltage insulation connections. Shorting terminal blocks shall be furnished on the secondary of all the current transformers.
   b. Three (3) ring type, multi-ratio current transformers shall be furnished in the metal clad auxiliary section for metering, as required.
   c. Three (3) ring type, single secondary current transformers shall be furnished for each main, tie and feeder breaker, and provisions for future feeder circuit breakers for overcurrent and short circuit relaying as required.
   d. Three (3) 1200/5, C200 bus differential C.T.'s shall be provided for the main, tie and each feeder breaker.
   e. One (1) zero sequence current transformer shall be provided for each feeder breaker.
   f. The thermal and mechanical ratings of the current transformers shall be coordinated with the circuit breakers. Their accuracy rating shall be equal to or higher than ANSI standard requirements. The standard location for the current transformers on the bus side and line side of the breaker units shall be front accessible to permit adding or changing current transformers without removing high-voltage insulation connections. Shorting terminal blocks shall be furnished on the secondary of all the current transformers.

3. Voltage Transformers
    a. Two (2) line-to-line voltage transformers, in an enclosed auxiliary compartment, of the quantity and ratings required for proper operation of the equipment shall be provided.
    b. Voltage transformers shall be mounted in draw-out drawers contained in an enclosed auxiliary compartment.
4. Control Power Transformers
    a. Fused control power transformers of the quantity and ratings required for proper operation of the equipment shall be provided.
    b. Control power transformers, up to 15 kV, 15 kVA, single phase shall be mounted in draw-out drawers. Control power transformers above 15 kV shall be fixed mounted with primary fuses in draw-out drawers.
    c. Primary and secondary protection shall be provided and a manual disconnect shall be provided ahead of the primary fuses.
    d. Rails shall be provided for each drawer to permit easy inspection, testing and fuse replacement. A means shall be provided to isolate primary bus stabs when drawers are withdrawn.
    e. A mechanical interlock shall be provided to require the secondary breaker to be open before the CPT drawer or CPT primary fuse drawer can be withdrawn.
    f. Control power transformers shall have adequate capacity to supply power to the transformer cooling fans.
    g. Control power transformers on double ended units shall include an automatic transfer scheme to maintain control power when one side of substation is de-energized.
5. Surge Arrestors
    a. Provide three 15 kV station class surge arrestors connected at the incoming terminations and securely grounded to the metal structure.
6. Grounding Apparatus
    a. Provide personnel protective grounding apparatus for incoming and outgoing medium voltage conductors at the point of cable termination within the cable compartment.
    b. Ground studs and covers shall be AB Chance #C-600-2102 with #C-406-0416 cover or Salisbury #21191 with #21236 cover.
7. Circuit Breaker Accessories
    a. Maintenance tool for manually charging the breaker closing spring and manually opening the shutter
    b. Test cabinet and jumper capable of testing and electrically operating all circuit breakers while outside the housing.
    c. Levering crank for moving the breaker between test and connected positions
    d. Portable breaker lifting yoke, floor mounted on rollers, used for attachment to breaker for lifting breaker on or off compartment rails
    e. "Dockable" transport dolly for moving breaker about outside its compartment
    f. Set of rail extensions and rail clamps
    g. Ramp for rolling breaker mounted in lower compartment directly onto the floor
    h. Electrical levering device
8. Space Heaters
    a. Each vertical section of the substation (primary, transformer and medium voltage secondary) shall be provided with thermostatically controlled space heaters. Tubular type heaters shall be provided, operated at half voltage for long life. 250 volt rated heaters shall be used at 120 volts.
    b. Power for the space heaters shall be obtained from a control power transformer within the switchgear. Supply voltage shall be 120 volts AC. Space heaters shall be wired to provide temporary heating during storage.

H. Wiring/Terminations
1. One two hole NEMA pad per phase shall be provided for attaching Electrical Subcontractor supplied compression, crimp type cable terminal suitable for copper cable lugs for the number and sizes of conductors as indicated on the drawings. Sufficient space

shall be supplied for Electrical Subcontractor supplied electrical stress relief termination devices.

2. The switchgear manufacturer shall provide suitable terminal blocks for secondary wire terminations and a minimum of 10% spare terminals shall be provided. One control circuit cutout device shall be provided in each circuit breaker housing. Switchgear secondary wire shall be #14 AWG, type SIS rated 600 volt, 90 degrees C, furnished with wire markers at each termination. Wires shall terminate on terminal blocks with marker strips numbered in agreement with detailed connection diagrams.
3. Small wiring, fuse blocks, and terminal blocks within the vertical section shall be furnished as required. Each control wire shall be labeled with wire markers and all wires leaving the switch shall be provided with terminal blocks having suitable numbering strips. Terminal blocks shall be provided for customer connections to other apparatus.

I. Utility Metering
1. Provide separate, barriered-off utility metering compartment, or full vertical switchgear section, sized as required by the Utility Co. in the medium voltage primary switchgear structure, complete with hinged sealable door. Bus work shall include provisions for mounting utility company current transformers and potential transformers as required by the utility company. Provide service entrance label and provide necessary applicable service entrance features per NEC and local code requirements.

J. Customer Metering
1. Provide customer metering devices as specified herein. Provide a separate customer metering compartment with front hinged door. Include associated instrument transformers.
2. Provide current transformers as required for each phase and neutral circuit with ratings sized for incoming service or associated feeder. Provide potential transformers as required for proper operation of the meter. Current transformers shall be wired to shorting type terminal blocks.
3. Provide potential transformers including primary and secondary fuses with disconnecting means or fused potential taps as the potential source for metering as required.
4. Microprocessor-based metering system.
   a. Provide a full function electronic meter on all medium voltage secondary main and feeder devices. The meter shall have the features and functions specified below. The meter shall be UL recognized, CSA certified and also meet ANSI Standard C37.90.
   b. The meter shall provide direct reading metered or calculated values of the items listed below and shall auto range between Units, Kilo-units, and Mega-units for all metered values. Accuracy indicated below to be of read or calculated values.
      1) AC Current (Amperes) in A, B, and C phase, 3 Phase Average and Neutral (N). Accuracy +/- 0.2% (provide phase and neutral current transformer).
      2) AC Voltage (Volts) for A-B, B-C, and C-A, Phase Average, A-N, B-N, and C-N and Average Phase to N. Accuracy +/-0.2%.
      3) Real Power (WATTS), Reactive Power (VARS), Apparent Power (VA), for each phase and system (system shall apply only for 3 wire applications). Accuracy +/- 0.4%. Forward/Reverse indication shall be provided.
      4) Real Energy (WHR), Reactive Energy (VARHR), Apparent Energy (VAHR) for each phase and system (system shall apply only for 3 wire applications). Accuracy +/- 0.4%. Forward/Reverse indication shall be provided.
      5) Frequency (HERTZ) Accuracy +/- 0.04%.
      6) Demand values for System Current (AMPERES), System Real Power (WATTS), System Reactive Power (VARS), and System Apparent Power (VA).
      7) Power Factor both Displacement only 60 cycle fundamental WATTS to VA and Apparent total WATTS to total VARS including harmonics for A, B, and C phase and system. Accuracy +/- 0.4%.
      8) Current Percent Total Harmonic Distortion (THD) in A, B, and C phase, and N.
      9) Voltage percent THD in A-B, B-C, and C-A phase, A-N, B-N, and C-N.
5. Communications

a. Meters shall be capable of transmitting all metering data to a central system for monitoring and storage as follows:
   1) Building Automation System via an optically isolated RS485 port
   2) To a Web Enabled Ethernet Local Area Network via Category 6 cable
   3) To the energy management system specified in Specification Section
b. Provide a separate compartment with a front facing hinged door as a central point of connection for all internally located communicating devices. The compartment shall have a lockable, hinged door with a functional through-the-door RJ45 network access port. Power for the components within the compartment shall be supplied by a pre-wired, bus-connected control transformer in the compartment that shall have a fused disconnecting means.

K. Enclosures
1. The equipment in these specifications shall have NEMA 1 general purpose, indoor enclosures, with devices arranged as shown on contract drawings, unless noted otherwise.

L. Finish
1. Prior to assembly, all internal and external steel and aluminum enclosure part shall be thoroughly cleaned and phosphatized. A polyester powder coating shall be applied electrostatically, and then fused on by baking in an oven. The coating shall have a thickness of not less than 1.5 mils for interior equipment and 3.0 mils for exterior equipment. The finish shall have the following properties:

a.	Impact resistance (ASTM D-2794):	60 Direct/60 Indirect
b.	Pencil Hardness (ASTM D-3363):	H
c.	Flexibility (ASTM D-522):	Pass 1/8 inch mandrel
d.	5% Salt Spray(ASTM B117-85 [20]):	600 hours
e.	Color:	ANSI 49 or 61 Gray

2.02 EQUIPMENT IDENTIFICATION

A. Manufacturers Standard Nameplate
1. A master nameplate, giving equipment designation, voltage rating, ampere rating, short circuit rating, impedance, manufacturer's name, general order number, item number, etc. shall be provided for all electrical distribution equipment specified herein.
2. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's drawings and/or wiring diagrams.

B. Unique Equipment Identification Nameplate
1. Furnish and install uniquely engraved nameplates, mounted on the face of each assembly, shall be furnished for all electrical distribution equipment specified herein.
2. Nameplates shall be laminated plastic and secured with screws.
3. Nameplates shall be a minimum of 2 inch high x 2 1/2 inch wide, laminated with black letters on white background.
4. Characters shall be 3/16 inch high, minimum.
5. Engraved nameplate shall include equipment designation, ampere rating of upstream device (if applicable), voltage, phase, number of wires (i.e. 3 wire or 4 wire), and upstream panel feeder. Examples follow:

STATION SS-1
13.8 KV, 3 PHASE, 3 WIRE PRIMARY
FED FROM UTILITY STATION U-1

SUBSTATION SS1
2,500 KVA, 13.8 KV, 3 PHASE, 3 WIRE PRIMARY
4,000 AMPERE, 480/277 VOLT, 3 PHASE, 4 WIRE SECONDARY
FED FROM STATION S-1

TRANSFORMER T-1a
1,500 KVA, 13,800 VOLT, 3 PHASE, 3 WIRE PRIMARY
480/277 VOLT, 3 PHASE, 4 WIRE SECONDARY

FED FROM STATION S-1
SERVES SUBSTATION SS1

6. Equipment that serves other electrical distribution equipment, such as substation serving distribution panels, motor control centers serving motors and equipment, distribution panels serving lighting and appliance panels and other equipment, engraved nameplates shall also be provided for all feeder breakers, mounted on the face of the assembly, with panel/equipment designations as indicated on the drawings. Examples follow:

SUBSTATION SS1
CHILLER 1

PART 3 – EXECUTION

3.01 COOPERATION AND WORK PROGRESS

A. The Electrical work shall be carried on under the usual construction conditions, in conjunction with all other work at the site. The Electrical Subcontractor shall cooperate with the Architect, General Contractor, all other Subcontractors and equipment suppliers working at the site. The Electrical Subcontractor shall coordinate the work and proceed in a manner so as not to delay the progress of the project.

B. The Electrical Subcontractor shall coordinate his work with the progress of the building and other Trades so that he will complete his work as soon as conditions permit and such that interruptions of the building functions will be at a minimum. Any overtime hours worked or additional costs incurred due to lack of or improper coordination with other Trades or the Owner by the Electrical Subcontractor, shall be assumed by him without any additional cost to the Owner.

C. The Electrical Subcontractor shall furnish information on all equipment that is furnished under this Section but installed under another Section to the installing Subcontractor as specified herein.

D. The Electrical Subcontractor shall provide all materials, equipment and workmanship to provide for adequate protection of all electrical equipment during the course of construction of the project. This shall also include protection from moisture and all foreign matter. The Electrical Subcontractor shall also be responsible for damage which he causes to the work of other Trades, and he shall remedy such injury at his own expense.

E. Waste materials shall be removed promptly from the premises. All material and equipment stored on the premises shall be kept in a neat and orderly fashion. Material or equipment shall not be stored where exposed to the weather. The Electrical Subcontractor shall be responsible for the security, safekeeping and damages, including acts of vandalism, of all material and equipment stored at the job site.

F. The Electrical Subcontractor shall be responsible for unloading all electrical equipment and materials delivered to the site. This shall also include all large and heavy items or equipment which require hoisting. Consult with the General Contractor for hoisting/crane requirements. During construction of the building, the Electrical Subcontractor shall provide additional protection against moisture, dust accumulation and physical damage of the main service and distribution equipment. This shall include furnishing and installing temporary heaters within these units, as approved, to evaporate excessive moisture and ventilate it from the room, as may be required.

G. It shall be the responsibility of the Electrical Subcontractor to coordinate the delivery of the electrical equipment to the project prior to the time installation of equipment will be required; but he shall also make sure such equipment is not delivered too far in advance of such required installation, to ensure that possible damage and deterioration of such equipment will not occur. Such equipment stored for an excessively long period of time (as determined in the opinion of the Architect) on the project site prior to installation may be subject to rejection by the Architect.

H. The Electrical Subcontractor shall erect and maintain, at all times, necessary safeguards for the protection of life and property of the Owner, Workmen, Staff and the Public.

I. Prior to installation, the Electrical Subcontractor has the responsibility to coordinate the exact mounting arrangement and location of electrical equipment to allow proper space requirements as indicated in the NEC. Particular attention shall be given in the field to group installations. If it is questionable that sufficient space, conflict with the work of other Subcontractors, architectural or structural obstructions will result in an arrangement which will prevent proper access, operation or maintenance of the indicated equipment, the Electrical Subcontractor shall immediately notify the Contractor and not proceed with this part of the Contract work until definite instructions have been given to him by the Architect.

J. The Electrical Subcontractor shall not allow any equipment or piping foreign to the electrical installation to be installed or pass through any room in which electrical systems or equipment are located, such as electric rooms, electric closets, telephone or data closets. The Electrical Subcontractor shall notify the Contractor of such violations and request immediate removal.

3.02 **INSTALLATION**

A. General
1. Unless specifically noted or indicated otherwise, all equipment and material specified in Part 2 of this specification or indicated on the drawings shall be installed under this Contract whether or not specifically itemized herein. This Section covers particular installation methods and requirements peculiar to certain items and classes or material and equipment.
2. The Electrical Subcontractor shall obtain detailed information from manufacturers of equipment provided under Part 2 of this specification as to proper methods of installation.
3. The Electrical Subcontractor shall obtain final roughing dimensions and other information as needed for complete installation of items furnished under other Sections or furnished by the Owner.
4. The Electrical Subcontractor shall keep fully informed of size, shape and position of openings required for material and equipment provided under this and other Sections. Ensure that openings required for work of this Section are coordinated with work of other Sections. Provide cutting and patching as necessary.
5. The Electrical Subcontractor shall coordinate the electric service installation with the Owner.
6. All miscellaneous hardware and support accessories, including support rods, nuts, bolts, screws and other such items, shall be of a galvanized or cadmium plated finish or of another approved rust-inhibiting coating.
7. Throughout this Section where reference is made to steel channel supports, it shall be understood to mean that the minimum size shall be 1 5/8" mild strip steel with minimum wall thickness of 0.105", similar to Unistrut P1000 or equal products manufactured by Kindorf or Husky Products Co.

B. Concrete Housekeeping Pads
1. Concrete pads shall be installed for all freestanding electrical distribution equipment.
2. The General Contractor shall provide the concrete work. Electrical Subcontractor shall supervise and coordinate concrete work to ensure that proper size and location, and grounding cable, rods, conduit, etc., are located as detailed and as required. The Electrical Subcontractor shall also ensure that the concrete is level to within manufacturers published tolerances.
3. All concrete housekeeping pads shall extend beyond the equipment supported as follows:
   a. Equipment with front and rear access, or equipment mounted freestanding with access in front and rear:
      1) 1” in front of the equipment
      2) 6" on each side of the equipment
      3) 6” in back of the equipment
   b. Equipment with front access only, mounted against a wall:
      1) 1” in front of the equipment
      2) 6" on each side of the equipment
      3) 0” in back of the equipment

4. Mounting height of the highest overcurrent/disconnect device in the above equipment shall not exceed 6'-6" above finished floor. If overcurrent devices exceed 6’-6” above finished floor as a result of the housekeeping pad, the pad shall extend in front of the gear a minimum of 4’-0”, and include ramps on each end.

C. Electrical Distribution Equipment
1. The Electrical Subcontractor shall install the electrical distribution equipment specified herein per the manufacturer’s recommendations and the Contract Drawings.
2. The installation of all equipment, including working space requirements, shall conform to all NEC and local codes.
3. All necessary hardware to secure the assembly in place shall be provided by the Electrical Subcontractor.
4. The Electrical Subcontractor shall ensure that no piping, ductwork or other equipment foreign to the electrical trade passes through the area extending from the floor to the structural ceiling with the width and depth equal to that of the electrical distribution equipment, plus 6" on either side of the equipment.
5. Floor mounted assemblies shall be installed on concrete housekeeping pads and shall be provided with adequate lifting means. Floor mounted assemblies shall be capable of being moved into installation position and bolted directly to the floor without the use of floor sills. The Electrical Subcontractor shall ensure the floor is level to 1/8 inch per 3-foot distance in any direction.
6. All electrical equipment shall be installed such that the handle of the highest circuit breaker does not exceed 6’-6” above finished floor.
7. The location of all electrical distribution equipment installed in mechanical or plumbing equipment rooms shall be coordinated with the respective Subcontractor.
8. The equipment shall be installed and checked in accordance with the manufacturer’s recommendations prior to first energization. This shall include but not limited to:
   a. Checking to ensure that the pad location is level to within .125 inches.
   b. Checking to ensure that all bus bars are torqued to the manufacturer's recommendations.
   c. Assemble all shipping sections, remove all shipping braces and connect all shipping split mechanical and electrical connections.
   d. Secure assemblies to foundation or floor channels.
   e. Measure and record megger readings phase-to-phase, phase-to-ground, and neutral-to-ground (four-wire systems only).
   f. Inspect and install all circuit breakers, components, etc. in their proper compartments.

3.03 MATERIALS AND WORKMANSHIP

A. All materials and equipment shall be new and unused and shall meet requirements of the latest Standards of NEMA, UL, IPCEA, ANSI and IEEE. Equipment shall have components required or recommended by OSHA, applicable NFPA documents and shall be UL listed and labeled.

B. Despite references in the specifications or on the drawings to materials or pieces of equipment by name, make or catalog number, such references shall be interpreted as establishing standards of quality for materials and performance.

C. Finish of materials, components and equipment shall not be less than Industry good practice. When material or equipment is visible or subject to corrosive or atmospheric conditions, the finish shall be as approved by the Architect.

D. Provide proper access to material or equipment that requires inspection, replacement, repair or service. If proper access cannot be provided, confer with the Architect as to the best method of approach to minimize effects of reduced access.

E. All work shall be installed in a neat and workmanlike manner and shall be done in accordance with all Local and State Codes.

F. The Owner will not be responsible for material, equipment or the installation of same before testing and acceptance.

3.04 **FACTORY TESTING**

A. Standard factory tests shall be performed on the electrical distribution equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

B. Medium voltage metal clad switchgear
   1. The following standard factory tests shall be performed on the circuit breaker element provided under this section. All tests shall be in accordance with the latest version of ANSI standards.
      a. Alignment test with master cell to verify all interfaces and interchangeability.
      b. Circuit breakers operated over the range of minimum to maximum control voltage.
      c. Factory setting of contact gap.
      d. One-minute dielectric test per ANSI standards.
      e. Final inspections and quality checks.
   2. The following production test shall be performed on each breaker housing.
      a. Alignment test with master breaker to verify interfaces.
      b. One-minute dielectric test per ANSI standards on primary and secondary circuits.
      c. Operation of wiring, relays, and other devices verified by an operational sequence test.
      d. Final inspection and quality check.

C. Medium Voltage Metal Enclosed Switchgear
   1. The following standard factory tests shall be performed on the circuit breaker element provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
      a. Alignment test with master cell to verify all interfaces.
      b. Circuit breaker operated over the range of minimum to maximum control voltage.
      c. Factory setting of contact gap.
      d. One-minute dielectric test per ANSI standards.
      e. Final inspections and quality checks.
   2. The following production test shall be performed on the circuit breaker housing:
      a. Alignment test with master cell to verify all interfaces.
      b. One minute dielectric test per ANSI standards on primary and secondary circuits.
      c. Operation of wiring, relays, and other devices verified by an operational sequence test.

D. Medium voltage load interrupter switchgear
   1. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

E. Medium Voltage Fuses
   1. The manufacturer shall supply, upon request, test results that show the high voltage fuse design that has been tested to the applicable ANSI and NEMA standards. All fuses shall be checked 100% for correct resistance values.

F. Medium Voltage Metal Enclosed Bus
   1. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
      a. Normal frequency dielectric.
      b. Instrument transformers case grounding.
      c. Electrical operating and control wiring check.
      d. Impulse test.

G. Medium Voltage Starters
   1. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

a. Dielectric Test (Hi Pot) per NEMA ICS 2-324.60 at 2000 volts plus 2.25 times nominal voltage, for 60 seconds, phase-to-phase and phase-to-ground.
b. Sequence of control circuits.
c. Style/part no. check of components.
d. Wiring check.

H. **[Factory tests as outlined above shall be witnessed by the Owner's representative.**
1. **The manufacturer shall notify the Owner two (2) weeks prior to the date the tests are to be performed.**
2. **The manufacturer shall include the cost of transportation and lodging for up to three (3) Owner's representatives. The cost of meals and incidental expenses shall be the Owner's responsibility.]**

I. The manufacturer shall provide three (3) certified copies of factory test reports.

3.05 **FIELD SETTINGS**

A. The Electrical Subcontractor shall perform field adjustments of the circuit breakers as required to place the equipment in final operating condition.

B. Where electrical distribution equipment is provided with adjustable settings, each setting on each piece of equipment shall be set in the field by a qualified representative of the manufacturer prior to initial energization. The qualified representative of the manufacturer shall be retained by the Electrical Subcontractor. Settings shall be as determined by the final coordination study of the distribution system. See Section 26 0570.

C. Transformers
1. Adjust taps to deliver appropriate voltage and measure primary and secondary voltage to confirm proper setting.

3.06 **FIELD QUALITY CONTROL**

A. Provide the services of a qualified factory-trained manufacturer's representative to assist the Electrical Subcontractor in installation and start-up of the equipment specified under this section for a period of **[ ]** working days. The manufacturer's representative shall provide technical direction and assistance to the Electrical Subcontractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. The Electrical Subcontractor shall provide three (3) copies of the manufacturer's field start-up report.

3.07 **MANUFACTURER'S CERTIFICATION**

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations.

B. The Electrical Subcontractor shall provide three (3) copies of the manufacturer's representative's certification before final payment is made.

C. A certified test report of all standard production tests shall be available to the Engineer upon request.

3.08 **TRAINING**

A. The Electrical Subcontractor shall provide a training session for up to 6 Owner's representatives for 3 normal workdays at a jobsite location determined by the Owner.

B. The training session shall be conducted by a manufacturer's qualified representative. The training program shall consist of the instruction on the operation of the assembly, circuit breakers, and major components within the assembly.

C. The training program shall include the following:
1. Review of the project one-line drawings and schedules.
2. Review of the factory record shop drawings.

3. Review of all equipment in the electrical distribution system.
4. Discuss the maintenance timetable and procedures to be followed in an ongoing maintenance program.
5. Provide three ring binders to participants complete with copies of drawings and other course material covered.

END OF SECTION

SECTION 26 20 10
LOW VOLTAGE DISTRIBUTION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. All of the Contract Documents, as listed on the Table of Contents and including General and Supplementary Conditions and Division 01, General Requirements, shall be included in, and made part of, this Section.

1.02 DESCRIPTION OF WORK

A. The Electrical Subcontractor shall furnish and install the low voltage distribution equipment as specified herein and as shown on the contract drawings.

B. The following low voltage distribution equipment shall be provided for the new building, as a minimum, but not necessarily limited to the following:
   1. Normal distribution system.
   2. Emergency (life safety) distribution system.
   3. Legally required distribution system
   4. Optional stand-by distribution system
   5. Hoisting, rigging, setting of all equipment.
   6. Testing, cleaning and adjusting.
   7. Fees, permits, royalties, guarantees.
   8. Shop drawings.
   9. Power system studies and trip settings.
   10. Contactors
   11. Enclosed circuit breakers.
   12. Fuses
   13. Low voltage distribution switchboards, group mounted.
   14. Motor controllers - magnetic starters.
   15. Panelboards - branch circuit and distribution. (100A-1200A)
   16. Safety switches, motor disconnect devices
   17. Transformers - dry type.

1.03 RELATED WORK

A. For work to be included as part of this Section, to be furnished and installed by the Electrical Subcontractor, refer to the Related Work section of Specification Section 26 0510.

B. Carefully examine all of the Contract Documents, criteria sheets and all other Sections of the specifications for requirements which affect work under this Section, whether or not such work is specifically mentioned in this Section.

1.04 REFERENCES

A. The equipment specified herein shall be designed, assembled, and tested and installed in accordance with latest applicable standards of NEMA, IEEE, ANSI and UL as follows:
   1. Transformers
      a. NEMA
      b. ANSI
   2. Low Voltage Switchboard
      a. UL 891
      b. NEMA PB-2
   3. Molded Case Circuit Breakers
      a. UL 489 - Molded Case Circuit Breakers
      b. NEMA AB1 - Molded Case Circuit Breakers
      c. NEMA 250 - Enclosures for Electrical Equipment
      d. Fed. Spec. W-C-375a
   4. Panelboards
      a. UL 67 – Panelboards

b. UL 50 – Enclosures for Electrical Equipment
c. NEMA PB-1
d. Fed. Spec. W-P115C
e. Fed. Spec. W-C-375a
f. Circuit Breaker – Type I, class I
g. Fusible Switch – Type II, class I

1.05 **QUALITY ASSURANCE**

A. The manufacturers listed within this specification have been preselected for use on this project. No submittal will be accepted from a manufacturer other than specified.

B. To ensure system compatibility, all medium voltage distribution equipment, primary and secondary unit substations, and low voltage distribution equipment shall be the products of one manufacturer.

1.06 **WARRANTY**

A. Attention is directed to provisions of the General Requirements, Supplementary General Requirements and Section 26 0510 regarding guarantees and warranties for the work under this Contract.

1.07 **QUALIFICATIONS**

A. The manufacturer of the low voltage distribution equipment shall be the manufacturer of the major components within the equipment.

B. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.08 **SEISMIC REQUIREMENTS**

A. The equipment and major components specified herein shall be suitable for, and certified by actual seismic testing to meet, all applicable seismic requirements of the 2006 International Building Code (IBC) Site Classification C.
   1. The following values shall be used:
      a. Site Coefficient, F_a = 1.3
      b. Site Coefficient, F_v = 1.5
      c. Spectral Response Acceleration, S_s 0.30 g
      d. Spectral Response Acceleration, S_1 0.06 g
   2. The test response spectrum shall be based upon a 5% damping factor, and a peak (S_{DS}) of at least 0.26 g's (3 -12 Hz) applied at the base of the equipment in the horizontal direction.
   3. The forces in the vertical direction shall be at least 66% of those in the horizontal direction.
   4. The tests shall cover a frequency range from 1 to 100Hz.

B. Guidelines for the installation consistent with these requirements shall be provided by the equipment manufacturer and based upon testing of representative equipment. Equipment certification acceptance criteria shall be based upon the ability for the equipment to be returned to service immediately after a seismic event within the above requirements without the need for repairs.

C. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.
   1. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed Civil Engineer in the project state. Mounting recommendations shall be provided by the manufacturer based upon the above criteria to verify the seismic design of the equipment.

2. The equipment manufacturer shall certify that the equipment can withstand, that is, function; following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.09 DELIVERY, STORAGE AND HANDLING

A. Manufacturer's directions shall be followed completely in the delivery, storage, protection and installation. Promptly notify the Architect in writing of any conflict between any requirements of the Contract Documents and the manufacturer's directions. Obtain the Architect's written instructions before proceeding with the work. Should Electrical Subcontractor perform any work that does not comply with the manufacturer's directions or written instructions from the Architect, he shall bear all costs arising in correcting any deficiencies that should arise.

B. Equipment and materials shall be delivered to the site and stored in original sealed containers, suitably sheltered from the elements, but readily accessible for inspection by the Architect until installed. All items subject to moisture damage such as controls shall be stored in dry, heated spaces. Equipment such as switchgear with heater elements installed shall have the heater elements energized after the equipment is received by the Electrical Subcontractor.

C. The Electrical Subcontractor shall be responsible to fully inspect all shipments for damage and report damage to the manufacturer and the Architect.

D. Equipment shall be tightly covered and protected against dirt, water, and chemical or mechanical injury and theft. At the completion of the work, equipment and materials shall be cleaned and polished thoroughly and turned over to the Owner in a condition satisfactory to the Architect. Damage or defects that develop before acceptance of the work shall be made good at the Electrical Subcontractor's expense.

E. The Electrical Subcontractor shall make necessary field measurements to ascertain space requirements, for equipment and connections to be provided under his respective Trade and shall furnish and install such sizes and shapes of equipment to allow for the final installation to conform to the drawings and specifications.

F. The low voltage distribution equipment shall be split into shipping groups for handling as directed by the Electrical Subcontractor or as the manufacturer’s limitations dictate. Shipping groups shall be designed to be shipped by truck, rail or ship. Shipping groups shall be bolted to skids. Accessories shall be packaged and shipped separately. Each switchgear shipping group shall be equipped with lifting eyes for handling solely by crane.

G. The low voltage distribution equipment being stored prior to installation shall be stored so as to maintain the equipment in a clean and dry condition. If stored outdoors, indoor gear shall be covered and heated, and outdoor gear shall be heated.

1.10 ACCEPTABLE MANUFACTURERS

A. Eaton

B. Siemens

C. Square D

D. GE by ABB

1.11 SELECTIVE COORDINATION

A. All overcurrent protection devices shall be selectively coordinated with all upstream overcurrent protection devices, to meet the requirements of the 2017 National Electrical Code, based on

the highest calculated value (from utility and/or generator) of available short circuit current, at the overcurrent protection device terminals, as follows:

2017 NEC

Distribution System:	Coordination Time, in Seconds	NEC Code Article
1. Emergency Distribution System	0.01	700.32
2. Legally Required Distribution System:	0.01	701.27
3. Information Technology Equipment	0.01	645.27
4. All Other Power Distribution Systems	0.10	240.12

B. The switchgear manufacturer shall be responsible to select appropriate overcurrent protective device, fuse and/or circuit breaker frame, sensor and trip sizes for all devices upstream of other devices for a completely coordinated system. Refer to specification 26 0570 for additional information.

1.12 **WITHSTAND AND INTERRUPTING RATINGS OF ELECTRICAL COMPONENTS**

A. Calculated available 3 phase and single phase to ground short circuit currents indicated on the drawings are provided for information only, to assist in the selection of withstand and interrupting ratings and coordination of devices and equipment.

B. Prior to submission of shop drawings, the manufacturer shall perform short circuit calculations in accordance with specification section 26 0570 to determine actual available 3 phase and single line to ground short circuit current at each component in the system based on actual equipment, feeder lengths, impedances, etc. of the equipment proposed for this project. Failure to perform the study prior to submission of shop drawings shall not relieve the manufacturer from providing devices that meet the requirements of the final study report.

C. Each component shall be UL listed and labeled and shall be fully rated to withstand and interrupt calculated available 3 phase and single phase to ground short circuit current levels. Series ratings will not be acceptable.

1.13 **SUBMITTALS**

A. Prepare and submit shop drawings in accordance with the requirements hereinbefore specified, and with Section 01 3300 – Submittal Procedures in the manner described therein, modified as indicated in Section 26 5010 and as noted hereinafter.

B. All shop drawings shall have clearly marked the appropriate specification number or drawing designation, for identification of the submittal.

C. Disposition of shop drawings shall not relieve the Electrical Subcontractor from the responsibility for deviations from drawing or specifications, unless he has submitted in writing a letter itemizing or calling attention to such deviations at time of submission and secured written approval from the Engineer, nor shall such disposition of shop drawings relieve the Electrical Subcontractor from responsibility for errors in shop drawings or schedules.

D. Refer to Specification Section 26 0570 - Power System Studies: Power system study report shall be submitted in advance, or in conjunction with distribution equipment shop drawings. If formal completion of the studies may cause delay in equipment manufacture, approval from the Architect may be requested to select device ratings and characteristics based on a preliminary submittal of the study using available data and reasonable assumptions. Any changes required as a result of the final power system study shall be made at no additional cost to the Owner.

E. Shop drawings shall include, but shall not be limited to, the following:
1. Contactors
2. Enclosed circuit breakers.
3. Fuses
4. Low voltage distribution switchboards, group mounted.
5. Motor controllers - magnetic starters.
6. Panelboards - branch circuit and distribution. (100A-1200A)
7. Power management system.

8. Safety switches, motor disconnect devices
9. Transformers - dry type.
10. Equipment identification
11. Shop drawings shall include floor plans of all electric rooms housing main electrical distribution equipment, including, but not limited to; the incoming service electric room, substation rooms, etc. Floor plans shall be 3/8" = 1'-0" scale drawings indicating actual equipment dimensions, required Code clearances, etc. Acceptance of these shop drawings shall be obtained prior to installation of equipment and feeder conduits:
    Notes:
    Equipment shop drawings will not be reviewed without the room/equipment layouts. The Architect/Engineer reserve the right to rearrange equipment in electrical equipment rooms or spaces once final equipment dimensional information is known and prior to installation of the equipment. Install equipment in the final location selected by the Architect/Engineer at no additional cost to the Owner.

F. The switchgear manufacturer shall submit the following information with each submittal:
1. Master drawing index.
2. Front view elevation.
3. Floor plan.
4. Top view.
5. Single line.
6. Control schematics and wiring diagrams.
7. Nameplate schedule.
8. Component list/bill of material.
9. Conduit entry/exit locations.
10. Assembly ratings including:
    a. Short circuit rating.
    b. Information regarding series short circuit ratings.
    c. Voltage.
    d. Continuous current.
    e. Basic Impulse level for equipment over 600 volts.
    f. KVA.
11. Major component ratings including:
    a. Voltage.
    b. Continuous current.
    c. Interrupting ratings.
12. Cable terminal sizes.
13. Connection details between close-coupled assemblies.
14. Composite floor plan of close-coupled assemblies.
15. Impedance for transformers.
16. Manufacturer's catalog data sheets.
17. Test reports.
18. The following additional information shall be submitted to the Engineer:
    a. Busway connection.
    b. Key interlock scheme drawing and sequence of operations.
19. The following product information shall be submitted:
    a. Descriptive bulletins.
    b. Product sheets.

1.14 CLOSEOUT SUBMITTALS AND O & M MANUALS

A. The following information shall be submitted for record purposes, in a binder, prior to final payment:
1. Final as-built drawings and information for items listed above.
2. Operation and maintenance manuals with the following information:
    a. Instruction books and/or instruction leaflets
    b. Recommended renewal parts
3. Wiring diagrams.

4. Certified production test reports.
5. Installation information.
6. Seismic certification and equipment anchorage details.

PART 2 – PRODUCTS

2.01 ENCLOSED CIRCUIT BREAKERS

A. Molded Case Circuit Breakers

1. Circuit breakers shall be molded case and shall provide circuit overcurrent protection with inverse time and instantaneous tripping characteristics.
2. Circuit breakers shall be bolt-on operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy, and arc extinction shall be accomplished by means of arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.
3. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the drawings.
4. Circuit breakers smaller than 250 ampere frame may be of the thermal-magnetic type with inverse time-current characteristics, unless adjustable trip settings are required to achieve selective coordination with upstream device(s). .

   NOTE: SEE REQUIREMENTS FOR SELECTIVE COORDINATION IN PART 1 OF THIS SECTION. NO REQUEST FOR ADDITIONAL COMPENSATION SHALL BE GRANTED IF THE FINAL POWER SYSTEM STUDY DETERMINES THAT ADDITIONAL ADJUSTABLE TRIP CIRCUIT BREAKERS ARE REQUIRED TO ACHIEVE SELECTIVE COORDINATION.

5. Circuit breakers 250 ampere frame and above, and circuit breakers smaller than 250 ampere frame, that require adjustable trip settings to achieve selective coordination with upstream device(s), shall be microprocessor-based with true RMS sensing trip units
   a. Each molded case circuit breaker microprocessor-based tripping system shall consist of three current sensors, a microprocessor, and a flux-transfer shunt trip. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached.
   b. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker. Rating plugs shall be interlocked so they are not interchangeable between frames, and interlocked such that a breaker cannot be closed and latched with the rating plug removed.
   c. The microprocessor-based trip system shall have thermal memory capabilities to prevent the breaker from being reset following an overload condition until after a preset time delay.
   d. Molded Case Circuit Breaker Trip Units
      1) System coordination shall be provided by the following microprocessor-based time-current curve shaping adjustments:
         a) Adjustable long time pick-up and delay
         b) Adjustable short time pick-up and delay, with selective curve shaping
         c) Adjustable instantaneous pick-up
         d) Adjustable ground fault pick-up and delay, with selective curve shaping.
      2) Adjustable settings for molded case circuit breaker trip units shall have restricted access to the adjustments by one of the following means:
         a) Removable and sealable covers over the adjusting means.
         b) Bolted equipment enclosure doors.
         c) Locked doors accessible only to qualified personnel.

6. Provide manufacturer-specified handle padlock attachments for all breakers.

B. Energy Reducing Maintenance Switch
   1. The following circuit breakers shall contain a means to reduce arc energy:
      a. Circuit breakers with no instantaneous trip function or breakers with an instantaneous trip intentionally set to “0” or “off”.
      b. All circuit breakers 1,200 amp frame and above, regardless of trip setting.
      c. All circuit breakers with adjustable trip unit if the highest continuous current trip setting can be set to 1,200 amps or above.
   2. Method of reducing clearing time shall be one of the following:
      a. Energy-reducing maintenance switch with local status indicator and auxiliary contacts for remote status monitoring.
      b. Zone-selective interlocking
      c. Differential relaying
      d. Energy-reducing active arc flash mitigation system

C. Miscellaneous Devices
   1. Circuit Breaker Accessories
      a. Provide shunt trips, bell alarms, and auxiliary switches as shown on the contract drawings.

D. Enclosures
   1. All enclosed circuit breakers shall have NEMA 1 general purpose enclosures unless otherwise noted. Provide enclosures suitable for locations as indicated on the drawings and as described below.
      a. NEMA 1 surface or flush-mounted general purpose enclosures primarily intended for indoor use.
      b. NEMA 12 dust-tight enclosures intended for indoor use primarily to provide protection against circulating dust, falling dirt, and dripping non-corrosive liquids.
      c. NEMA 3R raintight enclosures intended for outdoor use primarily to provide protection against rain, sleet, and damage from external ice formation.
      d. NEMA 4 watertight stainless steel intended for indoor or outdoor use primarily to provide protection against windblown dust and rain, splashing rain, hose-directed water, and damage from external ice formation.
      e. NEMA 7, Class I, Group D hazardous location cast aluminum intended for indoor use in locations classified as Class I, Group D as defined in the National Electrical Code.
      f. NEMA 9, Class II, Groups E, F, G hazardous location cast aluminum intended for indoor use in locations classified as Class II, Groups E, F, and G as defined in the National Electrical Code.
   2. All enclosed circuit breakers shall have metal nameplates, front cover mounted, that contain a permanent record of catalog number and maximum rating. Provide handle mechanisms that are padlockable in the "OFF" position.

E. Finish
   1. Prior to assembly, all internal and external steel and aluminum enclosure part shall be thoroughly cleaned and phosphatized. A polyester powder coating shall be applied electrostatically, and then fused on by baking in an oven. The coating shall have a thickness of not less than 1.5 mils for interior equipment and 3.0 mils for exterior equipment. The finish shall have the following properties:

a.	Impact resistance (ASTM D-2794):	60 Direct/60 Indirect
b.	Pencil Hardness (ASTM D-3363):	H
c.	Flexibility (ASTM D-522):	Pass 1/8 inch mandrel
d.	5% Salt Spray(ASTM B117-85 [20]):	600 hours
e.	Color:	ANSI 49 or 61 Gray

2.02 **LOW VOLTAGE DISTRIBUTION SWITCHBOARDS – GROUP MOUNTED**

A. Ratings
   1. Voltage rating shall be 480/277 volts, 3 phase, 4 wire, wye. The entire assembly shall be suitable for 600 volts maximum AC Service.

2. The assembly shall be rated to withstand mechanical forces exerted during short circuit conditions when connected directly to a power source having an available fault current as indicated on the drawings, at rated voltage.

B. Construction
1. The switchboard shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.
2. All sections of the switchboard shall be front and rear aligned. All protective devices shall be group mounted. Devices shall be front removable and load connections front accessible enabling switchboard to be mounted against a wall.
3. All sections of the switchboard shall align front and rear. All protective devices shall be group mounted. Devices shall be front removable and load connections front and rear accessible. Rear access shall be provided
4. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position.

C. Bus
1. All bus bars shall be silver plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on ANSI standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure).
2. Bus bars shall be arranged “A”, “B”, “C”, from front-to-back and/or top-to-bottom and/or left-to-right as viewed from the front of the equipment.
3. Provide a full capacity neutral bus.
4. A copper ground bus (minimum 1/4 X 2 inch) shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the equipment
5. All hardware used on conductors shall be high-tensile strength and zinc plated. All bus joints shall be provided with Bellville type washers.

D. Insulated Case Circuit Breakers
1. Main and Feeder protective devices shall be fixed mounted insulated case circuit breakers. Frame ratings shall be 800, 1200, 1600, 2000, 2500, 3000, or 4000 amperes, as shown on the drawings. All breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.
2. Insulated case circuit breakers shall be manually operated (MO).
3. The breaker control face plate shall include color coded visual indicators to indicate contact "open" and "closed" positions as well as mechanism "charged" and "discharged" positions. Manual control pushbuttons on the breaker front shall be provided for "opening" and "closing" the breaker.
4. Insulated case circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the drawings. Interrupting capacity and minimum short time ratings shall be as follows:
   a. Frame Size 800 – 4000 Amperes
   b. Interrupting Capacity: 65 Amperes at 508 Vac
   c. Short Time Withstand Rating 20 Amperes
5. All breakers shall be provided with a true, two-step stored energy mechanism providing a maximum of five cycle closing. All the energy required for closing the breaker shall be completely stored and held in readiness pending a release to close action. Both manual and electrically operated breakers shall have multiple charge/close provisions providing the following possible sequence: Charge-close-recharge-open-close-open. As a safety feature, provisions shall be available to manually discharge the stored energy without closing the breaker. Anti-pump provisions shall be provided as standard for motor operated breakers and optional for manual breakers with spring release solenoids.

6. The breakers shall have high endurance characteristics being capable of no-load and full-load interruptions at rated current equal to or exceeding the UL endurance ratings for encased breakers without maintenance.

E. Trip Units
1. Each fixed mounted low voltage insulated case breaker shall be equipped with a solid-state tripping system consisting of three current sensors, microprocessor-based trip device and flux-transfer shunt trip. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker.
2. Complete system selective coordination shall be provided by the addition of the following individually adjustable time/current curve shaping solid-state elements:
   a. All breakers shall have adjustments for long delay pick-up and time.
   b. Main and Feeder breakers shall have individual adjustments for short delay pick-up and time, and include I^2t settings.
   c. Main and Feeder breakers shall have an adjustable instantaneous pick-up.
   d. Main breakers shall have individually adjustable ground fault current pick-up and time, ground fault alarm and include I^2t settings.
3. Trip unit adjustable settings shall have a removable and sealable cover over the adjusting means to restrict access to the adjustments.
4. The trip unit shall contain an integral test panel with a test selector switch and/or a test pushbutton and/or a portable full function test set. The test kit shall enable the user to select the values of test currents within a range of available settings. The basic protection functions shall not be affected during test operations. The breaker may be tested in the Trip or No trip test mode.
   a. The test kit, when connected to a 120V, 50/60 Hz source, shall provide power for testing the trip unit while the breaker is out of the cell or in the disconnect or withdrawn position.
5. Trip unit shall have thermal memory for enhanced circuit protection.
6. The trip unit shall be equipped to permit communication via a network twisted pair for remote monitoring and control.
7. Furnish and install all required appurtenances, as required, within the switchgear for trip unit communications to a central software package
8. Display and Metering Capability
   a. The trip unit shall have a minimum 4 character alpha-numeric LCD display to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A trip reset button shall be provided to turn off the display indication after an automatic trip.
   b. The trip unit shall display the following data:
      1) Cause of trip.
      2) Instantaneous current on all three phases.
   c. The trip unit shall display the following metering values:
      1) Amperes (per phase)
   d. Metering display accuracy of the complete system including current sensors, auxiliary C.T.'s, and the trip unit shall be +/- 2% of full scale for current values.
   e. The trip unit shall include a power/relay module which shall supply control power to the readout display. Following an automatic trip operation of the circuit breaker, it shall maintain the cause of trip history and the trip target as long as its internal power supply is available.
   f. The energy-monitoring parameter values (peak demand, present demand, and energy consumption) shall be indicated in the trip unit alpha-numeric or full graphical display panel.

g. Metering display accuracy of the complete system of full scale shall be +/- 1% full scale for current values; +/-2% for power values and energy values.
h. The trip unit shall include a power/relay module which shall supply control power to the readout display. Following an automatic trip operation of the circuit breaker, it shall maintain the cause of trip history and the trip target as long as its internal power supply is available.

F. Molded Case Circuit Breakers
1. Circuit breakers shall be molded case and shall provide circuit overcurrent protection with inverse time and instantaneous tripping characteristics.
2. Circuit breakers shall be bolt-on operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy, and arc extinction shall be accomplished by means of arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.
3. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the drawings.
4. Circuit breakers smaller than 250 ampere frame may be of the thermal-magnetic type with inverse time-current characteristics, unless adjustable trip settings are required to achieve selective coordination with upstream device(s).

NOTE: SEE REQUIREMENTS FOR SELECTIVE COORDINATION IN PART 1 OF THIS SECTION. NO REQUEST FOR ADDITIONAL COMPENSATION SHALL BE GRANTED IF THE FINAL POWER SYSTEM STUDY DETERMINES THAT ADDITIONAL ADJUSTABLE TRIP CIRCUIT BREAKERS ARE REQUIRED TO ACHIEVE SELECTIVE COORDINATION.

5. Circuit breakers 250 ampere frame and above, and circuit breakers smaller than 250 ampere frame, that require adjustable trip settings to achieve selective coordination with upstream device(s), shall be microprocessor-based with true RMS sensing trip units.
a. Each molded case circuit breaker microprocessor-based tripping system shall consist of three current sensors, a microprocessor, and a flux-transfer shunt trip. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached.
b. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker. Rating plugs shall be interlocked so they are not interchangeable between frames, and interlocked such that a breaker cannot be closed and latched with the rating plug removed.
c. The microprocessor-based trip system shall have thermal memory capabilities to prevent the breaker from being reset following an overload condition until after a preset time delay.
d. Molded Case Circuit Breaker Trip Units
1) System coordination shall be provided by the following microprocessor-based time-current curve shaping adjustments:
a) Adjustable long time pick-up and delay
b) Adjustable short time pick-up and delay, with selective curve shaping
c) Adjustable instantaneous pick-up
d) Adjustable ground fault pick-up and delay, with selective curve shaping
2) Adjustable settings for molded case circuit breaker trip units shall have restricted access to the adjustments by one of the following means:
a) Removable and sealable covers over the adjusting means.
b) Bolted equipment enclosure doors.
c) Locked doors accessible only to qualified personnel.

6. Provide manufacturer-specified handle padlock attachments for all breakers.

G. Quick-Make, Quick-Break Fusible Switches
   1. Protective devices shall be quick-make/quick-break fusible switches. Fusible switches 100 amperes through 600 amperes frames shall be furnished with class "R", class “J” or class "T" fuse clips unless otherwise scheduled. Fusible switches 800 amperes through 1200 amperes shall be furnished with Class L fuse clips. Switches shall incorporate safety cover interlocks to prevent opening the cover with the switch in the "ON" position or prevent placing the switch in the "ON" position with the cover open. Provide defeater for authorized personnel. Handles shall have provisions for padlocking and shall clearly indicate the "ON" or "OFF" position. Front cover doors shall be padlockable in the closed position.

H. Energy Reducing Maintenance Switch
   1. The following circuit breakers shall contain a means to reduce arc energy:
      a. Circuit breakers with no instantaneous trip function or breakers with an instantaneous trip set to a value intentionally set to “0” or “off”.
      b. All circuit breakers 1,200 amp frame and above, regardless of trip setting.
      c. All circuit breakers with adjustable trip unit if the highest continuous current trip setting can be set to 1,200 amps or above.
   2. Method of reducing clearing time shall be one of the following:
      a. Energy-reducing maintenance switch with local status indicator and auxiliary contacts for remote status monitoring.
      b. Zone-selective interlocking
      c. Differential relaying
      d. Energy-reducing active arc flash mitigation system

I. Miscellaneous Devices
   1. Circuit Breaker Accessories
      a. Provide shunt trips, bell alarms, and auxiliary switches as shown on the contract drawings.
   2. Space Heaters
      a. Each vertical section of the switchboard shall be provided with thermostatically controlled space heaters. Tubular type heaters shall be provided, operated at half voltage for long life. 250 volt rated heaters shall be used at 120 volts.
      b. Power for the space heaters shall be obtained from a control power transformer within the switchboard. Supply voltage shall be 120 volts AC. Space heaters shall be wired to provide temporary heating during storage.

J. Wiring/Terminations
   1. Mechanical set screw type lugs shall be provided for all line and load, phase and neutral conductor terminations, suitable for copper or aluminum cable rated for 75 degrees C, of the size and type as indicated on the drawings.
   2. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of feeder grounding conductors shall be provided, quantity and size as indicated on the drawings.
   3. Small wiring, necessary fuse blocks and terminal blocks within the assembly shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.
   4. All control wire shall be type SIS. Wire bundles shall be secured with nylon ties and anchored to the assembly with the use of prepunched wire lances. All current transformer secondary leads shall first be connected to conveniently accessible short circuit terminal blocks before connecting to any other device. Four shorting screws with provisions for storage shall be provided. All groups of control wires leaving the switchgear shall be provided with terminal blocks with suitable numbering strips. Insulated locking spade terminals shall be provided for all control connections, except where saddle type terminals are provided integral to a device. Provide wire markers at each end of all control wiring.

5. Where control wiring passes between shipping splits of the equipment or from primary switchgear thru transformer enclosure to secondary equipment, provide plug in terminal blocks.
6. Terminal connections to remote devices or sources shall be front accessible via removable trays above each circuit breaker. Control fuses for each electrically operated circuit breakers shall also be located in these trays.

K. Customer Metering
1. Provide customer metering devices as specified herein. Provide a separate customer metering compartment with front hinged door. Include associated instrument transformers.
2. Provide current transformers as required for each phase and neutral circuit with ratings sized for incoming service or associated feeder. Provide potential transformers as required for proper operation of the meter. Current transformers shall be wired to shorting type terminal blocks.
3. Provide potential transformers including primary and secondary fuses with disconnecting means or fused potential taps as the potential source for metering as required.
4. Microprocessor-based metering system.
   a. Provide a full function electronic meter on all low voltage main and feeder devices. The meter shall have the features and functions specified below. The meter shall be UL recognized, CSA certified and also meet ANSI Standard C37.90.
   b. The meter shall provide direct reading metered or calculated values of the items listed below and shall auto range between Units, Kilo-units, and Mega-units for all metered values. Accuracy indicated below to be of read or calculated values.
      1) AC Current (Amperes) in A, B, and C phase, 3 Phase Average and Neutral (N). Accuracy +/- 0.2% (provide phase and neutral current transformer).
      2) AC Voltage (Volts) for A-B, B-C, and C-A, Phase Average, A-N, B-N, and C-N and Average Phase to N. Accuracy +/-0.2%.
      3) Real Power (WATTS), Reactive Power (VARS), Apparent Power (VA), for each phase and system (system shall apply only for 3 wire applications). Accuracy +/- 0.4%. Forward/Reverse indication shall be provided.
      4) Real Energy (WHR), Reactive Energy (VARHR), Apparent Energy (VAHR) for each phase and system (system shall apply only for 3 wire applications). Accuracy +/- 0.4%. Forward/Reverse indication shall be provided.
      5) Frequency (HERTZ) Accuracy +/- 0.04%.
      6) Demand values for System Current (AMPERES), System Real Power (WATTS), System Reactive Power (VARS), and System Apparent Power (VA).
      7) Power Factor both Displacement only 60 cycle fundamental WATTS to VA and Apparent total WATTS to total VARS including harmonics for A, B, and C phase and system. Accuracy +/- 0.4%.
      8) Current Percent Total Harmonic Distortion (THD) in A, B, and C phase, and N.
      9) Voltage percent THD in A-B, B-C, and C-A phase, A-N, B-N, and C-N.
5. Communications
   a. Meters shall be capable of transmitting all metering data to a central system for monitoring and storage as follows:
      1) Building Automation System via an optically isolated RS485 port
      2) To a Web Enabled Ethernet Local Area Network via Category 6 cable
   b. Provide a separate compartment with a front facing hinged door as a central point of connection for all internally located communicating devices. The compartment shall have a lockable, hinged door with a functional through-the-door RJ45 network access port. Power for the components within the compartment shall be supplied by a pre-wired, bus-connected control transformer in the compartment that shall have a fused disconnecting means.

L. Enclosures
1. The equipment in these specifications shall have NEMA 1 general purpose, indoor enclosures, with devices arranged as shown on contract drawings, unless noted otherwise.

M. Finish
1. Prior to assembly, all internal and external steel and aluminum enclosure part shall be thoroughly cleaned and phosphatized. A polyester powder coating shall be applied electrostatically, and then fused on by baking in an oven. The coating shall have a thickness of not less than 1.5 mils for interior equipment and 3.0 mils for exterior equipment. The finish shall have the following properties:
   a. Impact resistance (ASTM D-2794): 60 Direct/60 Indirect
   b. Pencil Hardness (ASTM D-3363): H
   c. Flexibility (ASTM D-522): Pass 1/8 inch mandrel
   d. 5% Salt Spray(ASTM B117-85 [20]): 600 hours
   e. Color: ANSI 49 or 61 Gray

2.03 **PANELBOARDS – BRANCH CIRCUIT AND DISTRIBUTION (100A – 1,200A)**

A. Ratings
1. Panelboards shall be 240 volt or 600 volt class suitable for operation on a three phase, 60 Hertz system. The panelboard phase, voltage and current ratings shall be as indicated on the Contract Drawings.

B. Construction
1. Interiors shall be completely factory assembled with bolt-on devices. They shall be designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.
2. All distribution panels and branch circuit panelboards shall be supplied with a front hinged trim with inner door. The inner door shall provide access to circuit breaker handles only, and shall not uncover any live parts. Inner door shall have a semi-flush cylinder lock and catch assembly. The outer trim shall be provided with a full length, vertical piano hinge to expose wiring gutters, secured closed with a minimum of 3 bolts. Doors over 48 inches in height shall have auxiliary fasteners. Switching device handles in distribution panelboards shall be accessible.
3. Surface trims shall be same height and width as box. Flush trims shall overlap the box by 3/4 of an inch on all sides.
4. Where double tub panels are indicated on the drawings, each tub shall contain the same number of breakers and spaces. Box and trim sizes shall be identical.
5. Where auxiliary gutters are indicated for feed through cables, a separate gutter shall be attached to the panelboard, sized as required based on conductor size. The outer door of the door-in-door trim shall expose the auxiliary gutter.
6. A directory card with a clear plastic cover shall be supplied and mounted on the inside of each door.
7. All locks shall be keyed alike.

C. Bus
1. Main bus bars shall be copper sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 65 degrees C above an ambient of 40 degrees C maximum.
2. Bus bars shall be arranged “A”, “B”, “C”, from front-to-back and/or top-to-bottom and/or left-to-right as viewed from the front of the equipment.
3. A bolted ground bus, of the same material as the phase and neutral bus, shall be included in all panelboards.
4. In addition to the bolted ground bus, an isolated copper ground bus, of the same material as the phase and neutral bus, shall be included in panels as indicated on the drawings.
5. Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices.
6. Neutral Bus
   a. Full-size neutral bus, of the same material as the phase bus, shall be included for panelboards shown with neutral.
   b. Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection.

c. For panels 600 amperes and below, fed directly via "K" factor transformers, neutral bus shall be 200% of phase busses.
d. For panels over 600 amperes, fed directly by "K" factor transformers, switchboards shall be provided with 200% neutral bus. Refer to Switchboard section of these specifications.

D. Molded Case Circuit Breakers
1. Circuit breakers shall be molded case and shall provide circuit overcurrent protection with inverse time and instantaneous tripping characteristics.
2. Circuit breakers shall be bolt-on operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy, and arc extinction shall be accomplished by means of arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.
3. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the drawings.
4. Circuit breakers smaller than 250 ampere frame may be of the thermal-magnetic type with inverse time-current characteristics, unless adjustable trip settings are required to achieve selective coordination with upstream device(s).

NOTE: SEE REQUIREMENTS FOR SELECTIVE COORDINATION IN PART 1 OF THIS SECTION. NO REQUEST FOR ADDITIONAL COMPENSATION SHALL BE GRANTED IF THE FINAL POWER SYSTEM STUDY DETERMINES THAT ADDITIONAL ADJUSTABLE TRIP CIRCUIT BREAKERS ARE REQUIRED TO ACHIEVE SELECTIVE COORDINATION.

5. Circuit breakers 250 ampere frame and above, and circuit breakers smaller than 250 ampere frame, that require adjustable trip settings to achieve selective coordination with upstream device(s), shall be microprocessor-based with true RMS sensing trip units.
a. Each molded case circuit breaker microprocessor-based tripping system shall consist of three current sensors, a microprocessor, and a flux-transfer shunt trip. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached.
b. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker. Rating plugs shall be interlocked so they are not interchangeable between frames, and interlocked such that a breaker cannot be closed and latched with the rating plug removed.
c. The microprocessor-based trip system shall have thermal memory capabilities to prevent the breaker from being reset following an overload condition until after a preset time delay.
d. Molded Case Circuit Breaker Trip Units
1) System coordination shall be provided by the following microprocessor-based time-current curve shaping adjustments:
a) Adjustable long time pick-up and delay
b) Adjustable short time pick-up and delay, with selective curve shaping
c) Adjustable instantaneous pick-up
d) Adjustable ground fault pick-up and delay, with selective curve shaping
2) Adjustable settings for molded case circuit breaker trip units shall have restricted access to the adjustments by one of the following means:
a) Removable and sealable covers over the adjusting means.
b) Bolted equipment enclosure doors.
c) Locked doors accessible only to qualified personnel.
6. Circuit Breakers – Branch Circuit Panelboards

a. Bolt-on type, heavy-duty, quick-make, quick-break, single- and multi-pole circuit breakers of the types specified herein, shall be provided for each circuit with toggle handles that indicate when unit has tripped.
b. Circuit breakers shall be thermal magnetic type with common type handle for all multiple pole circuit breakers. Circuit breakers shall be minimum 100 ampere frame and through 100 ampere trip sizes shall take up the same pole spacing. 20 ampere, single pole circuit breakers shall be UL listed as type SWD for lighting circuits.
c. Circuit breaker handle locks shall be provided for all circuits that supply exit signs, emergency lights, energy management and control system (EMCS) panels and fire alarm panels.
d. Circuit breakers serving fire alarm system panels shall be identified with a red nameplate with white letters, adjacent to the circuit breaker reading “FIRE ALARM CIRCUIT”. In addition the circuit breaker handle shall have a red marking.

E. Energy Reducing Maintenance Switch
1. The following circuit breakers shall contain a means to reduce arc energy:
a. Circuit breakers with no instantaneous trip function or breakers with an instantaneous trip intentionally set to “0” or “off”.
b. All circuit breakers 1,200 amp frame and above, regardless of trip setting.
c. All circuit breakers with adjustable trip unit if the highest continuous current trip setting can be set to 1,200 amps or above.
2. Method of reducing clearing time shall be one of the following:
a. Energy-reducing maintenance switch with local status indicator and auxiliary contacts for remote status monitoring.
b. Zone-selective interlocking
c. Differential relaying
d. Energy-reducing active arc flash mitigation system

F. Wiring Terminations
1. Mechanical set screw type lugs shall be provided for all line and load, phase and neutral conductor terminations, suitable for copper or aluminum cable rated for 75 degrees C, of the size and type as indicated on the drawings.
2. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of feeder grounding conductors shall be provided, quantity and size as indicated on the drawings.

G. Customer Metering
1. Provide customer metering devices as specified herein. Provide a separate customer metering compartment with front hinged door. Include associated instrument transformers.
2. Provide current transformers as required for each phase and neutral circuit with ratings sized for incoming service or associated feeder. Provide potential transformers as required for proper operation of the meter. Current transformers shall be wired to shorting type terminal blocks.
3. Provide potential transformers including primary and secondary fuses with disconnecting means or fused potential taps as the potential source for metering as required.
4. Microprocessor-based metering system.
a. Provide a full function electronic meter on all low voltage main and feeder devices. The meter shall have the features and functions specified below. The meter shall be UL recognized, CSA certified and also meet ANSI Standard C37.90.
b. The meter shall provide direct reading metered or calculated values of the items listed below and shall auto range between Units, Kilo-units, and Mega-units for all metered values. Accuracy indicated below to be of read or calculated values.
1) AC Current (Amperes) in A, B, and C phase, 3 Phase Average and Neutral (N). Accuracy +/- 0.2% (provide phase and neutral current transformer).
2) AC Voltage (Volts) for A-B, B-C, and C-A, Phase Average, A-N, B-N, and C-N and Average Phase to N. Accuracy +/-0.2%.

3) Real Power (WATTS), Reactive Power (VARS), Apparent Power (VA), for each phase and system (system shall apply only for 3 wire applications). Accuracy +/- 0.4%. Forward/Reverse indication shall be provided.
4) Real Energy (WHR), Reactive Energy (VARHR), Apparent Energy (VAHR) for each phase and system (system shall apply only for 3 wire applications). Accuracy +/- 0.4%. Forward/Reverse indication shall be provided.
5) Frequency (HERTZ) Accuracy +/- 0.04%.
6) Demand values for System Current (AMPERES), System Real Power (WATTS), System Reactive Power (VARS), and System Apparent Power (VA).
7) Power Factor both Displacement only 60 cycle fundamental WATTS to VA and Apparent total WATTS to total VARS including harmonics for A, B, and C phase and system. Accuracy +/- 0.4%.

5. Communications
   a. Meters shall be capable of transmitting all metering data to a central system for monitoring and storage as follows:
      1) Building Automation System via an optically isolated RS485 port
      2) To a Web Enabled Ethernet Local Area Network via Category 6 cable
   b. Provide a separate compartment with a front facing hinged door as a central point of connection for all internally located communicating devices. The compartment shall have a lockable, hinged door with a functional through-the-door RJ45 network access port. Power for the components within the compartment shall be supplied by a pre-wired, bus-connected control transformer in the compartment that shall have a fused disconnecting means.

H. Enclosures
1. The equipment in these specifications shall have NEMA 1 general purpose, indoor enclosures, with devices arranged as shown on contract drawings, unless noted otherwise.
2. Enclosures shall be at least 20 inches wide and 5 3/4 inches deep made from galvanized steel. Provide minimum gutter space in accordance with the National Electric Code. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, an auxiliary gutter shall be provided, sized to include the additional required wiring space. At least four interior mounting studs with adjustable nuts shall be provided.
3. Enclosures shall be provided with removable blank ends.

I. Panelboard Circuit Directories
1. Lighting and appliance panelboards shall be provided with typewritten directories with plastic protector indicating circuit numbers, equipment served and room number of the area served.
2. Coordinate all room numbers with Architect prior to final printing of directories. Room numbers used for directory cards shall be the room numbers assigned by the Owner and not necessarily room numbers indicated on the drawings.
3. Directory cards shall be edited and maintained during the course of construction to keep an accurate, up to date record of each feeder or branch circuit.

J. Finish
1. Prior to assembly, all internal and external steel and aluminum enclosure part shall be thoroughly cleaned and phosphatized. A polyester powder coating shall be applied electrostatically, and then fused on by baking in an oven. The coating shall have a thickness of not less than 1.5 mils for interior equipment and 3.0 mils for exterior equipment. The finish shall have the following properties:
   a. Impact resistance (ASTM D-2794): 60 Direct/60 Indirect
   b. Pencil Hardness (ASTM D-3363): H
   c. Flexibility (ASTM D-522): Pass 1/8 inch mandrel
   d. 5% Salt Spray(ASTM B117-85 [20]): 600 hours
   e. Color: ANSI 49 or 61 Gray

2.04 **SAFETY SWITCHES – MOTOR DISCONNECT DEVICES**

A. Ratings
   1. All safety switches / motor disconnect devices shall be heavy duty type
   2. Safety Switches 60 amperes and below (motors 10 HP, 480 volt; 5 HP, 208 volt, and smaller)
      a. 30 to 60 Amperes.
      b. 250 Volts AC, DC; 600 Volts AC.
      c. 2, 3 or 6 Poles.
      d. Fusible or Non-Fusible
      e. Copper-Aluminum Terminals.
   3. Safety Switches over 60 amperes (motors 15 HP, 480 volt; 7½ HP, 208 volt and above)
      a. 60 to 1,200 Amperes.
      b. 600 Volts AC.
      c. 3 or 6 Poles.
      d. Fusible or Non-Fusible
      e. Copper-Aluminum Terminals.

B. Construction
   1. All safety switches / motor disconnect devices shall include the following:
      a. Metal nameplates mounted on the front cover with:
         1) A permanent record of switch type
         2) Catalog number
         3) HP ratings (with both standard and time delay fuses)
      b. Handle whose position is easily recognizable and is padlockable in the "OFF" position
      c. Visible blades when the door is in the open position
      d. Reinforced fuse clips
      e. Non-teasible, positive, quick-make quick-break mechanisms
      f. Switch assembly and operating handle shall be an integral part of the enclosure base.
      g. All switches shall be Underwriters Laboratories, Inc. listed, HP rated, meet Federal Specification WS-865c, and NEMA Specifications KSI-1975.
      h. Switches shall have defeatable door interlocks that prevent the door from opening when the operating handle is in the "ON" position.
   2. Heavy-duty switches shall have line terminal shields.
   3. All fused switches shall have Class J time delay fuses.

C. Special Configurations
   1. Where motor disconnect devices are installed between variable speed drives and their associated motor, an interlock switch shall be provided on the motor disconnect devices and 2#14-1/2"C. shall run from the interlock switch to the associated variable speed drive to turn off the drive while the motor disconnect switch is in the off position.
   2. All two speed motors shall be provided with 6 pole motor disconnect devices.
   3. All motors/pumps/air handling units shall be provided with proper size/rating motor disconnect device whether indicated on drawings or not to comply with NEC. Install and connect motor disconnect devices furnished by other Trades.
   4. For all motors under 1/2 HP, furnish and install a manual starting thermal type switch with pilot light as a disconnecting means, unless otherwise indicated on the drawings. These thermal switches shall be toggle operated and shall be rated 1 HP, motor overload protection shall be provided by means of a bimetallic type thermal relay in combination with interchangeable heaters. Heaters shall be installed without removing the starter from the housing or disturbing the wiring. Toggle shall be trip free. Thermal switches shall be furnished in a NEMA, Type 1 enclosure in mechanical and utility areas and flush in walls with stainless steel plates in architecturally finished areas. All heaters shall be sized per the horsepower of the motor code letter. Coordinate with HVAC and Plumbing Trades.

D. Wiring/Terminations
   1. All power wiring shall be furnished and installed between disconnect switches, control cabinets, contactors and motor terminals required by equipment furnished by other Trades.

E. Enclosures
   1. The equipment in these specifications shall have NEMA 1 general purpose, indoor enclosures, with devices arranged as shown on contract drawings, unless noted otherwise.
   2. NEMA Type 3R enclosures shall be used where the disconnect switch is exposed to the weather or in wet areas.

F. Finish
   1. Prior to assembly, all internal and external steel and aluminum enclosure part shall be thoroughly cleaned and phosphatized. A polyester powder coating shall be applied electrostatically, and then fused on by baking in an oven. The coating shall have a thickness of not less than 1.5 mils for interior equipment and 3.0 mils for exterior equipment. The finish shall have the following properties:
      a. Impact resistance (ASTM D-2794): 60 Direct/60 Indirect
      b. Pencil Hardness (ASTM D-3363): H
      c. Flexibility (ASTM D-522): Pass 1/8 inch mandrel
      d. 5% Salt Spray(ASTM B117-85 [20]): 600 hours
      e. Color: ANSI 49 or 61 Gray

2.05 TRANSFORMERS – DRY TYPE DISTRIBUTION

A. Ratings
   1. kVA and voltage ratings shall be as shown on the drawings.
   2. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96.
   3. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:
      a. Up to 9 kVA: 40 dB
      b. 10 to 50 kVA: 45 dB
      c. 51 to 150 kVA: 50 dB
      d. 151 to 300 kVA: 55 dB
   4. Transformers shall meet or exceed efficiency levels per DOE 2016 requirements, or the latest adopted edition.

B. Construction
   1. The enclosure shall be made of heavy-gauge steel. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 degrees C. The core of the transformer shall be grounded to the enclosure.
   2. On units rated 15 kVA and below the enclosure construction shall be totally enclosed, non-ventilated, NEMA 3R, with lifting eyes.
   3. On units rated 30 kVA and above the enclosure construction shall be ventilated, NEMA 2, drip-proof, with lifting holes. All ventilation openings shall be protected against falling dirt. Ventilation openings shall not be blocked. Horizontal top surface of the transformer shall be marked to prohibit storage.
   4. Fan assisted convection cooling/ventilation shall not be acceptable

C. Insulation Systems
   1. Transformers shall be insulated as follows:
      a. Less than 15 kVA: 200 degrees C insulation system based upon 115 degree C rise.
      b. 15 kVA and above: 220 degrees C insulation system based upon 150 degree C rise.
   2. Required performance shall be obtained without exceeding the above indicated temperature rise in a 40 degrees C maximum ambient with a 30 degrees C average ambient over 24 hours.

3. All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635.

D. Core and Coil Assemblies
1. Transformer core shall be constructed with high-grade, nonaging, grain-oriented silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above the highest tap voltage. The core laminations shall be tightly clamped and compressed.
2. Coils shall be wound of electrical grade copper with continuous wound construction.
3. On units rated 15 kVA and below the core and coil assembly shall be completely encapsulated in a proportioned mixture of resin and aggregate to provide a moistureproof, shock-resistant seal. The core and coil encapsulation system shall minimize the sound level. Taps shall be two steps below nominal voltage in 5% increments.
4. On units rated 30 kVA and above the core and coil assembly shall be impregnated with non-hydroscopic, thermosetting varnish and cured to reduce hot spots and seal out moisture. The assembly shall be installed on vibration-absorbing pads and securely bolted to the base to minimize sound transmission. Taps shall be two steps above and 4 steps below nominal voltage in 2.5% increments.
5. Transformers 112.5 kVA and above shall have impedance levels of 5% or higher. If the transformer impedance levels are below 5%, it shall be the Electrical Subcontractor's responsibility to adjust the short circuit ratings of all panelboards downstream of the transformer to a rating higher than the maximum theoretical let-thru current of the proposed transformer.

E. Wiring/Terminations
1. Connectors shall be selected based on the conductor sizes indicated on the drawings.

F. Enclosure
1. The enclosure shall be made of heavy-gauge steel. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 degrees C. The core of the transformer shall be grounded to the enclosure.
2. On units rated 15 kVA and below the enclosure construction shall be totally enclosed, non-ventilated, NEMA 3R, with lifting eyes.
3. On units rated 30 kVA and above the enclosure construction shall be ventilated, NEMA 2, drip-proof, with lifting holes. All ventilation openings shall be protected against falling dirt.
4. Fan assisted convection cooling/ventilation shall not be acceptable

G. Finish
1. Prior to assembly, all internal and external steel and aluminum enclosure part shall be thoroughly cleaned and phosphatized. A polyester powder coating shall be applied electrostatically, and then fused on by baking in an oven. The coating shall have a thickness of not less than 1.5 mils for interior equipment and 3.0 mils for exterior equipment. The finish shall have the following properties:
   a. Impact resistance (ASTM D-2794): 60 Direct/60 Indirect
   b. Pencil Hardness (ASTM D-3363): H
   c. Flexibility (ASTM D-522): Pass 1/8 inch mandrel
   d. 5% Salt Spray(ASTM B117-85 [20]): 600 hours
   e. Color: ANSI 49 or 61 Gray

2.06 **EQUIPMENT IDENTIFICATION**

A. Manufacturers Standard Nameplate
1. A master nameplate, giving equipment designation, voltage rating, ampere rating, short circuit rating, impedance, manufacturer's name, general order number, item number, etc. shall be provided for all electrical distribution equipment specified herein.
2. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's drawings and/or wiring diagrams.

B. Unique Equipment Identification Nameplate
   1. Furnish and install uniquely engraved nameplates, mounted on the face of each assembly, shall be furnished for all electrical distribution equipment specified herein.
   2. Nameplates shall be laminated plastic and secured with screws.
   3. Nameplates shall be a minimum of 2 inch high x 2 1/2 inch wide, laminated with **[black letters on white background] [white letters on black background]**.
   4. Characters shall be 3/16 inch high, minimum.
   5. Engraved nameplate shall include equipment designation, ampere rating of upstream device (if applicable), voltage, phase, number of wires (i.e. 3 wire or 4 wire), and upstream panel feeder. Examples follow:

PANEL D42
1,600 AMPERE, 480/277 VOLT, 3 PHASE, 4 WIRE,
FED FROM SUBSTATION SSA
TRANSFORMER T4
75 KVA, 480 VOLT, 3 PHASE, 3 WIRE PRIMARY
208/120 VOLT, 3 PHASE, 4 WIRE SECONDARY
FED FROM PANEL D42
SERVES PANEL D22
PANEL D22
800 AMPERE, 208/120 VOLT, 3 PHASE, 4 WIRE,
FED FROM PANEL D42 VIA 225 kVA TRANSFORMER
PANEL R21
100 AMPERE, 208/120 VOLT, 3 PHASE, 4 WIRE
FED FROM PANEL D21

   6. Equipment that serves other electrical distribution equipment, such as substation serving distribution panels, motor control centers serving motors and equipment, distribution panels serving lighting and appliance panels and other equipment, engraved nameplates shall also be provided for all feeder breakers, mounted on the face of the assembly, with panel/equipment designations as indicated on the drawings. Examples follow:

CHILLER 1
PANEL D42
CHWP-1
PANEL L43
EAHU-4

PART 3 - EXECUTION

3.01 COOPERATION AND WORK PROGRESS

A. The Electrical work shall be carried on under the usual construction conditions, in conjunction with all other work at the site. The Electrical Subcontractor shall cooperate with the Architect, General Contractor, all other Subcontractors and equipment suppliers working at the site. The Electrical Subcontractor shall coordinate the work and proceed in a manner so as not to delay the progress of the project.

B. The Electrical Subcontractor shall coordinate his work with the progress of the building and other Trades so that he will complete his work as soon as conditions permit and such that interruptions of the building functions will be at a minimum. Any overtime hours worked or additional costs incurred due to lack of or improper coordination with other Trades or the Owner by the Electrical Subcontractor, shall be assumed by him without any additional cost to the Owner.

C. The Electrical Subcontractor shall furnish information on all equipment that is furnished under this Section but installed under another Section to the installing Subcontractor as specified herein.

D. The Electrical Subcontractor shall provide all materials, equipment and workmanship to provide for adequate protection of all electrical equipment during the course of construction of the project. This shall also include protection from moisture and all foreign matter. The Electrical

Subcontractor shall also be responsible for damage which he causes to the work of other Trades, and he shall remedy such injury at his own expense.

E. Waste materials shall be removed promptly from the premises. All material and equipment stored on the premises shall be kept in a neat and orderly fashion. Material or equipment shall not be stored where exposed to the weather. The Electrical Subcontractor shall be responsible for the security, safekeeping and damages, including acts of vandalism, of all material and equipment stored at the job site.

F. The Electrical Subcontractor shall be responsible for unloading all electrical equipment and materials delivered to the site. This shall also include all large and heavy items or equipment which require hoisting. Consult with the General Contractor for hoisting/crane requirements. During construction of the building, the Electrical Subcontractor shall provide additional protection against moisture, dust accumulation and physical damage of the main service and distribution equipment. This shall include furnishing and installing temporary heaters within these units, as approved, to evaporate excessive moisture and ventilate it from the room, as may be required.

G. It shall be the responsibility of the Electrical Subcontractor to coordinate the delivery of the electrical equipment to the project prior to the time installation of equipment will be required; but he shall also make sure such equipment is not delivered too far in advance of such required installation, to ensure that possible damage and deterioration of such equipment will not occur. Such equipment stored for an excessively long period of time (as determined in the opinion of the Architect) on the project site prior to installation may be subject to rejection by the Architect.

H. The Electrical Subcontractor shall erect and maintain, at all times, necessary safeguards for the protection of life and property of the Owner, Workmen, Staff and the Public.

I. Prior to installation, the Electrical Subcontractor has the responsibility to coordinate the exact mounting arrangement and location of electrical equipment to allow proper space requirements as indicated in the NEC. Particular attention shall be given in the field to group installations. If it is questionable that sufficient space, conflict with the work of other Subcontractors, architectural or structural obstructions will result in an arrangement which will prevent proper access, operation or maintenance of the indicated equipment, the Electrical Subcontractor shall immediately notify the Contractor and not proceed with this part of the Contract work until definite instructions have been given to him by the Architect.

J. The Electrical Subcontractor shall not allow any equipment or piping foreign to the electrical installation to be installed or pass through any room in which electrical systems or equipment are located, such as electric rooms, electric closets, telephone or data closets. The Electrical Subcontractor shall notify the Contractor of such violations and request immediate removal.

3.02 **INSTALLATION**

A. General

1. Unless specifically noted or indicated otherwise, all equipment and material specified in Part 2 of this specification or indicated on the drawings shall be installed under this Contract whether or not specifically itemized herein. This Section covers particular installation methods and requirements peculiar to certain items and classes or material and equipment.
2. The Electrical Subcontractor shall obtain detailed information from manufacturers of equipment provided under Part 2 of this specification as to proper methods of installation.
3. The Electrical Subcontractor shall obtain final roughing dimensions and other information as needed for complete installation of items furnished under other Sections or furnished by the Owner.
4. The Electrical Subcontractor shall keep fully informed of size, shape and position of openings required for material and equipment provided under this and other Sections. Ensure that openings required for work of this Section are coordinated with work of other Sections. Provide cutting and patching as necessary.
5. The Electrical Subcontractor shall coordinate the electric service installation with the Owner.

6. All miscellaneous hardware and support accessories, including support rods, nuts, bolts, screws and other such items, shall be of a galvanized or cadmium plated finish or of another approved rust-inhibiting coating.
7. Throughout this Section where reference is made to steel channel supports, it shall be understood to mean that the minimum size shall be 1 5/8" mild strip steel with minimum wall thickness of 0.105", similar to Unistrut P1000 or equal products manufactured by Kindorf or Husky Products Co.

B. Concrete Housekeeping Pads
1. Concrete pads shall be installed for all freestanding electrical distribution equipment.
2. The General Contractor shall provide the concrete work. Electrical Subcontractor shall supervise and coordinate concrete work to ensure that proper size and location, and grounding cable, rods, conduit, etc., are located as detailed and as required. The Electrical Subcontractor shall also ensure that the concrete is level to within manufacturers published tolerances.
3. All concrete housekeeping pads shall extend beyond the equipment supported as follows:
   a. Equipment with front and rear access, or equipment mounted freestanding with access in front and rear:
      1) 1” in front of the equipment
      2) 6" on each side of the equipment
      3) 6” in back of the equipment
   b. Equipment with front access only, mounted against a wall:
      1) 1” in front of the equipment
      2) 6" on each side of the equipment
      3) 0” in back of the equipment
4. Mounting height of the highest overcurrent/disconnect device in the above equipment shall not exceed 6'-6" above finished floor. If overcurrent devices exceed 6’-6” above finished floor as a result of the housekeeping pad, the pad shall extend in front of the gear a minimum of 4’-0”, and include ramps on each end.

C. Electrical Distribution Equipment
1. The Electrical Subcontractor shall install the electrical distribution equipment specified herein per the manufacturer’s recommendations and the Contract Drawings.
2. The installation of all equipment, including working space requirements, shall conform to all NEC and local codes.
3. All necessary hardware to secure the assembly in place shall be provided by the Electrical Subcontractor.
4. The Electrical Subcontractor shall ensure that no piping, ductwork or other equipment foreign to the electrical trade passes through the area extending from the floor to the structural ceiling with the width and depth equal to that of the electrical distribution equipment, plus 6" on either side of the equipment.
5. Floor mounted assemblies shall be installed on concrete housekeeping pads and shall be provided with adequate lifting means. Floor mounted assemblies shall be capable of being moved into installation position and bolted directly to the floor without the use of floor sills. The Electrical Subcontractor shall ensure the floor is level to 1/8 inch per 3-foot distance in any direction.
6. All electrical equipment shall be installed such that the handle of the highest circuit breaker does not exceed 6’-6” above finished floor.
7. The location of all electrical distribution equipment installed in mechanical or plumbing equipment rooms shall be coordinated with the respective Subcontractor.
8. The equipment shall be installed and checked in accordance with the manufacturer’s recommendations prior to first energization. This shall include but not limited to:
   a. Checking to ensure that the pad location is level to within .125 inches.
   b. Checking to ensure that all bus bars are torqued to the manufacturer's recommendations.
   c. Assemble all shipping sections, remove all shipping braces and connect all shipping split mechanical and electrical connections.

d. Secure assemblies to foundation or floor channels.
e. Measure and record megger readings phase-to-phase, phase-to-ground, and neutral-to-ground (four-wire systems only).
f. Inspect and install all circuit breakers, components, etc. in their proper compartments.

9. Points of access for all rooms and spaces containing equipment and wiring operating at 600 volts and above shall be kept locked and shall include conspicuously posted warning signs. The warning sign shall be legible and permanent and shall contain the following verbiage: DANGER – HIGH VOLTAGE – KEEP OUT.
10. Control wiring shall be provided as required. Interface all local and remote control wiring and operational systems for each load.

D. Wall Mounted Equipment
1. Recessed and surface mounted equipment shall be mounted on walls with studs and cross-bracing, as required to assure sufficient strength so as to restrict any movement of the equipment.

E. Dry Type Transformers
1. Floor mounted transformers shall be mounted a minimum of 6" from walls with proper clearance in front. Floor mounted transformers shall be installed on non-metallic, vibration isolating pads meeting seismic requirements and selected for at least 0.2” deflection. Panelboards shall not be mounted on wall above transformers.
2. Trapeze mounted transformers shall be supported with threaded rods and channel and shall be isolated with hanger isolators meeting seismic requirements and suitable for the weight and size of the transformer.

3.03 **MATERIALS AND WORKMANSHIP**

A. All materials and equipment shall be new and unused and shall meet requirements of the latest Standards of NEMA, UL, IPCEA, ANSI and IEEE. Equipment shall have components required or recommended by OSHA, applicable NFPA documents and shall be UL listed and labeled.

B. Despite references in the specifications or on the drawings to materials or pieces of equipment by name, make or catalog number, such references shall be interpreted as establishing standards of quality for materials and performance.

C. Finish of materials, components and equipment shall not be less than Industry good practice. When material or equipment is visible or subject to corrosive or atmospheric conditions, the finish shall be as approved by the Architect.

D. Provide proper access to material or equipment that requires inspection, replacement, repair or service. If proper access cannot be provided, confer with the Architect as to the best method of approach to minimize effects of reduced access.

E. All work shall be installed in a neat and workmanlike manner and shall be done in accordance with all Local and State Codes.

F. The Owner will not be responsible for material, equipment or the installation of same before testing and acceptance.

3.04 **FACTORY TESTING**

A. Standard factory tests shall be performed on the electrical distribution equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

B. Low Voltage Distribution Switchboard
1. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
a. The switchboard shall be completely assembled, wired, adjusted and tested at the factory. After assembly, the complete switchboard will be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment.

b. The bus system shall be given a dielectric test of 2200 volts for one minute between live parts and ground, and between opposite polarities.
c. The wiring and control circuits shall be given a dielectric test of 1500 Volts for one minute or 1800 Volts for one second between live parts and ground in accordance with ANSI C37.20.1.

C. Dry type Transformers
1. Ratio tests at the rated voltage connection and at all tap connections.
2. Polarity and phase relation tests on the rated voltage connection.
3. Applied potential tests.
4. Induced potential test.
5. No-load and excitation current at rated voltage on the rated voltage connection.
6. Resistance measurements on all windings at the rated voltage connection of each unit and at the tap extremes of the first unit made of a new design.

D. The manufacturer shall provide three (3) certified copies of factory test reports.

3.05 **FIELD SETTINGS**

A. The Electrical Subcontractor shall perform field adjustments of the circuit breakers as required to place the equipment in final operating condition.

B. Where electrical distribution equipment is provided with adjustable settings, each setting on each piece of equipment shall be set in the field by a qualified representative of the manufacturer prior to initial energization. The qualified representative of the manufacturer shall be retained by the Electrical Subcontractor. Settings shall be as determined by the final coordination study of the distribution system. See Section 26 0570.

C. Transformers
1. Adjust taps to deliver appropriate voltage and measure primary and secondary voltage to confirm proper setting.

3.06 **FIELD QUALITY CONTROL**

A. Provide the services of a qualified factory-trained manufacturer's representative to assist the Electrical Subcontractor in installation and start-up of the equipment specified under this section for a period of 2 working days. The manufacturer's representative shall provide technical direction and assistance to the Electrical Subcontractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. The Electrical Subcontractor shall provide three (3) copies of the manufacturer's field start-up report.

3.07 **MANUFACTURER'S CERTIFICATION**

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations.

B. The Electrical Subcontractor shall provide three (3) copies of the manufacturer's representative's certification before final payment is made.

C. A certified test report of all standard production tests shall be available to the Engineer upon request.

3.08 **TRAINING**

A. The Electrical Subcontractor shall provide a training session for up to 6 Owner's representatives for 2 normal workdays at a jobsite location determined by the Owner.

B. The training session shall be conducted by a manufacturer's qualified representative. The training program shall consist of the instruction on the operation of the assembly, circuit breakers, and major components within the assembly.

C. The training program shall include the following:
   1. Review of the project one-line drawings and schedules.
   2. Review of the factory record shop drawings.
   3. Review of all equipment in the electrical distribution system.
   4. Discuss the maintenance timetable and procedures to be followed in an ongoing maintenance program.
   5. Provide three ring binders to participants complete with copies of drawings and other course material covered.

END OF SECTION

SECTION 26 30 10
ELECTRICAL POWER GENERATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. All of the Contract Documents, as listed on the Table of Contents and including General and Supplementary Conditions and Division 01, General Requirements, shall be included in, and made part of, this Section.

1.02 DESCRIPTION OF WORK

A. Furnish a Standby, Legally Required and Optional Standby power generation system to automatically sense the loss of utility power, start the generator set and transfer the critical load between the normal and backup power source. The system shall also sense the return of utility power and automatically restore the system to its normal operating state.

B. The following general systems and equipment shall be provided for the new building and, as a minimum, but not necessarily limited to the following:
   1. Hoisting, rigging, setting of all equipment.
   2. Testing, cleaning and adjusting.
   3. Shop drawings.
   4. Standby generator.
   5. Generator Control Switchgear and integrated on-board microprocessor based control.

1.03 RELATED WORK

A. Carefully examine all of the Contract Documents, criteria sheets and all other Sections of the specifications for requirements which affect work under this Section, whether or not such work is specifically mentioned in this Section.

B. For work related to, and to be coordinated with, the electrical work, but not included in this Section and required to be performed under other designated Sections, see the following:
   1. Division 03 – Concrete housekeeping pad
   2. Division 26 – Natural Gas system
   3. Division 26 - Engine Exhaust System, including installation and insulation of muffler
   4. Division 26 - Generator enclosure air intake and exhaust systems

1.04 REFERENCES

A. The electrical power generation covered by these specifications shall be designed, tested and assembled in strict accordance with the latest edition of all applicable standards including, but not limited to, the following:
   1. National Electrical Code (NEC)
   2. National Fire Protection Association (NFPA) 110
   3. NFPA 101
   4. American National Standards Institute (ANSI)
   5. Underwriters Laboratories (UL)
   6. Institute of Electrical and Electronics Engineers (IEEE)

B. Standby Generator
   1. The standby generator and all components shall be designed, manufactured and tested in accordance with the latest applicable standards as follows:
      a. American Society of Mechanical Engineers (ASME)
      b. EEC 89/392 Safety and Health
      c. Electrical Generating Systems Association
      d. Institute of Electrical and Electronic Engineers (IEEE)
      e. National Electrical Code (NEC)
      f. National Electrical Manufacturers Association (NEMA)
      g. National Fire Protection Agency (NFPA)
      h. Occupational Safety and Health Act (OSHA)

1.05 **QUALITY ASSURANCE**

A. The manufacturers listed within this specification have been preselected for use on this project. No submittal will be accepted from a manufacturer other than specified.

B. To ensure system compatibility, standby generators, generator control and automatic transfer switches shall be furnished to the Electrical Subcontractor by the Medium Voltage Switchgear Manufacturer for single source responsibility. Coordination with the on-generator set paralleling controls shall be provided.

C. The manufacturer shall have a local, authorized dealer who can provide factory trained servicemen, the required stock of replacement parts, technical assistance and warranty administration within a reasonable distance from the project.

1.06 **WARRANTY**

A. In addition to the requirements above, the manufacturer of the generator set shall provide a full five (5) year/2,500 hour extended warranty starting from the date of the accepted job site testing. The warranty shall include the following:
   1. Repair parts
   2. Labor
   3. Travel expenses
   4. Expendables including:
   5. Lubricating oil
   6. Filters
   7. Antifreeze
   8. Other service items made unusable by the defect.
   9. In the event the generator and/or on-generator paralleling controls require replacement, the warranty shall also cover the following, including installation, hoisting and rigging:
      a. Removal of the defective unit.
      b. Installation of the new unit.
      c. Temporary generator and/or transfer switch to maintain occupancy of the facility.
      d. All required electrical disconnections and connections to restore the system to its original condition.

B. Warranty Nameplate
   1. A warranty nameplate, 6” x 8” shall be affixed to the generator set with the following data:
      a. Warranty period
      b. Start-up date
      c. Termination date
      d. Supplier name
      e. Supplier address
      f. 24 hour emergency telephone number
      g. Preventative maintenance to be performed by:

1.07 **MAINTENANCE AND REPAIR CONTRACT**

A. The generator set supplier shall provide a one (1) year maintenance and repair contract, which shall begin following final acceptance by the Owner, which shall guarantee all support costs of the specified system. It shall include routine and 24 hour emergency access to a factory account manager to expedite emergency repairs. The contract shall include, as a minimum:
   1. Annual lube, oil and filter replacement.
   2. Fuel and air filter replacement.
   3. Fluid analysis, including
      a. Oil
      b. Coolant
   4. Function testing of all generator safeties and alarms
   5. Visual inspection of all belts, hoses, etc. and replacement as needed.

B. The generator set supplier shall offer, to the Owner, an extended maintenance and repair contract, upon expiration of the initial one (1) year maintenance contract, to be renewed

annually which shall guarantee all support costs of the specified system for the duration of the contract, as indicated above. It shall include routine and 24 hour emergency access to a factory account manager to expedite emergency repairs.

1.08 **SELECTIVE COORDINATION**

A. All overcurrent protection devices shall be selectively coordinated with all upstream overcurrent protection devices, to meet the requirements of the 2017 National Electrical Code, based on the highest calculated value (from utility and/or generator) of available short circuit current, at the overcurrent protection device terminals, as follows:
2017 NEC

	Distribution System:	Coordination Time, in Seconds	NEC Code Article
1.	Legally Required Distribution System:	0.01	701.27
2.	Fire Pump Distribution System	0.01	695.3 (C)(3)
3.	All Other Power Distribution Systems	0.10	240.12

B. The generator and on-generator set paralleling controls manufacturer shall coordinate with medium voltage distribution equipment manufacturer, and shall be responsible to select appropriate overcurrent protective device, fuse and/or circuit breaker frame, sensor and trip sizes for all devices upstream of other devices for a completely coordinated system.

1.09 **WITHSTAND AND INTERRUPTING RATINGS OF ELECTRICAL COMPONENTS**

A. Calculated available 3 phase and single phase to ground short circuit currents indicated on the drawings are provided for information only to assist in the selection of withstand and interrupting ratings and coordination of devices and equipment.

B. Prior to submission of shop drawings, the generator manufacturer shall obtain short circuit calculations from the low voltage distribution equipment manufacturer to determine actual available 3 phase and single line to ground short circuit current at each component in the system based on actual equipment, feeder lengths, impedances, etc. of the equipment proposed for this project. Failure to obtain the calculated short circuit values prior to submission of shop drawings shall not relieve the generator switchgear manufacturer from providing devices that meet the requirements of the final study report.

C. Each component shall be UL listed and labeled and shall be fully rated to withstand and interrupt calculated available 3 phase and single phase to ground short circuit current levels. Series ratings will not be acceptable.

1.10 **SUBMITTALS**

A. All shop drawings shall have clearly marked the appropriate specification number of drawing designation, for identification of the submittal.

B. Disposition of shop drawings shall not relieve the Electrical Subcontractor from the responsibility for deviations from drawing or specifications, unless he has submitted in writing a letter itemizing or calling attention to such deviations at time of submission and secured written approval from the Engineer, nor shall such disposition of shop drawings relieve the Electrical Subcontractor from responsibility for errors in shop drawings or schedules.

C. Shop drawings shall include, but shall not be limited to, the following:
   1. Component List - A breakdown of all components and options.
   2. Generator Set
      a. Technical Data - Manufacturer produced generator set specification or data sheet identifying make and model of engine and generator, and including relevant component design and performance data.
      b. Performance - Based on standard conditions of 100 kPa (29.61 in Hg) and 25C (77F); and an LHV of 905 BTU/SCFH
      c. Engine Manufacturers Data Sheet:
         1) Type, aspiration, compression ratio, and combustion cycle
         2) Bore, stroke, displacement, and number of cylinders

3) Horsepower
4) Engine lubricating oil capacity
5) Engine coolant capacity without radiator
6) Engine coolant capacity with radiator
7) Derating basis and rates
8) Cooling system maximum temperature and air flow with maximum restrictions
9) Combustion air inlet flow rate
10) Exhaust gas, flow rate
11) Stack temperature
12) Exhaust system backpressure (maximum)
13) Heat rejection to:
    a) Coolant
    b) Aftercooler
    c) Exhaust
    d) Atmosphere from engine
    e) Atmosphere from generator

d. Alternator:
1) Model
2) Frame
3) Insulation class
4) Number of leads
5) Nominal kVA and temperature rise
6) Starting kVA
7) Derating factors based on altitude and temperature
8) Weight, total
9) Weight, rotor
10) Conduit entrance locations
11) At rated voltage:
    a) Efficiency at 0.8 power factor for:
        (1) 50% load
        (2) 75% load
        (3) 100% load
    b) Time constants; short circuit transient (T'D)
    c) Time constants, armature short circuit (TA)
    d) Reactance, subtransient - direct axis (X"D),
    e) Reactance, transient - saturated (X'D)
    f) Reactance, synchronous - direct axis (XD)
    g) Reactance, negative sequence (X2)
    h) Reactance, zero sequence (X0)
    i) Fault current, single phase and 3 phase symmetrical
    j) Decrement curve

e. Radiator:
1) Model
2) Type
3) Fan drive ratio
4) Coolant capacity, radiator
5) Coolant capacity, radiator and engine
6) Weight, dry
7) Weight, wet
8) Airflow
9) Static pressure

f. Generator set characteristics:
1) Power rating at 0.8 power factor based on conditions as specified herein
2) kVA rating
3) Fuel consumption at standard conditions for:
    a) 50 % load

b) 75 % load
c) 100% load
4) Overall dimensions:
a) Length
b) Width
c) Height
5) Weight, dry
6) Weight, wet
7) Sound data in a free field environment

g. Mounting and anchoring requirements to meet seismic zone requirements.
h. Drawings - General dimensions drawings showing overall generator set measurements, mounting location, and interconnect points for load leads, fuel, exhaust, cooling and drain lines.
i. Wiring Diagrams - Wiring diagrams, schematics and control panel outline drawings published by the manufacturer showing interconnected points and logic diagrams for use by contractor and owner.
j. Specification or data sheets for auxiliary equipment, including:
1) Vibration isolators
2) Silencer
3) Enclosure
4) Battery charger
5) Batteries

3. Written statement of warranty.
4. EPA certificate of compliance.
5. Service - Location and description of supplier's parts and service facility including parts inventory and number of qualified generator set service personnel.
6. The following equipment rooms with all the electrical equipment laid out with dimensions, Code clearances, etc., indicated shall be submitted with the equipment shop drawings. Acceptance of these shop drawings shall be obtained prior to installation of feeder conduits:
a. All emergency electrical rooms and closets.
b. Standby generators.
c. Automatic transfer switches/distribution switchgear.

Notes:

Equipment shop drawings will not be reviewed without the room/equipment layouts.

The Architect/Engineer reserve the right to rearrange equipment in electrical equipment rooms or spaces once final equipment dimensional information is known and prior to installation of the equipment. Install equipment in the final location selected by the Architect/Engineer at no additional cost to the Owner.

PART 2 - PRODUCTS

2.01 STANDBY GENERATORS

A. General
1. Furnish and install (2) new natural gas engine driven generator sets, with physical capacities and on-generator set paralleling controls, as specified herein and shown on drawings. Each engine generator set shall be mounted in an individual walk-in, sound attenuated, weatherproof enclosure.
2. The generator sets and accessories specified herein shall be paralleled via the on-generator control. Furnish and install all controls and interfaces required to accomplish this.
3. Each engine-generator set shall be 2500 kW, 3104 kVA standby rated, 3 phase, 4 wire, 13200 volts, 60 Hz, 12 lead and 0.8 power factor.

4. The generator set shall provide the above specified kW output power at 25 feet above sea level, an external ambient air temperature of 77F and with all parasitic loads, such as water pump, etc. attached.
5. All units shall be capable of picking up their rated capacity in one (1) step and provide a transition time, from instant failure of the normal power source to the standby generator source, of ten (60) seconds or less.
6. Each engine generator set shall be as manufactured by Caterpillar, Model Number G3520 or equivalent product as manufactured by KOHLER/Cummins/MTU/Siemens.
7. The engine generator set supplier shall submit documentation to prove that service and parts are available 24 hours/day, 7 days/week, 365 days/year. Service time, after receipt of notification of problem or failure, shall not exceed four (4) hours for response and arrival of technical service representative at the jobsite. Generator sets shall be furnished by the authorized distributors of the equipment who have assigned territory in the area in which the generator sets are to be installed. Equipment furnished by others not having a defined assigned territory will not be considered.

B. Engine
1. The engine shall operate satisfactorily on a natural gas. Ratings shall be as listed in the manufacturers published data sheets, and have been in service for a minimum of five (5) years. Engines with non-published, new, or special ratings will not be considered.
2. The generator set shall be EPA factory certified for stationary standby use and comply with all state and local Codes / Ordnances at the time of installation and commissioning. This shall include, but not be limited to, engine exhaust emissions and sound emissions.
3. If after coolers are required, the only source of water shall be engine jacket water.
4. The gas engine shall be of the vertical, minimum 8-cylinder, maximum 20-cylinder. Two-cycle engines will be unacceptable and will not be considered. The nominal speed of the engine in the service anticipated shall not exceed 1,800 rpm. The cylinder liners of the engine shall be of the wet type and removable. The complete natural gas engine generator unit shall be free from critical and torsional vibration within the operating speed range as demonstrated by prototype testing.
5. Each engine shall be furnished complete with the following accessories:
    a. Spin-on full flow and bypass type lubricating oil filters with lube oil sump drain extension.
    b. Dry type replaceable dual-element type air cleaner for air intake system. Fuel oil cooler shall be provided and factory piped on the radiator by the engine supplier when required by the engine manufacturer for full load operation under the ambient condition specified.
    c. Replaceable, spin-on dual element type filters and strainers, to be engine mounted in fuel line between supply tank and fuel pump.
    d. A fuel strainer shall be provided as per the generator set MFG requirements to remove particles and debris from the incoming fuel supply line
    e. Provide the incoming fuel train as required per the MFG requirements for a natural gas fired engine generator set. Pressure losses through the fuel train shall be kept to a minimum. Provide fuel train per NFPA 37.
    f. Flexible fuel lines between engine and fuel supply shall be installed to isolate vibration.
    g. The engine speed shall be governed by an electronic isochronous governor, to maintain governed speed at 0% control for rated frequency operation. The frequency at any constant load, including no load, shall remain within a steady state band width or ±0.25% of rated frequency (isochronous operation).
    h. Overspeed shutdown control for protection against overspeeding. Overspeed control shall be solid state type.
    i. Jacket water heater(s), 208 volt, single phase, with thermostatic control and oil pressure disconnect switch to maintain engine at a temperature which allows for starting and full load pick up within 10 seconds in a 40 degrees F generator room or enclosure environment. Coolant heaters shall be supplied from normal facility power.

Jacket water heaters shall be furnished with ball valve shut-offs at the inlet and outlet and factory wired relays to disconnect power during engine operation. Provisions to replace the heater, without draining the engine cooling system fluid, shall be provided.

j. The engine shall have a full guard system for all belts, pulleys, vibration dampers. The guard system shall meet the requirements of OSHA.
k. Furnish and install exhaust manifold and turbo charger guards in accordance with OSHA requirements.

6. Radiator
   a. Each engine shall be furnished with a unit mounted radiator cooling system having sufficient capacity for cooling the engine when the generator set is delivering full-rated load at the above referenced altitude and ambient temperature. Manufacturer shall supply factory test data to verify radiator cooling at full load with manufacturers default ambient temperature, measured 10'-0" behind generator set and with an external static pressure drop of 0.5” WC (in addition to the radiator core restriction).
   b. Radiator shall be supplied with radiator duct flange and pressure cap.
   c. Low coolant level warning contacts with audible and visual alarm shall be furnished in radiator expansion tanks.
   d. The engine cooling system shall be filled with a solution of 50% ethylene glycol, with engine manufacturer's recommended additives, and 50% distilled water.
7. Each engine generator set shall be supplied with a unit mounted control and engine gauge panel, mounted and wired by the generator set manufacturer. Combination engine/generator controls and indicator shall include:
   a. Control panel shall have built-in diagnostic capability to annunciate loss for shutdown sensing control.
   b. Fuel pressure gauge and tachometer.
   c. Digital AC 3 phase metering, true RMS, 0.5% accuracy, of the following:
      1) Amps
      2) Volts
      3) kW (total and per phase)
      4) power factor
      5) kVAR (total and per phase)
      6) frequency
   d. DC voltmeter, digital.
   e. Water temperature gauge, digital.
   f. Oil pressure gauge, digital.
   g. Running time meter with reset switch indicating total hours since last reset, and total operating hours.
   h. Three (3) Current transformers and potential transformers as required for functions specified.
   i. Necessary fuses.
   j. Generator voltage regulator, microprocessor-based, true RMS sensing, full wave rectified, with pulse-width modulated output to the alternator field.
   k. Provide voltage adjustment up to ±10% from nominal voltage. The voltage and voltage regulator gains shall be adjustable from the operator panel.
   l. The engine control panel shall monitor the integrity of the generator start circuit wiring from the generator control switchgear thru the normally open and normally closed starting contacts in the master cubicle. If one contact changes state, and the other does not, the engine shall start and the generator local control panel, master cubicle annunciator panel and all remote annunciator(s) shall indicate a visual and audible Start Signal Wiring Derangement alarm.
   m. The control system shall display all alarm and shutdown conditions via fault code and plain language displays. At a minimum, the control system shall display all alarm and shutdown conditions as required by NFPA 110. In addition, each fuel tank in the

system shall be monitored for high, low and shutdown fuel level. All AC protective functions shall also be displayed by the control when initiated

n. Auto-start control consisting of:
   1) All alarm and shutdown conditions indicated via fault code and plain language displays. In addition to the minimum alarm and shutdown conditions required by NFPA 110, the control system shall also display the following:
      a) All AC protective functions, such as Ground Fault initiation.
      b) Low Oil Pressure Prewarn
      c) Low Oil Pressure Shutdown
   2) Alarm status for all shutdown and prewarns shall be connected to the Building Automation System via RS485 modbus / ethernet network. Also, provide a common alarm relay providing at least one set of normally closed dry contacts opening on any shutdown or prewarn condition.
   3) Alarm contacts for the following indications, wired to terminal strip for fire alarm system annunciation:
      a) Standby generator "ON"
      b) Standby generator "start failure"
      c) Standby generator "common pre-alarm"
      d) Standby generator "common shutdown"
   4) Mode selector switch - "Auto-Off/Reset Manual".
   5) Control power fuse.
   6) Panel illuminating lights.
   7) Remote start contacts.

o. Each generator shall be provided with on-board paralleling control mounted on the package or remotely.

p. Each generator set shall be furnished with an RS485 or CAN network for connection to generator control switchgear cubicles, for remote annunciation at the building manager office, for remote annunciation at the fire command center (see fire alarm system specification) and to the building automation system. All control and power wiring between each generator, remote annunciators, main oil tanks, etc., shall be installed in conduit and shall be installed in accordance with generator manufacturer's and switchgear manufacturer's requirements by the Electrical Subcontractor. Termination points shall be for:
   1) Generating.
   2) Generator derangement alarm point for each prewarn and shutdown. Provide common generating and common alarm point for each generator for connection to the building automation system.

8. The engine manufacturer shall provide the necessary lube oil for the crankcase and antifreeze for the cooling system to provide protection to -20°F. Oil and coolant drains with lockable valves shall also be provided.

C. Alternator
   1. The alternator shall be standby rated. 60 Hz, and 0.8 power factor. The voltage output shall be 13200 volts, 3 phase, 4 wire. It shall meet all requirements of NEMA MG 1, Section IV, Part 32 (2014), in design, performance and factory test procedures. The regulator shall be factory wired and tested with the generator set.
   2. The alternator shall have a calculated motor starting capability of **[ ]** sKVA at a maximum 20 percent voltage dip based on the alternator transient reactance in compliance with the requirements of NEMA MG1, and shall have a subtransient reactance between 11% - 16%.
   3. Cast iron end brackets and fabricated steel frames shall be used. The unit shall be fully guarded per NEMA MG-1-1.25. Bearings shall be of the shielded anti-friction type with provisions for adding and/or changing grease through grease pipes extended to the generator exterior. Minimum B-10 bearing life shall be 40,000 hours.
   4. Each alternator shall be of brushless construction using a full-wave, 3 phase rotating rectifier assembly with hermetically sealed, metallic type silicon diodes to supply the main

field excitation. The rotating exciter shall be mounted to allow removal of all or any part of the exciter without disassembly of the generator. It shall be possible to check the rotating diodes without breaking any solder connection. A multi-plate solenium surge suppressor shall be connected across the rotating diode network to protect it against transient conditions. A permanent magnet (PMG) type generator shall be furnished.

5. The insulation system of both the rotor and stator shall be of NEMA Class F or Class H materials and shall be synthetic and non-hygroscopic. The temperature rise of both the rotor and stator, as measured by the resistance method, shall be in accordance with NEMA MG-1-22.40 and shall not be greater than 130°C rise over 40°C ambient.
6. The voltage regulation shall be ±1.0% from no-load to full load and 5% frequency variation. Regulator drift shall be less than 1% per 72°F (40°C) ambient temperature change. The voltage regulator shall be 3 phase sensing type, volts per hertz static type with radio interference suppression to normally acceptable commercial levels. The regulator printed circuit board shall be covered with a conformal coating to protect it from moisture. Regulator shall include under-frequency, over-voltage and overload protection. Regulator shall have a circuit which removes excitation when generator is overloaded and the alternator is approaching its thermal damage limit.
7. Voltage dip shall not exceed 20% upon application of standby loads, at 0.8 power factor, with recovery to steady state band conditions within five (5) seconds as measured on a digital recorder.
8. The wave form harmonic distortion shall not exceed 5% total RMS measured line-to-line at full rated load. The TIF factor shall not exceed 50.
9. Each generator shall be self-ventilated and shall have a one (1) piece, cast aluminum alloy, uni-directional internal fan for high volume, low noise air delivery.
10. All performance and temperature rise data submitted by the generator manufacturer shall be the result of the actual test of the same or duplicate generators. Temperature rise data shall be the result of full load, 0.8 power factor heat runs at the rated voltage and hertz. All performance testing shall be done in accordance with Mil. Std. 705 and/or IEEE Std. 115. Voltage adjusting rheostat for ±10% shall be incorporated in the generator control switchgear.
11. Each alternator shall be furnished with an oversized wiring chamber with copper bus bars, mounted on the generator end of the unit. Lugs shall be suitable for the conductors installed in flexible liquidtight conduit with sufficient slack to compensate for generator deflection, and shall be mounted on bus bar assembly prior to shipment. Provide a solid state electronic ground fault sensing device that will provide an alarm output contact, for indication only, for integration into the generator control panel local and remote annunciator. The unit shall be mounted in the generator control panel and be fully wired to the generator by the generator manufacturer. The unit shall be UL Listed, 24VDC powered, and have fully adjustable pick-up and time delay settings.
12. Nameplates
    a. Each alternator shall include a factory installed nameplate to include, as a minimum, the following information:
        1) Manufacturers name
        2) Rated Frequency
        3) Number of phases
        4) Rated kW/kVA
        5) Power factor
        6) Rated voltage
        7) Rated amperes at rated voltage
        8) Rated RPM
        9) Rated ambient temperature
        10) Rated temperature rise
        11) Transient and subtransient reactance
        12) Insulation system class
        13) Time rating

b. In addition, marking shall be provided by the manufacturer to indicate whether or not the alternator neutral is bonded to the generator frame.
c. If the bonding of the alternator is modified in the field, the marking on the alternator shall also be modified accordingly.

13. Circuit Breakers
    a. The manufacturer shall furnish fully assembled medium voltage vacuum circuit breakers as detailed in these specifications.
    b. Drawings, instruction books, and other materials included with the inquiry shall be considered part of the specification.
    c. The vacuum circuit breakers shall be designed for maximum voltages of either 5 kV or 15 kV, as designated.
    d. The applicable codes and standards listed below shall be considered part of this specification. The latest revision in effect on the date the request for proposal was issued shall apply for all standards referenced.
        1) IEEE C37.013 Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis.
        2) IEEE C37.013a Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis. Amendment 1: Supplement for Use with

D. Exhaust System
1. Exhaust silencer shall be selected to maintain the integrity of the enclosure sound levels specified. IT shall be provided with valved condensate drain that extends beyond the depth of the insulation, and of the proper size for use with the engine shall be furnished. It shall have a bottom inlet and top outlet with a 12 inch water column maximum pressure drop. Flexible, full length stainless steel connector shall be furnished. The generator set manufacturer shall furnish a wye connector with all appropriate fittings, flanges, etc., as required.
2. Exhaust silencer shall be mounted and insulated within the enclosure and prepiped to the generator and exhaust stack.

E. Battery / Charger
1. Two (2) 12 volt heavy duty lead acid storage batteries for each starter shall be provided, connected for 24 volt output, having a capacity of 205 amperage hours at 20-hour rate; 1050 amperes, 1.5 minutes at 0°F; and 1250 amperes, 1.5 minutes at 32°F, complete with necessary cable and connectors, sized in accordance with manufacturer's recommendation. In no event shall less than Size 000 cable be used. A battery rack shall be provided. Battery heater pad shall be provided for 120 volt operation.
2. A float battery charger shall be provided for the units, to maintain batteries at full charge at all times and maximize battery and charger life. The charger shall be of sufficient size to return batteries to nominal voltage, following engine start, within the timeframe required by NFPA 110. For generators 1,000 kW and larger, the charger shall be in a steel enclosure for wall mounting, and be fed from the enclosure panelboard at 120 volt, single-phase, 60 Hz and the DC output shall be wired to the batteries. The charger shall be capable of withstanding temperatures as low as 0°F. The charger shall be as manufactured by LaMarche Mfg. Co., 24 volt DC output with 120 volts, single-phase, 60 Hz, AC input.
3. Charge rate shall be temperature compensated over a range of -40C to 60C to prevent over or under charging the generator set batteries. The charger shall be fully operational over a temperature range of 0 to 110 degrees Fahrenheit. Charger(s) shall NOT be mounted on the generator set. Charger(s) shall be sized based number of batteries and battery type using the following table:

Battery Size	Minimum Charger Output (Amps)	Number of Batteries for 24V System
Group 24	10	2
Group 27, 31	15	2
4D	20	2
8D	20	2
2 x 8D	30	4
3 x 8D	50	6

4. The charger shall employ transistorized controlled magnetic amplifier circuits to provide continuous taper charging. The charge shall vary from 0.05 amperes on a low battery to a milliampere current on a fully charged battery. It shall maintain rated output voltage within ±1.0% from no-load to full-load with AC variations of ±10%. It shall have float and equalize ranges, 0 to 24 hour equalizing charger timer, AC line compensation, automatic overload protection (current limiting), fused AC input and DC output, automatic DC regulation and automatic surge suppressors.
5. The charger shall have a DC ammeter and DC voltmeter. Low DC voltage, high DC voltage, alarm relays and AC power failure relay shall be included and annunciated at the generator set control panel.

F. Remote Annunciator
1. A recessed mounted remote alarm annunciator per NFPA 110 shall be included for installation by the Electrical Subcontractor in the building manager's office in the Central Utility Plant. Annunciator shall be in compliance with NEC and shall include interface terminal block to match numerically and sequentially with generator mounted annunciator terminal block. Panel shall have stainless steel faceplate with permanent nameplates for audio and visual indication.

G. Load Bank (Add Alternate)
1. General
   a. Power source to load bank connection shall be 3-phase, 3-wire, plus ground. Furnish and install control wire connections for remote control as required by the manufacturer.
   b. The load bank manufacturer shall provide one day start-up service of the load bank, on site, after the load bank has been installed and connected.
   c. The load bank shall be supplied with a 2-year manufacturer's warranty which covers all materials and service labor. The manufacturer shall demonstrate the availability of factory service technicians in support of the load bank.
   d. The load bank for this application shall be as manufactured by one of the following:
      1) Asco
      2) Avtron
      3) Simplex Inc., Springfield, Illinois
2. Rating
   a. Load bank capacity shall be 50% of the generators standby kW rating, 1.0 p.f.
   b. Load Steps 5
   c. Voltage: 13200 volts AC, 3-ph., 3-W
   d. Frequency: 60 Hertz
   e. Air intake temperature: 155ºF maximum (radiator air outflow)
   f. Airflow requirements: Radiator air outflow
   g. Duty Cycle: Continuous
   h. Air temp. rise: 100ºF, nominal
   i. Air back pressure: .25-50" water column
3. Design
   a. The load bank shall be a completely self-contained unit which includes all resistive load elements, load control devices, load element branch circuit fuse protection, main load bus and terminals, control terminals, system protection devices and enclosure of required type.

b. The load bank shall be the manufacturer's standard product that has been investigated, tested and listed by Underwriters Laboratories or equivalent NRTL as a system.
c. NEMA Type 3R, welded sheet steel, UL approved finished painted consisting of an epoxy primer and a polyurethane top coat, consisting of a power section, for installation and wiring of the load elements and a control section for installation and wiring of control components. The control section shall be physically and thermally isolated from both the hot load elements and the heated airflow. Mounting adapters suitable for the installation method selected shall be supplied with the load bank. The exhaust of the load bank shall be screened.
d. Load elements shall be UL listed, labeled or recognized, Simplex Power Web Open wire, helically wound, chromium alloy, thermally derated to 60%. 5% tolerance, 2% balance, 0.995 p.f. element wire mechanically supported over entire length such that if a wire should break, the broken wire segments will not short to adjacent conductors or to ground. Load elements are individually serviceable and replaceable in the field without major disassembly of the load bank.
e. Branch circuit fuses shall be provided for each 50KW load branch circuit. Fuses shall be 200,000 A.I.C current limiting type.
f. One magnetic contactor shall be provided for each fused branch circuit.
g. Load bank power wiring shall be 150ºC insulated. Control wiring shall be 105ºC insulated.
h. Main terminals shall be plated bus bar with a hole pattern to accept customer supplied cable
i. Control power shall be derived internally from the main load bus. Control and protective circuits shall operate at 120V via control power transformer or line-neutral circuit and shall be fused.
j. The load bank shall include a comprehensive protection system to protect against overheating. The system shall function to disconnect the load elements from the power source and activate an alarm upon sensing a loss of cooling airflow, or an exhaust air temperature greater than 300˚F.

4. Remote Control Panel
   a. A NEMA type 1 control panel for automatic operation shall be provided. The panel shall include:
      1) Control power on-off push-buttons
      2) "Normal operation" indicator lamp
      3) Master load control switch
      4) Load step control switches
      5) "Cooling failure" alarm indicator lamp
      6) Remote control panel shall be UL listed.
5. Automatic load bank controller
   a. The load bank shall be equipped with an automatic controller which will be activated when the load bank mode control selector switch is placed in the "automatic" position.
   b. In automatic mode, the load bank shall be on-line and continuously operative whenever the power source runs. The load bank shall provide a component of the total power source load and shall be automatically variable in response to dynamic total load demands upon the power source.
   c. The automatic controller shall include control logic, solid-state sensors and time delays which shall act to apply/remove load bank component in multiple steps in response to dynamic output of the power source.
   d. The automatic controller shall function to maintain total load upon the power source within a preset bandwidth by adding load bank load component as external load component drops and removing load bank component as external load rises.
   e. The automatic controller shall sense load (amperes, kilowatts)
   f. Full manual control of the load bank shall be restored when the mode selector switch is placed in the "manual" position.

g. The automatic controller shall include a solid-state load sensor with level and time delay adjustment and output contacts for each load step. A current transformer for external installation shall be provided.

6. Automatic load step addition/subtraction
   a. The load bank shall be equipped with a programmable logic controller (PLC) for automatic load step addition/subtraction which will be activated when the load bank mode control selector switch is placed in the "automatic" position.
   b. In automatic mode, the load steps are initiated by a switch closure signal from generator exercise program (provided by the generator controller). Controller shall include provision for an adjustable delay between up/down steps and duration of test period length. Typical connection method is to provide contact closure from either the generator breaker or the ATS. Auto load step addition initiates on closures of this contact and ends on opening of contact. The contact opening then puts the load bank back into normal mode.
   c. The automatic controller shall include control logic, solid-state sensors and time delays which shall act to apply/remove load bank component in sequential steps in during the generator exercise cycle.
   d. Control power shall be 120v, single-phase from an external power source.

H. Portable Eyewash Station
   1. At the exit of the generator enclosure containing lead acid batteries, furnish and install an Acran #5PEW0001, 16 gallon self-activated portable eyewash station as required for OSHA 29CFR1910.151(c) compliance. Eyewash station shall be capable of delivering 0.7 gpm for 15 minutes.
   2. Eyewash station shall be filled with clean, potable water with a bacteriostatic additive to protect against bacteria, fungus, algae and acanthamoeba.
   3. Immediately adjacent to the eyewash station, provide a 16 gallon portable eyewash storage tank to accept all eyewash discharge. Storage tank shall be Acran #5PET0016.

I. Weatherproof Housing
   1. Each generator set shall be individually enclosed in a walk-in weatherproof enclosures as detailed on the drawings and constructed of aluminum throughout. The housing shall be designed to accommodate heavy snow loads and shall be equipped with motorized intake and exhaust louvers, pre-wired and pre-piped prior to shipment. Housing shall be Pritchard Brown #2130, Robinson enclosure MFG's or Modutek Intl, and shall be constructed per BOCA requirements.
   2. The housing shall have the following dimensions:
      a. Width: 12'-0" Minimum
      b. Length: 55'-0" Maximum
      c. Height: 13'-0" Maximum
   3. Housing shall have hinged, lockable, keyed alike doors with stainless steel hardware. The doors shall be so arranged as to provide access to vital parts of the generator set for service. Oil pan well and oil drain extension shall be included. Coolant drain and oil drain shall be extended outside housing with lockable rustproof valves.
   4. Housing shall be prepainted with manufacturers standard baked-on aluminum exterior finish or spray painted with custom color. Baked-on or spray paint color shall be as selected by the Architect at the time of submission. Submit paint chart of baked-on finishes with submittal. Interior shall be anodized aluminum.
   5. Housing shall include sound attenuation with thickness and type of sound insulation and intake and exhaust baffles necessary to achieve a minimum reduction of 25 dB at 1 meter in a free field environment. There shall be no puretone. Walls and ceiling shall be lined with perforated aluminum liner.
   6. Housing shall include intake and exhaust air louvers for the generator set. Louvers shall be normally open, and electrically held closed, so that they immediately open on loss of power, or on a start command to the generator set.
   7. Standby Generator Break-Glass Station

a. Furnish and install an standby generator break-glass station, mounted on the exterior of the enclosure so that it is within sight of the building served for grade mounted unit(s). Enclosure manufacturer shall consult with the Electrical Subcontractor as to the final location and arrangement of the generator to determine the proper location of the station.
b. Standby generator break-glass station shall be as manufactured by Pilla Electrical Products, Inc. Model number ST120SN3RSL – PILCLHCOV5A and shall have the following features and accessories:
    1) Box shall be surface mounted, metallic with NEMA 3R enclosure
    2) Round break glass pushbutton
    3) Contacts rated as required by the engine manufacturer
    4) Audible alarm when cover is raised
    5) Pad lockable cover with pad lock and keys
c. Station shall be factory wired to the standby generator stop contacts. Manual intervention shall be required to restart the generator following actuation of the standby stop pushbutton.

8. Housing shall be equipped with enclosed and gasketed fluorescent fixtures with 0° ballasts, octron lamps and on/off switch, and two (2) duplex receptacles. The enclosure shall also have two (2) DC lighting fixtures with self-contained battery with 120 volt input from enclosure panel.
9. Housing shall be equipped with a minimum of two (2) electric unit heaters, prewired to the enclosure panelboard to maintain a minimum of 50°F with an exterior design temperature of 0°F.
10. Housing shall be completely wired prior to shipment including main circuit breakers and enclosure panelboard as indicated on the drawings. Lugs shall be provided for incoming feeders.
11. Enclosure panelboard shall be 225A, 3 phase, 4 wire, 208/120 volt with 150 ampere, 3 pole main circuit breaker and branch breakers, sized as required, (minimum 20 ampere, single phase) for the following equipment including, but not limited to:
    a. Jacket water heaters
    b. Battery pad heaters
    c. Enclosure heaters (2)
    d. Battery charger
    e. Motorized dampers
    f. Circuit for ATC (2)
    g. 20 ampere, single pole spares (6)
12. All lighting (including battery light) and receptacles within the enclosure shall be prewired to a separate junction box for field wiring to a life safety panelboard. Lighting circuit shall be independent of receptacle circuit.
13. The generator housing manufacturer shall commission the services of a registered Professional Engineer from the state of New York to certify that the construction of the generator housing is in accordance with [Seismic Zone Group IIB with effective peak ground acceleration of 0.10 Verify]. The registered Professional Engineer shall stamp the enclosure shop drawings prior to submission, indicating compliance.

PART 3 - EXECUTION

3.01 COOPERATION AND WORK PROGRESS

A. The Electrical work shall be carried on under the usual construction conditions, in conjunction with all other work at the site. The Electrical Subcontractor shall cooperate with the Architect, General Contractor, all other Subcontractors and equipment suppliers working at the site. The Electrical Subcontractor shall coordinate the work and proceed in a manner so as not to delay the progress of the project.

B. The Electrical Subcontractor shall coordinate his work with the progress of the building and other Trades so that he will complete his work as soon as conditions permit and such that interruptions of the building functions will be at a minimum. Any overtime hours worked or

additional costs incurred due to lack of or improper coordination with other Trades or the Owner by the Electrical Subcontractor shall be assumed by him without any additional cost to the Owner.

C. The Electrical Subcontractor shall furnish information on all equipment that is furnished under this Section but installed under another Section to the installing Subcontractor as specified herein.

D. The Electrical Subcontractor shall provide all materials, equipment and workmanship to provide for adequate protection of all electrical equipment during the course of construction of the project. This shall also include protection from moisture and all foreign matter. The Electrical Subcontractor shall also be responsible for damage which he causes to the work of other Trades, and he shall remedy such injury at his own expense.

E. Waste materials shall be removed promptly from the premises. All material and equipment stored on the premises shall be kept in a neat and orderly fashion. Material or equipment shall not be stored where exposed to the weather. The Electrical Subcontractor shall be responsible for the security, safekeeping and damages, including acts of vandalism, of all material and equipment stored at the job site.

F. The Electrical Subcontractor shall be responsible for unloading all electrical equipment and materials delivered to the site. This shall also include all large and heavy items or equipment which require hoisting. Consult with the General Contractor for hoisting/crane requirements. During construction of the building, the Electrical Subcontractor shall provide additional protection against moisture, dust accumulation and physical damage of the main service and distribution equipment. This shall include furnishing and installing temporary heaters within these units, as approved, to evaporate excessive moisture and ventilate it from the room, as may be required.

G. It shall be the responsibility of the Electrical Subcontractor to coordinate the delivery of the electrical equipment to the project prior to the time installation of equipment will be required; but he shall also make sure such equipment is not delivered too far in advance of such required installation, to ensure that possible damage and deterioration of such equipment will not occur. Such equipment stored for an excessively long period of time (as determined in the opinion of the Architect) on the project site prior to installation may be subject to rejection by the Architect.

H. The Electrical Subcontractor shall erect and maintain, at all times, necessary safeguards for the protection of life and property of the Owner, Workmen, Staff and the Public.

I. Prior to installation, the Electrical Subcontractor has the responsibility to coordinate the exact mounting arrangement and location of electrical equipment to allow proper space requirements as indicated in the NEC. Particular attention shall be given in the field to group installations. If it is questionable that sufficient space, conflict with the work of other Subcontractors, architectural or structural obstructions will result in an arrangement which will prevent proper access, operation or maintenance of the indicated equipment, the Electrical Subcontractor shall immediately notify the Contractor and not proceed with this part of the Contract work until definite instructions have been given to him by the Architect.

3.02 **INSTALLATION**

A. General
   1. Unless specifically noted or indicated otherwise, all equipment and material specified in Part 2 of this specification or indicated on the drawings shall be installed under this Contract whether or not specifically itemized herein. This Section covers particular installation methods and requirements peculiar to certain items and classes or material and equipment.
   2. The Electrical Subcontractor shall obtain detailed information from manufacturers of equipment provided under Part 2 of this specification as to proper methods of installation.
   3. The Electrical Subcontractor shall obtain final roughing dimensions and other information as needed for complete installation of items furnished under other Sections or furnished by the Owner.

4. The Electrical Subcontractor shall keep fully informed of size, shape and position of openings required for material and equipment provided under this and other Sections. Ensure that openings required for work of this Section are coordinated with work of other Sections. Provide cutting and patching as necessary.
5. All miscellaneous hardware and support accessories, including support rods, nuts, bolts, screws and other such items, shall be of a galvanized or cadmium plated finish or of another approved rust-inhibiting coating.
6. Throughout this Section where reference is made to steel channel supports, it shall be understood to mean that the minimum size shall be 1 5/8" mild strip steel with minimum wall thickness of 0.105", similar to Unistrut P1000 or equal products manufactured by Kindorf or Husky Products Co.

B. Concrete Housekeeping Pads
1. A concrete pad shall be installed for each generator.
2. The General Contractor shall provide the concrete work. Electrical Subcontractor shall supervise and coordinate concrete work to ensure that proper grounding cable, rods, conduit, etc., are located as detailed and as required. The electrical Subcontractor shall also ensure that the concrete is level to within manufacturers published tolerances.
3. All concrete housekeeping pads shall extend a minimum of 6" on each side from the equipment mounted on it. Mounting height of each overcurrent/disconnect device in the above equipment shall not exceed 6'-6" above finished floor. If overcurrent devices exceed 6’-6” above finished floor as a result of the housekeeping pad, the pad shall extend in front of the gear a minimum of 4’-0”.

C. Electrical Distribution Equipment
1. The Electrical Subcontractor shall install all standby electrical distribution equipment per the manufacturer’s recommendations and the Contract Drawings.
2. The installation of all equipment, including working space requirements, shall conform to all NEC and local codes.
3. All necessary hardware to secure the assembly in place shall be provided by the Electrical Subcontractor.
4. The Electrical Subcontractor shall ensure that no piping, ductwork or other equipment foreign to the electrical trade passes through the area extending from the floor to the structural ceiling with the width and depth equal to that of the electrical distribution equipment plus 6" on either side of panel.
5. Floor mounted assemblies shall be installed on concrete housekeeping pads and shall be provided with adequate lifting means. Floor mounted assemblies shall be capable of being moved into installation position and bolted directly to the floor without the use of floor sills. The Electrical Subcontractor shall ensure the floor is level to 1/8 inch per 3-foot distance in any direction.
6. All floor and wall mounted electrical equipment shall be installed such that the handle of the highest circuit breaker does not exceed 6’-6” above finished floor.
7. The equipment shall be installed and checked in accordance with the manufacturer’s recommendations prior to first energization. This shall include but not limited to:
    a. Checking to ensure that the pad location is level to within .125 inches.
    b. Checking to ensure that all bus bars are torqued to the manufacturer's recommendations.
    c. Assemble all shipping sections, remove all shipping braces and connect all shipping split mechanical and electrical connections.
    d. Secure assemblies to foundation or floor channels.
    e. Measure and record megger readings phase-to-phase, phase-to-ground, and neutral-to-ground (four-wire systems only).
    f. Inspect and install all circuit breakers, components, etc. in their proper compartments.
8. Identification shall be provided for all electrical distribution equipment. The electrical system identification shall clearly describe the equipment connected. Method of identification shall be by laminated nameplate made of bakelite or similar material with engraved letters at least 1/4" high and securely attached to the equipment with galvanized

screws. Adhesives or cements shall not be used. A list of nameplates shall be submitted to the Architect for approval prior to fabrication.

9. Control wiring shall be provided as required. Interface all local and remote control wiring and operational systems for each load.

D. Standby Generator - Mounting and Vibration Isolation
   1. The engine and generator shall be close-coupled and mounted on a structural steel base designed to maintain proper alignment of the unit.
   2. The unit shall be certified by the manufacturer to be free from any critical torsional vibrations within a range of plus or minus 10% of synchronous speed.
   3. Isolate the genset with combination steel-spring and elastomer isolators with restraint hardware, made of materials suited for the service.
   4. The standby generator and exterior enclosure shall have IBC seismic certification for Category C, with an Importance Factor of **[ ]**. In addition, the vibration isolators for the standby generator set shall meet all applicable seismic requirements of the latest adopted edition of the New York State Building Code. Guidelines for the installation consistent with these requirements shall be provided by the standby generator set manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, with a peak acceleration and ZPA as required per the Code. The tests shall fully envelope the response spectrum for all equipment natural frequencies up to at least 35 Hz.
   5. Generator(s) shall be located in spaces with a minimum two (2) hour fire resistance rating.
   6. The Electrical Subcontractor shall ensure that no piping, ductwork or other equipment foreign to the electrical trade passes through the area extending from the floor to the structural ceiling with the width and depth equal to that of the generator and the electrical distribution equipment plus 6" on either side of panel.
   7. All connections to the genset, including exhaust pipe, main power feeds, control systems, fuel lines, etc., shall be flexible in order to allow free movement of the genset on its isolators, and to prevent transmission of noise and vibration.

3.03 MATERIALS AND WORKMANSHIP

A. All materials and equipment shall be new and unused and shall meet requirements of the latest Standards of NEMA, UL, IPCEA, ANSI and IEEE. Equipment shall have components required or recommended by OSHA, applicable NFPA documents and shall be UL listed and labeled.

B. Despite references in the specifications or on the drawings to materials or pieces of equipment by name, make or catalog number, such references shall be interpreted as establishing standards of quality for materials and performance.

C. Finish of materials, components and equipment shall not be less than Industry good practice. When material or equipment is visible or subject to corrosive or atmospheric conditions, the finish shall be as approved by the Architect.

D. Provide proper access to material or equipment that requires inspection, replacement, repair or service. If proper access cannot be provided, confer with the Architect as to the best method of approach to minimize effects of reduced access.

E. All work shall be installed in a neat and workmanlike manner and shall be done in accordance with all Local and State Codes.

F. The Owner will not be responsible for material, equipment or the installation of same before testing and acceptance.

3.04 SPECIFIC PROTOTYPE TESTS

A. Engine
   1. Performance (part-load, full load, lug)
   2. Oil Consumption
   3. Fuel Consumption
   4. Exhaust Emissions
   5. Noise Levels, Mechanical and Exhaust

6. Startability (cold and hot ambients)
7. Piston, Ring, and Liner Wear Rates
8. Piston Structural Integrity
9. Lubrication System Evaluation
10. Cooling System Evaluation
11. Valve Train Overspeed Qualification
12. Deep Thermal Cycle Endurance
13. Field Endurance

B. Generator
1. Temperature Rise (per NEMA MG1-22.40 & Mil. Std. 705B-680.1b)
2. Motor Starting
3. Wave Form Harmonic Analysis
4. Insulation Resistance (per Mil. Std. 705B-301.1)
5. High Potential Test (per Mil. Std. 705B-302.1)
6. Winding Resistance (per Mil. Std. 705B-401.1)
7. Saturation, Open Circuit (per Mil. Std. 705B-410.1)
8. Saturation, Short Circuit (per Mil .Std. 705B-411.1)
9. Saturation, Rotating Exciter (per Mil. Std. 705B-414.1)
10. Reactance and Impedance, Negative Sequence (per Mil. Std. 705B-422.1)
11. Reactance, Zero Sequence (per Mil. Std. 705B-423.1)
12. Overspeed (at 150% and per Mil. Std. 705B-505.3)
13. Phase Sequence (per Mil. Std. 705B-507.1)
14. Phase Voltage Balance (per Mil. Std. 705B-508.1)
15. Circulating Currents (per Mil. Std. 705B-509.1)
16. Regulator Voltage Adjustment (per Mil. Std. 511.1)
17. Voltage Waveform Oscillographic (per Mil. Std. 705B-601.1)
18. Voltage Waveform Harmonic (per Mil. Std. 705B-601.4)
19. Voltage Frequency Curve
20. Voltage Dip and Rise
21. Voltage Drift
22. Voltage Spike Check
23. Voltage Sensing Loss
24. Voltage Waveform Deviation
25. No Load Losses
26. Efficiency
27. Overload Capability
28. Short Circuit Capability
29. Electromagnetic Interference (EMI) Evaluation
30. Telephone Influence Factor (TIF)

C. Generator Set
1. Mechanical Compatibility
2. Structural Integrity
3. Mounting Evaluation
4. Wiring Compatibility
5. Control Panel Functionality
6. Linear Vibration Measurement
7. Torsional Vibration Analysis (per Mil. Std. 705-504.2)
8. Radiator Performance
9. Noise Level
10. Transient Response, Voltage and Frequency
11. Load Performance
12. Safety Shutdowns and Alarms
13. Start/Stop Evaluation

3.05 SPECIFIC PRODUCTION TESTS

A. Each engine, generator, and generator set shall be subjected to production performance tests and quality controls to ensure reliable operation. These tests and controls shall include but not be limited to:
   1. Specific observances of engine blow-by, slobber, combustion gas leaks, inlet air leaks, excessive vibration, and unusual noise.
   2. Fuel system setting confirmation which shall not be altered to rectify non-conformance to established performance specifications.
   3. Retest after any change affecting airflow through the engine, fuel injected into the engine, engine combustion, or any reassembly which potentially affects mechanical integrity.
   4. Periodic extended tests to confirm baseline data.
   5. Recording of:
      a. Engine
         1) Corrected Power
         2) Full Load Speed
         3) Full Load Torque
         4) Turbo Boost
         5) Inlet Air Restriction
         6) High Idle Speed
         7) Low Idle Speed
         8) Fuel Pressure
         9) Oil Pressure
         10) Oil Temperature
         11) Fuel System Setting
         12) Response (RPM-Time) for Full Load Removal
         13) Timing
         14) Barometric Pressure
         15) Water Vapor Pressure
         16) Inlet Air Temperature
      b. Generator
         1) Voltage Gain Range at Load
         2) Voltage Level Range
         3) Regulation Adjustment at 0.8 PF
         4) Voltage Droop Range, when applicable
         5) Circulating Current Between Phases
         6) Voltage Balance Between Phases
         7) Residual Voltage

3.06 FACTORY TESTING

A. Each complete natural gas generator set shall be factory tested at its full factory standby rating. This test shall be conducted with resistive and reactive load banks, at 0.80 power factor and shall demonstrate governor transient response for pickup of full load and rejection of full load.

B. Sequence and duration of the testing shall be as follows:
   1. Following a minimum of 12 hours in the off (shut-down) condition, start unit
   2. Within 10 seconds apply 100% load for 1 hour
   3. Reduce to 0% load for 15 minutes
   4. Increase to 25% load for 15 minutes
   5. Increase to 50% load for 15 minutes
   6. Increase to 75% load for 15 minutes
   7. Increase to 100% load for 4 hours

C. Transient response shall be tested as follows:
   1. From 0% to 50%
   2. From 50% to 0%
   3. From 0% to 100%
   4. From 100% to 0%

D. Metering shall be provided on the output of the generator that shall measure and record the following at 15 minute intervals:
   1. AC Current (Amperes) per phase
   2. AC Voltage (Volts) for A-B, B-C, and C-A, A-N, B-N, and C-N
   3. Real Power (WATTS), Reactive Power (VARS) and Apparent Power (VA)
   4. Frequency (HERTZ) Accuracy +/- 0.04%.
   5. Power Factor
   6. Current - Percent Total Harmonic Distortion (THD)
   7. Voltage - Percent THD in A-B, B-C, C-A, A-N, B-N, and C-N.
   8. Crest Factor (ratio of peak current to RMS current).
   9. Waveform capture and display during changes in load/transient

E. In addition, the following shall be tested and documented prior to shipment.
   1. Overcrank
   2. High engine temperature
   3. Low lube oil pressure
   4. Overspeed safeties

F. The Owner reserves the right to witness factory testing. If the Owner exercises his/her right to witness the testing, pre-testing shall be performed prior to the testing witnessed by the Owner to assure that the testing is completed satisfactorily. Copies of the pre-testing reports, as well as any corrective measures performed shall be submitted to the Architect two (2) weeks prior to the test.

G. Certified copies of the factory test results shall be furnished to the Architect within three (3) weeks following the date of the test and prior to on-site acceptance testing. Test results shall include the following:
   1. Rated load (full 100% load)
   2. Rated power factor
   3. Ambient temperature
   4. Altitude
   5. Fuel grade

3.07 **START-UP**

A. Generator start-up shall include battery installation, fuel system priming, and a general inspection of the exhaust and ventilation systems to ensure proper installation and operation. All accessory and support equipment shall be installed and operating.

B. Each generator set shall then be started and observations shall be made by a factory trained technician as to proper operation of the engine, generator, generator controls, and all external engine generator support systems. All safety shutdowns and pre-alarm devices shall be checked for proper operation of the circuit and corresponding indicating lights on the control panel and at the remote annunciator panel, in the presence of the Owner and the Electrical Engineer. Phase rotation shall be checked.

3.08 **ON-SITE ACCEPTANCE TESTS**

A. General
   1. On-site acceptance testing shall be conducted after start-up is complete. Load testing shall be conducted in accordance with the latest adopted edition of NFPA 110. The testing shall consist of an on-site installation test utilizing available connected load supplemented by load banks.
   2. All generators shall be tested simultaneously and shall continue to run for the duration of the test. Automatic load shed functions shall be disabled during the test.
   3. The Authority Having Jurisdiction (AHJ) as well as the Owner and Electrical Engineer shall be given sufficient advanced notification of the date and time of testing so that they have the opportunity to witness the test.
   4. Prior to testing, the following shall be made available to the AHJ:
      a. Prototype testing results of the same model and rating indicating ability to survive without damage from common and abnormal disturbances in actual load circuits.

b. Certified analysis of the torsional compatibility of the rotating element of the prime mover and generator.
c. Manufacturers letter of compliance with NFPA 110
d. Manufactures certification of factory testing.

B. Building Load Test
1. With the prime mover in a cold start condition and the standby load at operating level, simulate a normal power failure by opening main normal power to the building and observe and record the following:
a. Time delay on start
b. Cranking time until the prime mover starts and runs
c. Time taken to reach operating speed
d. Time taken to achieve steady state condition
e. Time for each transfer switch to transfer to the standby position
f. Voltage, frequency and amperage shall be recorded continuously
g. Record prime mover oil pressure, water temperature and battery charge rate at five (5) minute intervals for the first fifteen (15) minutes and at fifteen (15) minute intervals thereafter.
h. Generator run time
2. If there is no standby load available for the testing, load banks shall be provided and connected so that each transfer switch carries load.
3. Continue building load test for a minimum of 1.5 hours and continue to record readings at fifteen (15) minute intervals. Additionally, observe and record load changes and the resultant effect on voltage and frequency.
4. Restore normal power and record the time delay on retransfer to normal position (minimum of 5 minutes).
5. Time delay on cool down period shall be recorded

C. Full Load Test
1. After completion of the above building load test, allow the prime mover to cool for a minimum of five (5) minutes. At this point, a test shall be conducted for two (2) hours utilizing available building load, supplemented with resistive load banks. It shall be permitted to perform the load test individually for each generator.
2. Any means to initiate engine start is acceptable. Once the prime mover has reached rated voltage and frequency, apply load to prime mover as follows:
a. Not less than 30 percent of nameplate kW rating for the first 30 minutes
b. Not less than 50 percent of nameplate kW rating for the next 30 minutes
c. Not less than 100 percent of nameplate kW rating for the remaining 60 minutes
3. Record the following when applying additional load and every fifteen (15) minutes until completion of the test:
a. Cranking time until the prime mover starts and runs
b. Time taken to reach operating speed
c. Time taken to achieve steady state condition
d. Voltage, frequency and amperage shall be recorded continuously
e. Prime mover oil pressure, water temperature and battery charge rate

D. Cycle Crank Test
1. The cycle crank test shall be performed using manufacturers recommended method to prevent the prime mover from running.
2. The control switch shall be set to “run” to cause the prime mover to crank for 15 seconds.
3. The battery charge rate shall be recorded at five minute intervals for a minimum of 15 minutes, or until the charge rate stabilization.

E. Safety Indication and Shutdown Tests
1. The following safety indications and shutdown functions shall be tested as recommended by the manufacturer:
a. Low water temperature
b. High engine temperature pre-alarm

c. Low coolant level
d. EPS supplying load
e. Control switch not in automatic position
f. High battery voltage
g. Low cranking voltage
h. Low voltage in battery
i. Battery charger ac failure
j. Lamp test
k. Contacts for local and remote common alarm
l. Audible alarm silencing switch
m. Low starting air pressure
n. Low starting hydraulic pressure
o. Air shutdown damper
p. Remote emergency stop
q. Start circuit derangement

F. After all testing is completed and accepted by the AHJ, Owner and Engineer, provide six (6) copies of a detailed test record including all recordings and test logs. Also, provide a letter on manufacturer's letterhead indicating that testing has been successfully completed and the emergency system is in first class operating condition.

G. The testing organization shall be responsible for providing all necessary equipment and materials to perform the above tests, including, but not limited to:
1. Load banks
2. Interconnecting cables of appropriate length with interconnections as required
3. Cable lugs
4. Overcurrent protection device(s) between generator and load bank(s) (if required).

H. Manufacturer shall provide copies of test reports upon request.

3.09 TRAINING

A. The Electrical Subcontractor shall provide a training session for up to 6 Owner's representative for 2 normal workdays at a jobsite location determined by the Owner.

B. The training session shall be conducted by a manufacturer's qualified representative. The training program shall consist of the instruction on the operation of the assembly, circuit breakers, and major components within the assembly.

C. The training program shall include the following:
1. Review of the project one-line drawings and schedules.
2. Review of the factory record shop drawings.
3. Review of all equipment in the standby electrical distribution system.
4. Discuss the maintenance timetable and procedures to be followed in an ongoing maintenance program.
5. Provide three ring binders to participants complete with copies of drawings and other course material covered.

3.10 OPERATION INSTRUCTIONS AND MAINTENANCE MANUALS

A. After completion of work and start-up of the equipment at the jobsite, deliver to the Contracting Officer, copies of operating instructions, maintenance manuals and drawings presenting full details for care and maintenance of each item of equipment furnished and/or installed under this Contract.

B. Each manual shall contain the operating and maintenance information and parts lists furnished by the manufacturer, for all equipment provided in the Contract. When necessary, provide supplemental drawing to show system operation and servicing and maintenance points. For all electrical components, furnish wiring and connection diagrams. Manuals shall include instructions required to accomplish specified operation and functions. Data shall be neat, clean, legible copies. Drawings shall be accordion folded. Non-applicable information shall not be included. Five (5) sets of manuals shall be furnished to the Owner.

C. Switchgear drawings and wiring diagrams shall be furnished complete and up to date at the completion of start-up and system acceptance by the Owner. Drawings and wiring diagrams shall include any field modifications or changes to reflect actual as built conditions.

END OF SECTION